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IDEAS: Intelligent NeighbourhooD Energy Allocation & Supervision

Deliverable 5.4

Impact report French demo

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Deliverable Administration & Summary					IDEAS
No & name	**D5.4 Impact report French demo**				
Status	Final	**Due**	M34	**Date**	2015/10/31
Author(s)	Pascale Brassier (NOBATEK), Igor Perevozchikov (NOBATEK), Tracey Crosbie (UoT), Muneeb Dawood (UoT), Denis Gras (IBM-F)				
Editor	NOBATEK/UoT/CSTB/IBM-F				
DoW	**Task Description:** operation and evaluation of the upgraded neighbourhood in the French demo-site. In this task, the upgraded neighbourhood in the French demonstration site has been operated over several months and the evaluation of the influence and benefits of the implemented solutions has been conducted considering all the specificities of the site and the particular levers for energy savings targeted by the IDEAS solutions. To do so, a methodology has been defined in order to cover the different aspects targeted by the demonstration: energy positivity, demand-response optimisation, users' awareness… The IPMVP methodology is used as a basis for the evaluation of energy savings that are reached during the demonstration. **Deliverable Description:** Report detailing the impact of the internet based infrastructure and decision support system for control management in the French demonstration case measured against the baseline data supplied by D5.1.				
Comments					

Document change history			IDEAS
V	**Date**	**Author**	**Description**
1.	2015/07/21	Pascale BRASSIER (NOBATEK)	First version – outline of content, description of the implemented tools, description of the methodology used for the analysis and partners expected contribution.
2.	2015/09/28	Pascale BRASSIER (NOBATEK)	Second version – further drafting: main outcomes coming from the 3DVW visits, results of the data analysis, main lessons learnt and conclusions.
3.	2015/10/08	Tracey CROSBIE (UoT)	Restructure of Conclusions & lessons learned
4.	2015/10/14	Pascale BRASSIER (NOBATEK)	Version submitted to reviewers
5.	2015/10/28	Pascale BRASSIER (NOBATEK), Tracey CROSBIE (UoT)	Redraft of the executive summary, corrections made according to the reviewers comments
6	2015/10/30	Pascale BRASSIER (NOBATEK), Tracey CROSBIE (UoT)	Final version

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ACRONYMS

CHP	Combined Heating and Power
DNO	Distribution Network Operator
DoW	Description of Work
DSM	Demand Side Management
ECM	Energy Conservation Measures
EDF	Électricité de France
EMS	Energy Management System
EPC	Energy Performance Contracting
EPI	Energy Positivity Indicator (%)
EPN	Energy Positive Neighbourhood
EPNSP	Energy Positive Neighbourhood Service Provider
ESC	Energy Supply Contracting
ESCo	Energy Service Company
FIT	Feed-In Tariff
FM	Facility Manager
GWh	GigaWatt Hour
HDD	Heating Degree Days
HVAC	Heating, Ventilation and Air Conditioning
IBM-F	IBM Montpellier, France (project partner)
IBM-H	IBM Haifa, Israel (project partner)
ICT	Information and Communication Technology
IOC	IBM®Intelligent Operations Centre
IUT	University Institute of Technology, Bordeaux (project partner)
KPI	Key Performance Indicator
kWh	KiloWatt Hour
kWp	KiloWatt Peak
LED	Light-Emitting Diode
MWh	Megawatt Hour
PV	Photovoltaic
PWN	Private Wire Network
ROI	Return on Investment
SSM	Supply Side Management
TNO	Transmission Network Operator
UI	User interface
UoT	University of Teesside (coordinating project partner)
VTT	VTT Technical Research Centre of Finland (project partner)
WT	Wind Turbine
3DVW	3D Virtual World

EXECUTIVE SUMMARY

The main objective of the IDEAS project is to illustrate how communities, public authorities and utility companies can be engaged in the development of energy positive neighbourhoods (EPNs). These are neighbourhoods in which the annual energy demand is lower than the annual energy supply from local renewable energy sources.

This report concerns the demonstration and validation phase of the project. It presents the findings from a pilot study undertaken as part of the project. This study involved testing the tools, interfaces and business models developed in the project at part of a University campus in Bordeaux, France which houses the University Institute of Technology (IUT).

The French pilot site has no meaningful renewable energy sources and a high energy demand. The logic underpinning the French pilot study is to identify if the tools and elements of the business model tested at the pilot site could move the neighbourhood towards a financially viable energy positive neighbourhood in the French context (see figure below).

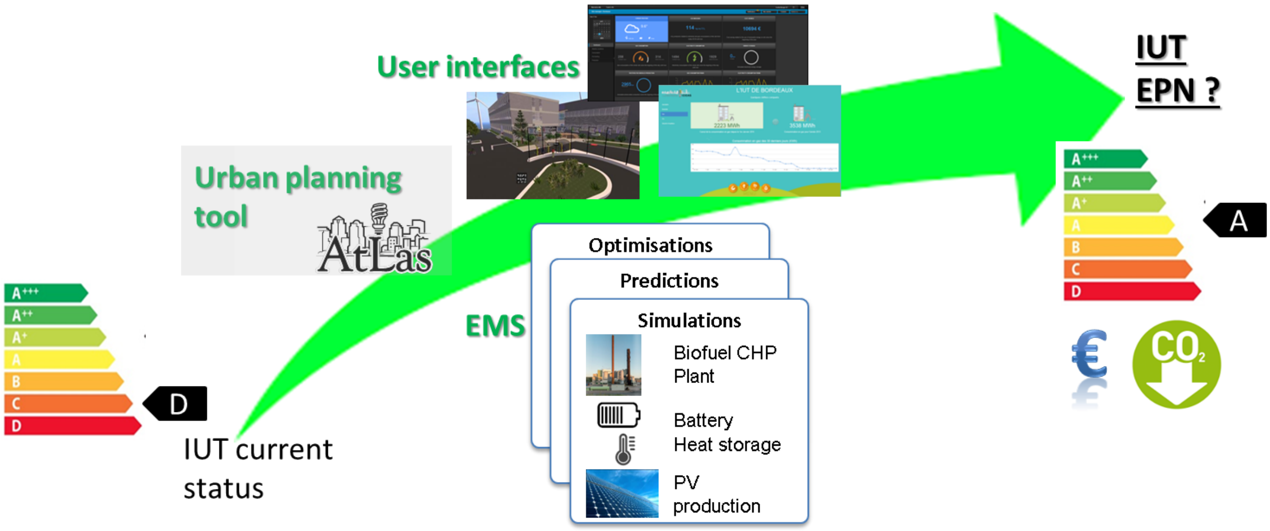


Figure 1: Logic underpinning the demonstration phase within IDEAS

The tools and interfaces tested in the French pilot study include:

1. A neighbourhood energy management system (EMS) developed to optimise storage/retrieving and buying/selling energy and supply energy demand predictions for energy trading.
2. Innovative user interfaces developed to interact with the occupants of an EPN:
   a. Interfaces required for energy consumers and producers to interact with the services required for Demand Side Management, Supply Side Management and energy trading energy etc.
   b. Community based interfaces, in the form of a wide screen and a 3D virtual environment, that raise energy awareness and ‘promote’ the concept of an EPN to the occupants of the EPN and the wider public.

The research presented includes simulations conducted to test the viability of one of the key revenue streams underpinning business models developed in the IDEAS project: Namely reduced costs for energy production and increased profits from optimising the production, storage/retrieval and buying/selling of energy. This report also describes how user interfaces were tested through the deployment of the tools and interfaces on site and the qualitative assessment of their impact on the occupants and managers of the site through questionnaires, interviews and logging online activities.

The scheme illustrated in the figure below was employed to test the EMS. Two local energy sources are simulated and several optimisation scenarios are tested in order to identify the most promising or realistic approaches to move the neighbourhood towards energy positivity.

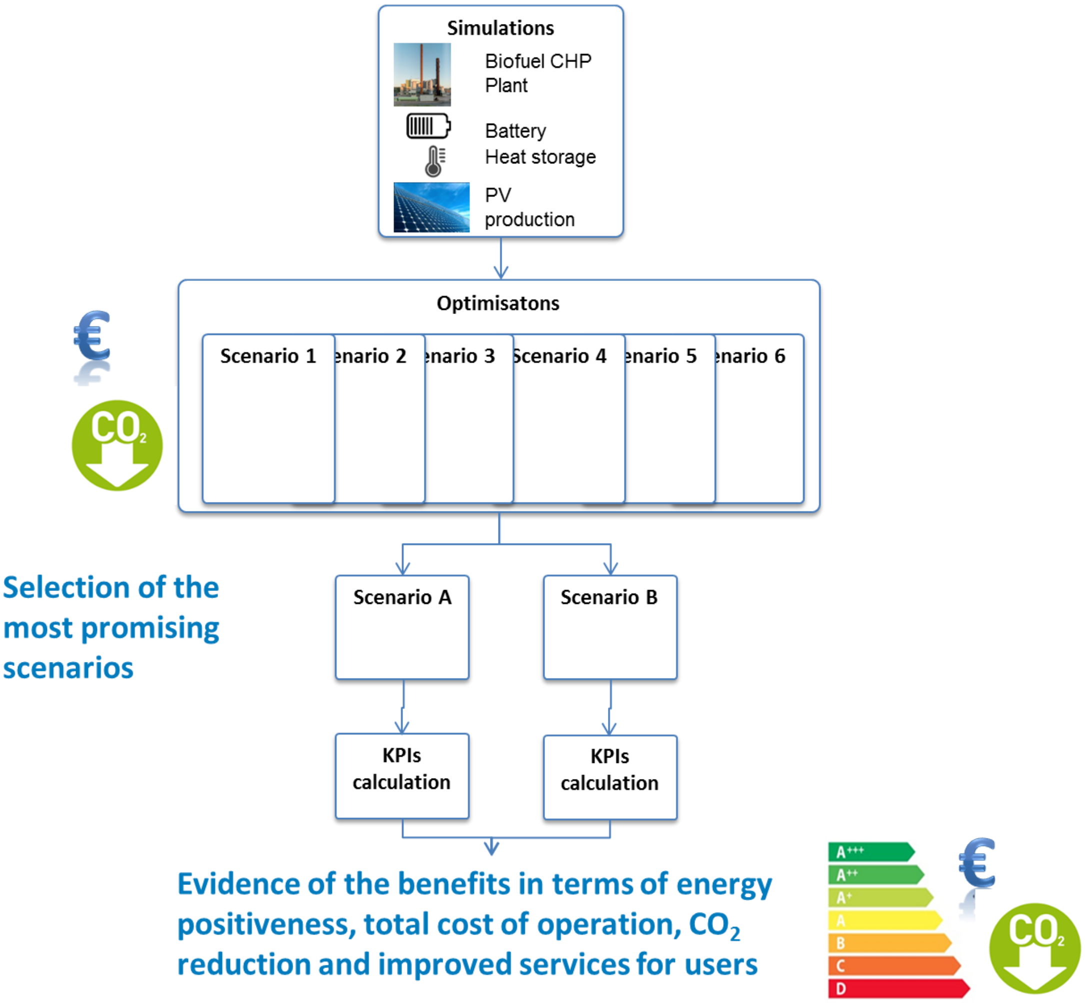


Figure 2: Scheme used to test the EMS

For the two most promising scenarios, the Key Performance Indicators (KPIs) developed in the IDEAS project to measure the energy ‘positiviness’ of a neighbourhood are calculated. These KPIs are compared to the current situation at the site based on a calculation of the same KPIs for the French Pilot site as it was at the beginning of the project. Table 1 summarises the results in terms of impact on the French pilot site of the different simulated scenarios that were tested in comparison to the baseline period.

The primary KPI is the On-site Energy Ratio (OER) which is the annual energy supply from local renewable sources/annual energy demand (all types combined) expressed as a percentage. This is used to indicate the level of on the energy ‘positiveness’ scale. In both scenarios, the IUT site reaches level A on the energy ‘positiveness’ scale and so the tested optimisation scenarios raise the energy positivity of the site more than three levels.

In terms of energy costs, the reductions calculated for the most promising scenarios are close to fifty percent (40.6% for scenario A and 57.8% for scenario B). In terms of CO2 emissions, the reductions are above 30% for both tested scenarios which is above the initial objectives stated for the IDEAS project.

	BASELINE PERIOD 19/2/13 TO 07/ 10/ 13	REPORTING PERIOD 19/2/15 TO 07/ 10/ 15 NO INTERVENTION	19/2/15 TO 07/ 10/ 15 SIMULATED PV	19/2/15 TO 07/ 10/ 15 SCENARIO A (PV+CHP 2000KW)	19/2/15 TO 07/ 10/ 15 SCENARIO B (PV+CHP 600KW)
OER (%)	0 % (no local Energy Supply)	0 % (no local Energy Supply)	26 %	98 %	235 %
ENERGY COSTS (€)	104403	60157	47585.8	35709.51	25378.12
COSTS SAVINGS (%)			20.9	40.6	57.8
CO_2 EMISSIONS (G $EQCO_2/M^2$)	8109,4	5715,3	5574,9	2405.1	3791,9
CO_2 EMISSIONS AVOIDED (G $EQCO_2/M^2$)		2394,1	140,4	3310,2	1923,4
CO2 EMISSIONS AVOIDED (%)		29,5 %	2,5 %	57,9 %	33,7 %
ENERGY POSITIVITY LABEL	D	D	C	Nearly A	A+++

Table 1: Evolution of the main features for the IUT site according to the scenarios tested with the EMS

The income generated by selling the locally produced electricity back to the grid or the costs savings generated through the introduction of local energy sources could be used to pay for implementation of the IDEAS tools as well as for CHP, PV and energy storage installations required to bring the site to level A on the energy ‘positivity’ scale. Table 2 provides an outline the cost and benefit analysis conducted.

In Case 1, the CHP plant is sized to provide baseload thermal output, with any shortfall in heat during peak winter demand being provided by a gas fired back-up boiler.

In Case 2, the CHP plant is sized to provide thermal output to meet peak winter heat demand and therefore is larger.

In Case 3, the CHP plant is sized to more than meet the heat demand of the site enabling a greater percent of the energy produced to be sold to the national grid.

The findings from the cost analysis indicate the following when employing an EMS to optimise local renewable energy production, storage and sale in the French context:

- In the current situation (selling price higher than buying price), the investment in large capacity CHP is economically justified because the ROI is the shortest for the 2000kW CHP presented in Case 3 scenario 1. However in this case all the heat generated during the summer months is wasted as the CHP is running simply to generate electricity. This suggests that future work should look at the possibilities of combined cooling heat and power (CCHP) which could reduce the ROI further.
- However it must be considered that in the future situation of the IUT site (selling price lower than buying price), it does not make economic sense to invest in larger

CHP capacity to increase the OER and sell the excess electricity back to the grid as income generated in this way extends the payback period.

- These two situations correspond to extreme cases and the realistic scenario would be somewhere between the two values.

Case 1 / Scenario 1	
CHP 600 kW PV 367kWp γ=0, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 600 kW	406850
Heat Storage 500 kWh	20000
PV 367 kWp	734000
Battery Li-ion 150 kWh	126540
Total investment	1287390
Yearly savings	55646,2
ROI (years)	23,1
OER (%)	235%

Case 2 / Scenario 1	
CHP 1200 kW PV 367kWp γ=0, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 1200 kW	628850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1663930
Yearly savings	110188,8
ROI (years)	15,1
OER (%)	444%

Case 3 / Scenario 1	
CHP 2000 kW PV 367kWp γ=0, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 2000 kW	914850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1949930
Yearly savings	161581,7
ROI (years)	12,1
OER (%)	722%

Case 1 / Scenario 4	
CHP 600 kW PV 367kWp γ=0, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 600 kW	406850
Heat Storage 500 kWh	20000
PV 367 kWp	734000
Battery Li-ion 150 kWh	126540
Total investment	1287390
Yearly savings	25012,2
ROI (years)	51,5
OER (%)	69%

CASE 2 / Scenario 4	
CHP 1200 kW PV 367kWp γ=0, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 1200 kW	628850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1663930
Yearly savings	36937,6
ROI (years)	45
OER (%)	96%

Case 3 / Scenario 4	
CHP 2000 kW PV 367kWp γ=0, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 2000 kW	914850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1949930
Yearly savings	39116
ROI (years)	49,8
OER (%)	98%

Table 2: Cost benefit analysis of the different simulation scenarios

The findings from the deployment and qualitative assessment of the user interfaces at the pilot site show that the interfaces were well received by users and occupants of the site are more aware of their energy consumption and how to reduce it.

The energy consumption information made available to staff through the different interfaces developed and implemented as part of the IDEAS project has underpinned new initiatives in energy management at the site. As a result of this information and the discussions and experience of taking part in the IDEAS project the IUT administration is currently investigating the option of hiring an external facility management enterprise (COFELY) to manage the site (P3 take care of the maintenance contract). Thus the IUT is evolving in terms of site management and this could have a huge impact on the way an EPNSP approach can be implemented in the future. As the need for a site facilities manager was highlighted during the implementation and use of the tools at the French pilot site.

1 INTRODUCTION

1.1 Purpose and target group

This report concerns the demonstration and validation phase of the IDEAS project. It reports the findings from the deployment and testing of the IDEAS tools implemented at the French demonstration site. As such the work presented involved operating and evaluating the following tools at the upgraded neighbourhood at French demo site[1].

- A neighbourhood energy management system (EMS) developed to optimise storage/retrieving and buying/selling energy and supply energy demand predictions for energy trading[2].
- Two broad types of innovative user interfaces to interact with the occupants of an EPN:
    a. Interfaces required for energy consumers and producers to interact with the services required for DSM, SSM and energy trading energy etc.: the EPNSP (Energy Positive Neighbourhood Service Provider) interface.
    b. Community based interfaces and virtual environments that 'sell' the concept of an EPN to the occupants of the EPN and the wider public: the awareness interfaces (website and large screens) and the 3D Virtual World,

The French pilot site is currently level D[3] on the energy positivity scale. There is no local renewable energy production on the area. To reach energy neutrality (level A), and cover the current energy demand, it would be necessary to produce 4700 MWh of more renewable energy annually. This means e.g. a bio based CHP (producing all the heat and 70 % of electricity) and around 3000 m^2 of solar panels and local energy storage.

The EMS implemented for the IUT site has allowed the testing of different optimisation scenarios. These scenarios are based on the introduction of local energy production (CHP plant and PV system) and energy storage.

As illustrated in Figure 3, the aim of the demonstration phase is to provide empirical evidence of the benefits of the internet based infrastructure and decision support system for control management in terms of progress towards energy 'positiveness', total cost of operation, CO_2 emissions reduction and improved services for users. As such the evaluation is conducted based on:

- The analysis of real measurements conducted in the pilot site (energy consumption);
- The qualitative assessment of the impact of the user interfaces;
- The simulated operation of the EMS following 13 different energy optimisation scenarios.

[1] This report does not discuss the decision support urban planning tool ATLAS which is discussed in another deliverable (D5.6, Ala-Juusela et al., 2015) in which estimates for the ROI period on different renewable energy supply options and future building development and redevelopment are presented.

[2] The EMS consists of the IBM Intelligent Operations Center (IOC) and models developed by Teesside University. It optimises storage/retrieving and buying/selling of energy and supplies energy demand predictions for energy trading.

[3] The levels for energy positivity were adjusted during the project, and in earlier reports level C is used for IUT.

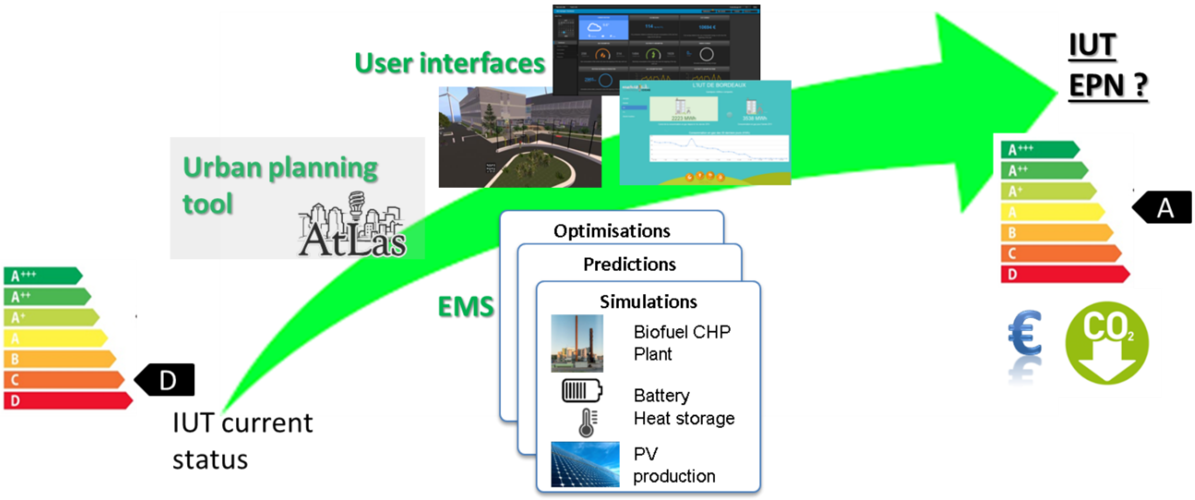


Figure 3: Logic underpinning the demonstration phase within IDEAS

1.2 Contribution of partners

NOBATEK as the task leader structured the work in this report and conducted the data analysis for the comparison with the baseline data presented in Deliverable D5.1 (Gras et al., 2014a). NOBATEK also wrote the following parts of this report: chapter 1, chapter 2, chapter 4, chapter 5 and the executive summary. In addition NOBATEK established the methodology of evaluation and demonstration and conducted the interviews that allowed collecting the feedback from the end-users at the French pilot site. NOBATEK also established the lessons learnt from the demonstration period and highlighted the main benefits and impacts from the implemented tools.

Technical contributions, comments, recommendations and revisions to this document were made by the following partners: UoT, CSTB, VTT, and IBM-F. Specifically:

- UoT provided:
    - The content of the section related to the optimisation scenarios tested during the demonstration phase,
    - The analysis of the results of these different scenarios.

UoT also supported NOBATEK in the production of the executive summary, introduction and the conclusions as well as edited the final draft of the report.

- IBM-F contributed to the section dedicated the cost analysis.
- CSTB conducted the final peer review of this deliverable.
- VTT conducted the final peer review of this deliverable.

Regarding the task itself:

- IBM-F monitored the data collection process and implemented a follow-up approach related to the maintenance of the system during the demonstration phase.
- UoT developed the scenarios used to test the EMS, developed the optimisation algorithms required to implement the demonstration scenarios developed to test the EMS at the French pilot site. UoT provided the results of the optimisation calculations. UoT managed and extracted the information related to the log of

activities on the 3D Virtual World. UoT also provided the simulated data corresponding to the two scenarios used for the KPI calculations.

- CSTB conducted several adjustments to the large screen interface regarding the first comments collected from the end users of the French site. CSTB also implemented a google analytics to monitor the logs activity on the large screen website.
- NOBATEK operated and evaluated the different tools implemented in the French demonstration site during the demonstration phase. This includes the following tasks:
    - Deploy the tools in the French demonstration site (installation and set-up of the five large screens, presentation of the EPNSP interface to the virtual facility managers of the pilot site, diffusion of the instructions for installation of the 3D Virtual World tool, diffusion of information related to the large screens objective to the end-users of the site).
    - Conduct several visits in the 3D virtual world and collect the feedbacks from the visitors and discussed the application of this kind of tool to different areas.
    - Organise and conduct a workshop with the local stakeholders of the IUT site in order to assess the usability of the tools deployed at the French site, discuss the main outcomes/benefits from the IDEAS project with the end-users, and identify any suggestions for improvements of the tools in order for them to be more efficient and more reliable.
    - Analyse the data extracted from the EMS based on the IPMVP protocol and compare this analysis with the data collected during the baseline period (i.e. before the introduction of the IDEAS tools in the pilot site).
    - Calculate the KPIs on the basis of the simulated data provided by UoT and corresponding to the two optimisation scenarios that were retained.
    - Analyse the log activity related to the large screens interface.
    - Identify the benefits of the implemented tools.
    - Identify the main lessons learnt from the demonstration phase and provide evidence of the replication potential of the developed solution.

1.3 Relations to other activities in the project

Figure 4 illustrates the relationship between the work presented in this report and the other activities in the project. As illustrated, the work presented in this report:

- Builds on the earlier work conducted in the IDEAS project as part of WP4 in task 4.1 “Prototyping the Neighbourhood Energy Management tool” and task 4.3 “Prototyping the user interfaces”. Task 5.4 is started as soon as the tools developed within tasks 4.1 and 4.3 were available.
- Is closely related to the Task 5.1 that constitutes a reference (baseline) to which the data collected during the demonstration phase is compared.
- Contributes to the plans being developed for future commercial exploitation of the assets produced during the lifetime of the IDEAS project in Task 2.4 “*Exploitation Planning”*.
- Is framed by the stakeholder engagement undertaken as part of Work Package 6 *“Dissemination and Community Engagement”*.

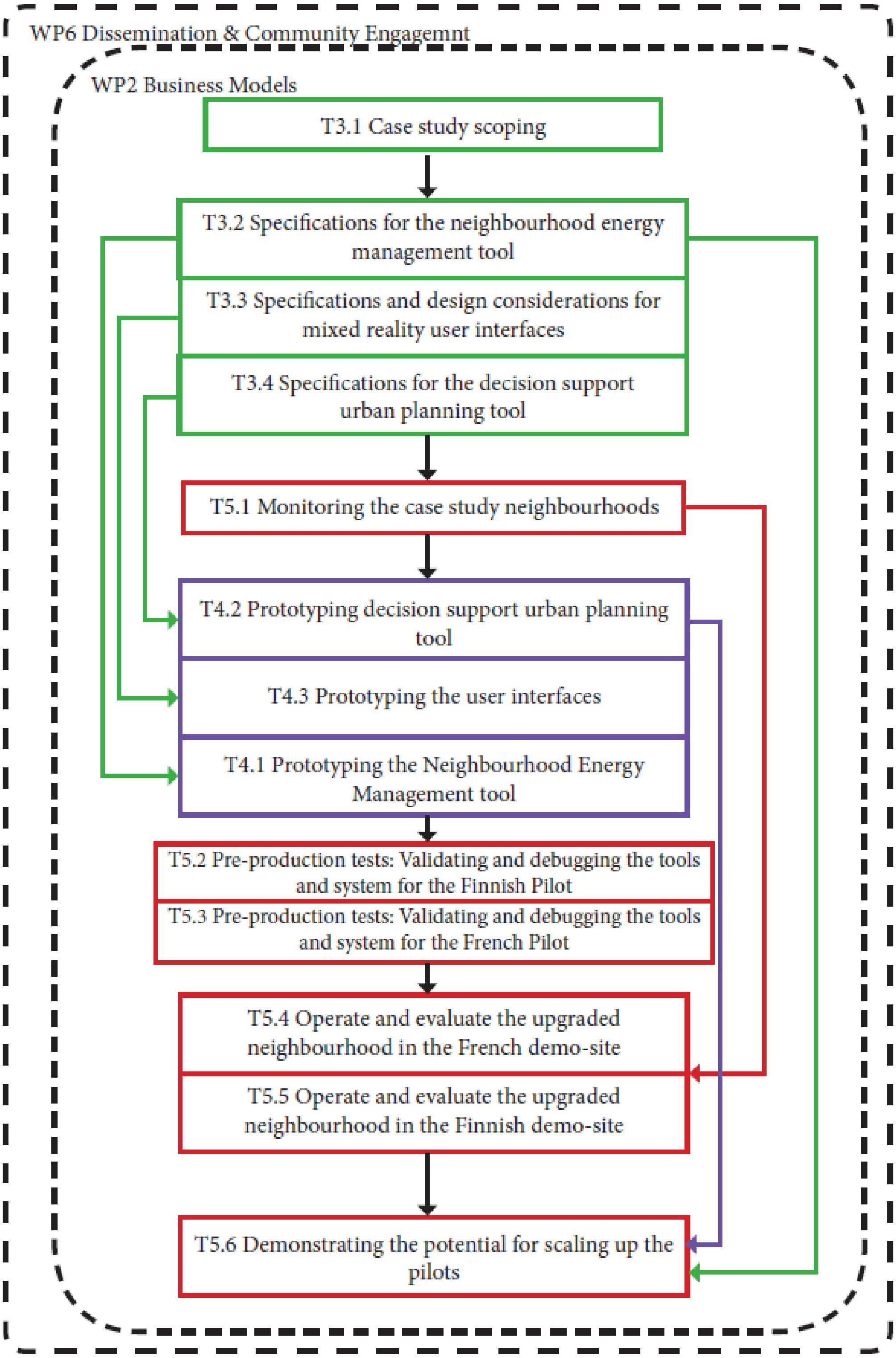


Figure 4: Relationship to other tasks in the project

1.4 Structure of the report

Chapter 2 of this report introduces the pilot site, the energy infrastructure that was simulated to test the EMS and the tools implemented at the French pilot site, describing the content and the aim of each tool.

Chapter 3 describes the privacy strategy adopted in relation to the data collected on site and post-processed to feed the different tools.

Chapter 4 presents the methodology used for the analysis of the data collected during demonstration phase and the analytical approach used to extract useful information from the data and feedbacks collected.

Chapter 5 provides the mains results achieved in terms of energy savings and awareness as well as progress towards an energy positivity of the site thanks to the tools implemented in the French pilot site and specifically the EMS.

Chapter 6 identifies the lessons learnt from the demonstration in the French pilot site and sets out courses of enhancements of the approach.

Chapter 7 concludes this report with a discussion of:

- The benefits of the IDEAS tools implemented at the French demonstration site
- The cost of the IDEAS EMS solution in comparison to its effectiveness.
- A strategy to ensure the wider replicability of the piloted solutions.
- The contribution of the work presented to the IDEAS project overall,
- The lessons learned in relation to the wider research domain.

2 PILOT SITE: TOOL IMPLEMENTATION AND SIMULATION

This chapter provides a short description of the pilot site, describes the energy infrastructures that are simulated in the testing of the energy monument system and the tools implemented at the French pilot site. In doing so it offers the reader an overview of the targeted demonstration objectives.

2.1 Description of the demo site

The French pilot site selected for the demonstration of the IDEAS project is the Institute of Technology (IUT Bordeaux 1; see Figure 5) located in the Bordeaux campus 5 km southwest of the centre of the city of Bordeaux. The institute provides teaching and office facilities for some 2000 students and 500 staff (teachers-researchers; technicians, maintenance workers and administrative staff) in 11 buildings. The total area of the site is 80000 m^2 with around 40000 m^2 of buildings (Ala-Juusela et al., 2014). Almost all of the buildings are used for teaching, although some of them also house offices, workshops, computer laboratories, research laboratories, cafeterias, but also dwellings.

Figure 5: French pilot site – IUT Bordeaux1, Gradignan, FRANCE

The use of the site is highly variable with many parts of the buildings occupied only occasionally. Some researchers-teachers working on energy and ICT issues are key contacts for pedagogical purposes and for getting in touch with students. Similarly, the facilities energy management team on the site is really committed to improving energy efficiency and they constitute key actors for the IDEAS demonstration.

2.2 The simulated energy infrastructures

A major focus of the IDEAS French pilot was to provide tools enabling the end-users and Energy Manager of the IUT site a better understanding of how the site consumes and can produce energy and to visualise the output of the energy optimisation process. The purpose of the implemented tools is to increase occupants' awareness about energy and induce changings in occupants' behaviours. The major objective is to reduce and optimise the energy consumption by improving and raising the energy awareness of students and IUT staff inducing reactions at the occupants' level. Another major objective is to take into account the occupancy of the site in the energy optimisation process.

The main heat supply for the site is a general gas boiler fed with the gas network. And, the pilot site is of course connected to the national power grid. As part of the demonstration, the physical pilot was equipped with simulated extensions, such as a PV system and a biofuel

CHP plant[4]. The main features of these systems are detailed hereafter. These features are in accordance with the work conducted for deliverable D2.2 related to elaboration of the specific business models for demo cases (Crosbie et al., 2014).

Simulated PV system

A PV system has been simulated in order to have a local renewable system production on site enabling to go towards energy 'positiveness' of the site. The simulated PV system has the following features:

The total number of Solar PV panels is 144 covering a total surface of 2880m^2. The peak power of the simulated PV system is 366.968 kWp covering 30% of the electricity demand of the IUT site. The PV production is based on real irradiation conditions measured on site and electricity storage is also simulated so that optimisation of the use of electricity energy can be virtually done by the Energy Manager of the site.

Simulated biofuel CHP

A biofuel CHP plant has been simulated. Three sets of parameters for CHP size have been tested:

- CHP plant size of 600 kW (67% heat and 33% electricity generation capacity). A CHP plant of 600 kW running at full capacity for 8760 hours will give annual heat and electricity production of 3521.52 MWh and 1734.48 MWh respectively.
- CHP plant size of 1200 kW (67% heat and 33% electricity generation capacity). A CHP plant of 1200 kW running at full capacity for 8760 hours will give annual heat and electricity production of 7043.04 MWh and 3468.96 MWh respectively.
- CHP plant size of 2000 kW (67% heat and 33% electricity generation capacity). A CHP plant of 2000 kW running at full capacity for 8760 hours will give annual heat and electricity production of 11738.4 MWh and 5781.6 MWh respectively.

These three sizing of CHP have been tested because they correspond to different use cases (the first case covers the energy demand of the IUT site without being economical on the financial aspects whereas the second case over-covers the energy demand but is better on the financial aspects. The third case corresponds to what has been discussed within the specific business models definition for demo cases).

The simulated electricity storage system used with 600 kW CHP plant has the following characteristics:
Maximum limit (kWh) = 150.0
Minimum limit (kWh) = 0.0
Maximum increase/hour (kWh/hour) = 38.0
Maximum decrease/hour (kWh/hour) = -38.0
Storage capacitive efficiency, alpha, (energy [i] = energy [i-1] * alpha) = 1.0
Storage input efficiency, beta, (energy[i] += beta x energy in[i]) = 0.8
Cost of storage per kW per hour (Eur) = 0.0

[4] The energy generation from Wind Turbines has been simulated only to feed the wind turbine model in the 3D Virtual World and show it to the visitors in the virtual world. Therefore, it is not considered in any KPI calculation since the introduction of this kind of systems on IUT site is not realistic.

The simulated heat storage system used with 600 kW CHP plant has the following characteristics:

Maximum limit (kWh) =500.0
Minimum limit (kWh) =0.0
Maximum increase/hour (kWh/hour) =125.0
Maximum decrease/hour (kWh/hour) =-125.0
Storage capacitive efficiency, alpha, (energy [i] = energy [i-1] * alpha) = 0.95
Storage input efficiency, beta, (energy[i] += beta x energy in[i]) = 1.0
Cost of storage per kW per hour (Eur) = 0.0

The simulated electricity storage system used with 1200 and 2000 kW CHP plant has the following characteristics:
Maximum limit (kWh) = 300.0
Minimum limit (kWh) = 0.0
Maximum increase/hour (kWh/hour) = 60.0
Maximum decrease/hour (kWh/hour) = -60.0
Storage capacitive efficiency, alpha, (energy [i] = energy [i-1] * alpha) = 1.0
Storage input efficiency, beta, (energy[i] += beta x energy in[i]) = 0.8
Cost of storage per kW per hour (Eur) = 0.0

The simulated heat storage system used with 1200 and 2000 kW CHP plant has the following characteristics:
Maximum limit (kWh) = 1200.0
Minimum limit (kWh) =0.0
Maximum increase/hour (kWh/hour) = 300.0
Maximum decrease/hour (kWh/hour) = -300.0
Storage capacitive efficiency, alpha, (energy [i] = energy [i-1] * alpha) = 0.95
Storage input efficiency, beta, (energy[i] += beta x energy in[i]) = 1.0
Cost of storage per kW per hour (Eur) = 0.0

The following cost and CO_2 parameters have been used for the different calculations and analysis:
Cost of per unit of energy generation by CHP (Eur/kWh) = 0.016
Cost per unit of buying heat energy from grid (Eur/kWh) = 0.055
Cost of per unit of energy generation by Solar PV panel (Eur/kWh) = 0.010
CO2 emissions related to CHP (g eqCO_2/kWh) = 16.19987
CO2 emissions related to buying heat from grid (g eq CO_2/kWh) = 234
CO2 emissions related to PV generation (g eqCO_2/kWh) = 0

2.3 Energy Management System (EMS)

An Internet based ICT infrastructure has been developed to support all the required functionalities of the tools developed within IDEAS. A high-level overview of the inter-relationships and functionalities of the French demonstration site has been specified and is shown on the figure below.

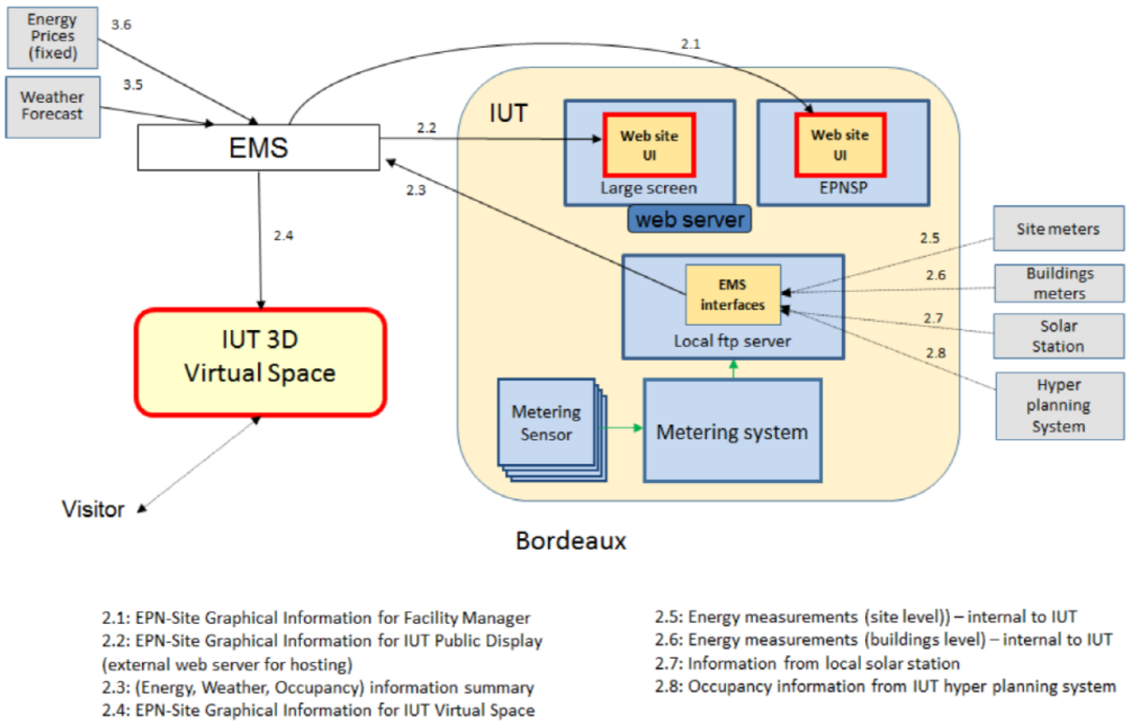


Figure 6: ICT infrastructure – IUT Bordeaux1, FRANCE

Within this global infrastructure, the IOC (IBM®Intelligent Operations Centre), a software solution that is designed to facilitate effective supervision and coordination of operations, is used in IDEAS to provide a central control centre to implement the Energy Management System (EMS) of IDEAS including database and data management, geographical information systems, web hosting and internet interfaces, performance metrics/analytical engines and optimisation tools.

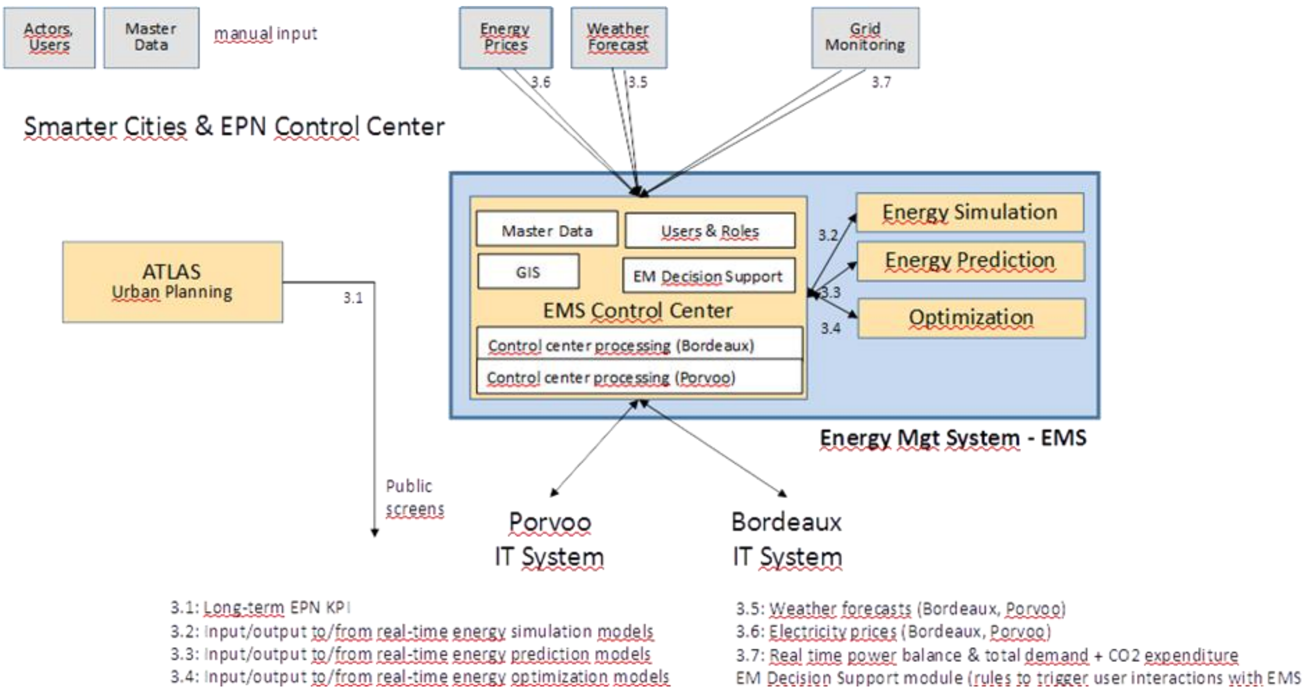


Figure 7: Base EMS Architecture

The EMS is composed of:

- Data interfaces to acquire metering data, weather conditions and energy prices from the two pilot sites;
- A Control Centre based on the IOC, which is both the main data repository and the engine for the hourly processing (see Use Cases 5 and 8 in the D3.2 specifications (Short et al., 2013)), hosted by IBM-F;
- Data interfaces for coupling the Control Centre and models developed for simulation, prediction, optimisation, decision support;
- A portal for IOC based User Interfaces (IUT EPNSP in France);
- Data interfaces for external User Interfaces.

Further details about the EMS and its validation can be found in D4.1 (Gras et al., 2014b) and D5.3 (Gras et al., 2015).

2.4 Awareness interfaces (website and large screens)

The IDEAS project has developed an "energy awareness" user interface (Figure 8) which has been installed on wide screens in public spaces within the French pilot site (5 large screens have been installed in relevant locations, see D5.3 (Gras et al., 2015). The large screens interface applications at the French site aim to achieve two specific objectives: to educate students, teachers, and the other building occupants about energy efficiency of their surrounding environment and to provide and inform them about the impact they have on their university.

This interface is displaying general information related to energy efficiency of the surrounding environment and related to the impact the neighbourhood occupants have on their own neighbourhood. The interface offers a big picture/overview of the neighbourhood and then zooms slowly to arrive at a more detailed level. The interface zooms from the big picture of the national level down to the neighbourhood detail level, including measured data of energy consumption of the whole site. They show nearly real-time consumption as well as historical data. In order to attract the attention of the occupants, tailored notifications, tips and a quiz are also proposed to promote sustainable behaviours.

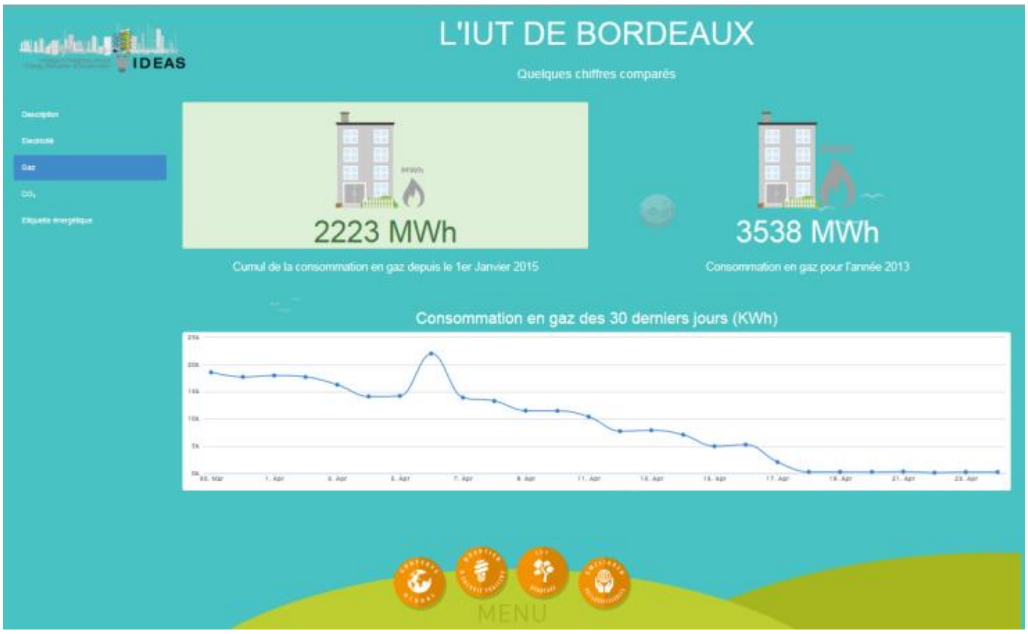


Figure 8: Public screens interface – Electrical consumptions at the French site

The website feeding the large screens is also available directly for a higher interactivity with the end-user and a section dedicated to a quiz is also present. A QR code is available next to the public screens on a tag, so that the occupants can also access the full user interface on their personal devices, and interact with it. A Google analytics has been implemented behind the application URL to track the number of visitors.

The technical architecture implemented for the large screens interfaces is reminded below (see Figure 9). In order to display local information, the application interacts with the EMS.

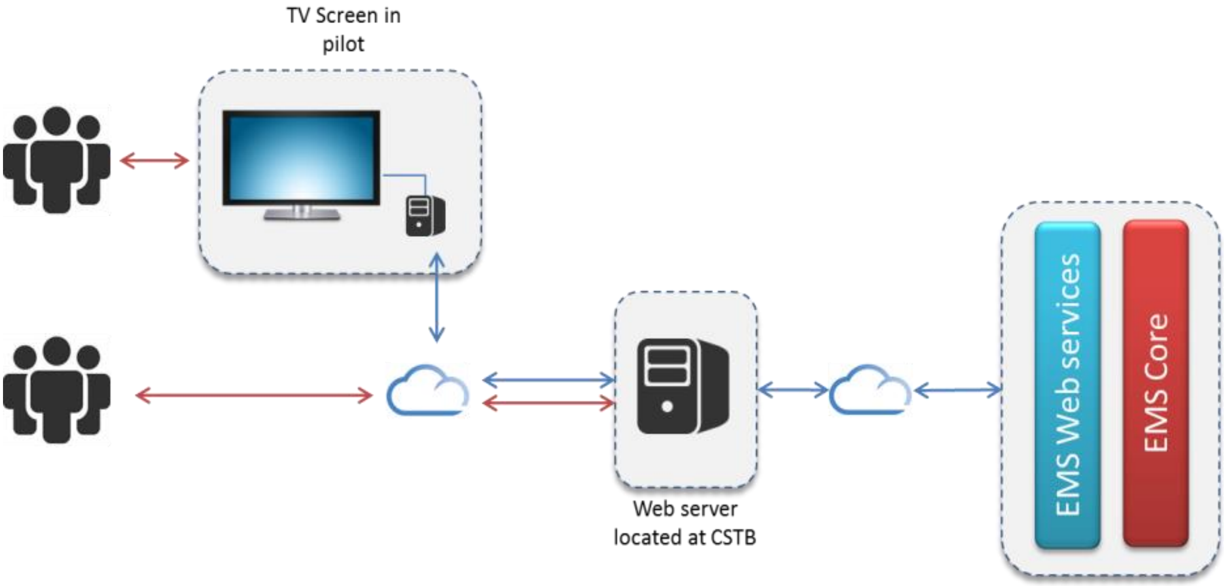


Figure 9 Technical architecture for the large screen interfaces

2.5 Energy Managers interface

The Energy Managers interface (see figure 10) provides energy related professional information that enables managing the EPN. The primary intended user of this tool is a new type of actor, the Energy Positive Neighbourhood Service Provider (EPNSP, described in D2.2, Crosbie et al., 2014).

Figure 10: Energy Manager Interface – Dashboard for the French site

The developed interfaces are hosted by the IBM® WebSphere Portal embedded by the Intelligent Operations Center ® (IBM® IOC) as part of the EMS. The main view of the Energy Managers interface is a manager dashboard (Figure 10) which summarises most relevant data in real time: for instance, the current solar irradiation measured on site and the associated simulated energy production, the energy consumption of the whole site but also at building level for electricity

This interface can help the Energy Manager in the coordination and optimisation of demand side management (DSM) and supply side management (SSM) which are the two key goals of the EPN service provider. Further details about the EPNSP interface content can be found in D5.3 (Gras et al., 2015).

2.6 3D Virtual World

The IDEAS project shared 3D virtual space demonstrates the Energy-Positive Neighbourhoods (EPN) concepts to remote visitors. The idea is to provide remote visitors with a virtual venue to learn about the IDEAS project, an immersive rich collaborative environment without the need to actually visit the project pilot site. A unique aspect of the virtual environment is the incorporation of simulated energy production and storage elements into the neighbourhood representation that do not exist in the real sites, and to show how these are integrated into the intelligent energy management system that is developed as part of the project.

The shared 3D virtual space replicates a portion of the IUT pilot site in Bordeaux, France. The environment attempts to be "realistic" in order to involve the students as much as possible. It enables local IUT employees to host external visitors in (virtual) person and to demonstrate the IDEAS project using the visual and data contexts from the physical IUT site.

The virtual site enables the visualisation of the site global energy consumptions that are available through the actual measurements equipment installed on the site. It focuses on the Civil Engineering department (see Figure 11) that is engaged through its activities in energy management and which is equipped with multiple energy systems from which the students can learn (see D5.3 for further details about the tool, Gras et al., 2015).

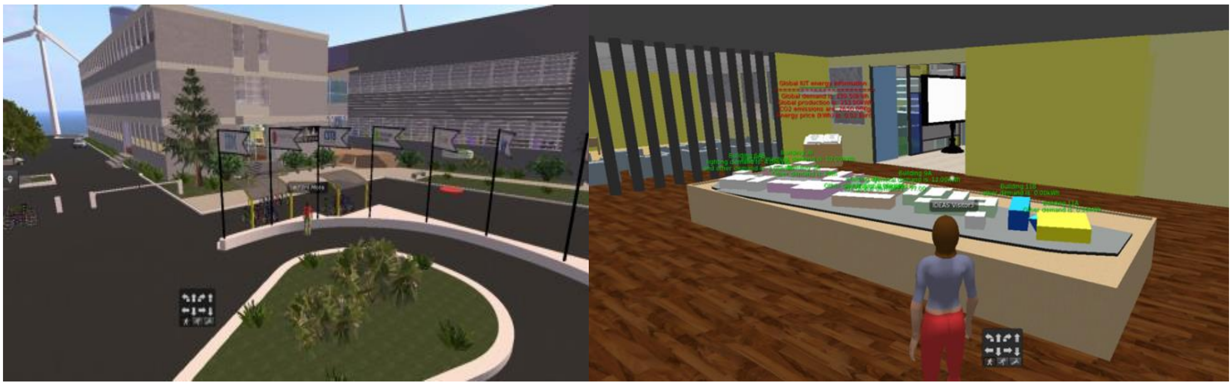


Figure 11: Replica of the Civil Engineering Department building in the 3DVW (left), Interactive mock-up showing the stakes at site level (right)

2.7 Calendar of the deployment of the tools

The following table provides the calendar according to which the tools have been deployed on the French pilot site.

IDEAS Tool	Availability	Deployment
EMS simulations and optimisations	Simulated data are available from 19/02/2015 until 07/10/2015	
3DVirtual World	Operational (EMS connected since 28/04/2015)	1st visit conducted on the 29th of May 2015
EPNSP interface	First version available (EMS connected): 02/04/2015	Interface presented to the facility managers of the IUT site on the 14th of April 2015
Large screens interface	Operational (EMS connected) and large screens turned on since 16/04/2015	General emailing to all the IUT members (students, teachers, …): 20/05/2015

Table 3: Calendar of the tools deployment

According to the DoW of the IDEAS project, the demonstration phase was to last nine months with a one month period prior to the operation and evaluation dedicated to the implementation of the tools. Due to delay in the development of the tools, the evaluation phase has lasted 5.5 months (from mid-April until end of September) for the end users interfaces and 7.5 months for the EMS functionalities related to simulation and optimisation.

2.8 End users at the demo site

The following table provides the list of the end-users of the tools developed within IDEAS and gives their respective roles in the field of use of the tools and administration of the whole system during the demonstration phase of the project.

Currently, there is no energy manager at the IUT site. But people in charge of the technical aspects of buildings and site are already concerned by the energy questions. Therefore people included in the following table have appeared to be the most suitable and relevant people to be involved in the demonstration phase of the project.

End-user	Name of the person	Organisation	Role/position in the pilot site	Additional role during the demonstration phase of the IDEAS project
1	Yves FAYE	IUT	Manager of the technical services	Facility manager (buildings and site level)
2	Jérôme MALVESTIO	IUT	Engineer in the field of energy-attached to the Civil Engineering department	Facility manager and end-user at building level (Civil Engineering department)
3	Laurent MORA	IUT	Teacher attached to the Civil Engineering department	End-user at building level (Civil Engineering department)
4	Denis PIPONNIER	IUT	Services manager	Facility manager (site level)
5	Jocelyn SABATIER	IUT	Teacher attached to the Industrial computing and electrical	Facility manager and end-user at building level (Industrial computing and electrical engineering department)

			engineering department	
6	IUT staff (administrative and technical)	IUT	Users	End-user at building and site level
7	Students	IUT	Users	End-user at building and site level
8	Frédéric FERRERE	IUT	IT manager for the IUT site	End-user at building level +IT administrator (management of the network infrastructure)
9	Pascale BRASSIER	NOBATEK	Project manager- Coordinates the link between the IUT pilot site and the IDEAS project	Management of the monitoring systems deployed in the French pilot site

Table 4 - List of the end-users involved in the demonstration phase of the IDEAS project

3 STRATEGY FOR TACKLING THE PRIVACY ISSUES

3.1 Identification of sensitive data

The French pilot site is a part of the Bordeaux 1 University Campus and therefore could be considered as a tertiary site including activities related to teaching activities essentially.

The energy consumption is not as sensitive as they are for the Finnish pilot site mainly because IUT campus is a public site. The energy consumption data can reveal the way the site is used during the year but this is not a problem since the occupancy rhythm is defined by the school national holidays.

The consumption data is collected at site level as well as building level providing an aggregated set of data that cannot be associated with particular individuals and can therefore be considered statistical data which can be made public. Some data are collected from a solar station installed on site. This solar station is also used for pedagogical purpose by the Civil Engineering department staff for courses support and therefore is considered as public data also as they are measurements of outdoor conditions. The occupancy data collected from the Hyperplanning tool used by the IUT teaching staff are used in an aggregated way (buildings aggregation) and thus cannot be associated with particular individuals.

3.2 The data security within the IUT site

The measurement data from the IUT site are collected using two types of meters: electrical sub-meters attached to the buildings of the site and belonging to the IUT and the Energy providers' meters (EDF and Gaz de Bordeaux) used for the billing. Regarding these last meters, all the necessary authorizations have been established with the energy providers in collaboration with the IUT staff in order to connect the acquisition modules on the billing meters present on site.

The measurement data from the IUT site are collected through two kinds of network: a wireless network (WAVENIS technology) and the Ethernet network of the site which is secured and fully managed by the IUT.

3.2.1 WAVENIS network

The WAVENIS radio transmission system is wireless and works on the 868 MHz frequency. Its wireless range is long enough to cover the whole site in terms of radio transmission but too short for any intrusion attempts on the WAVENIS network from outside the site. The WAVENIS network is also secured in the sense that it is predefined through the implementation of the network itself (thanks to the receiver module included in the gateway installed securely on site) and therefore requires a specific interaction (with this gateway) when a new module needs to be added to the network. This is physically impossible since the gateway is located in a secured room and only accessible to the site manager (NOBATEK) and the IUT staff.

3.2.2 Ethernet network

The transfer through the Ethernet network is fully secured and managed by the IUT. A specific VLAN has been attributed and dedicated to the monitoring infrastructure.

3.2.3 The security of the data transfers

The access to the ftp server is done through the definition of specific access rights. An IP address range (NOBATEK and IBM-F) are given the right to access the ftp server.

3.3 The security of the data storage

3.3.1 Local server at French site

A virtual server is installed at the French site and fully managed by the IT staff of IUT. Data from gas collection system, general electricity meter collection system, electricity sub-meter collection system and solar station is transmitted and stored at this local server in which data management software is installed. Data is converted into appropriate format by this software and then sent to the FTP Server where the IOC connects in order to capture the data.

The virtual server is hosted in a secured IT infrastructure, which complies with all of the required security policies of the University of Bordeaux that is managed by IUT staff. The storage and transfer of monitoring data are managed with the same security level as the one applied for the internal topics at IUT. Restricted access to the virtual server has been implemented by the IUT staff. The access to the server is restricted to the staff of IUT and people from NOBATEK working on the IDEAS project.

3.3.2 FTP server

Formatted data is pushed onto the French site FTP server at regular intervals. From the FTP site, the French pilot site energy and solar data is acquired by the IBM Intelligent Operations Centre (IOC). Access to the French site FTP server is protected by a login and password.

3.3.3 Back-up copy of data

All the source data are back-up saved by the site manager (NOBATEK) on its own storage server. This server is hosted in a secured IT infrastructure managed by NOBATEK with all the required security policies which are related to the security of the enterprise data of NOBATEK.

3.3.4 EMS and IOC

The EMS is getting anonymized data which are used as inputs to simulation and optimisation models provided by UoT. Regarding security, the two IBM IOC environments are hosted in a secured ICT infrastructure. IBM-F is putting significant efforts into managing these environments and applying the related security policies. For example at the network level a virtual private network is used to communicate with the IOC. This requires a valid VPN certificate. The information exchanged with the IOC is secured (HTTPS) requiring authentication.

4 METHODOLOGY

4.1 Quantitative evaluation approach

The quantitative evaluation is conducted according to the specificities of the French pilot site (tertiary site, specific occupancy, specific energy uses, multiple stakeholders associated to the pilot site…) and following the rules derived from the IPMVP protocol.
The strategy is based on the following approaches:

- Multiple levels of analysis: one month to one month comparison, but also typical days and weeks analysis,
- Two energy sources considered (gas for heating and electricity),
- Use of a unique set of measuring equipment for both monitoring purpose and feeding with data the ICT system implemented in the pilot site,
- Savings evaluation based on the comparison of the reporting period data (collected after implementation of the IDEAS tools) to a reference period that was previously established within the task 5.1 (D5.1, Gras et al., 2014a),
- Initial definition of a set of indicators associated to the Energy Positive Neighbourhood concept (see D3.2, Short and al., 2013),
- Initial definition of adjustment methods mainly for heating (HDD adjustments). These adjustment allows the comparison of data collected during different periods of time and for instance during different years.

4.1.1 Comparison between baseline and reporting period

In order to assess the evolutions of energy consumptions within the pilot site, a comparison is conducted between the data collected after the implementation of the tools developed within IDEAS and the data collected during the baseline period (before the implementation of the IDEAS tools).

The IPMVP[5] provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects in commercial and industrial facilities. It may also be used by facility operators to assess and improve facility performance.

In the frame of IDEAS, the IPMVP protocol is used to evaluate the savings associated to different ECM (Energy Conservation Measures) implemented in the French pilot site:

-virtual implementation of renewable energy systems (PV production simulated on site + simulated biofuel CHP plant, see chapter 2.2),

-community based interfaces for energy awareness raising (large screens interface, EPNSP interface, 3DVW).

The option C is used in the analysis (option C=whole site) because the assessment is done at site level (EPN level) so that general energy meters are used for the analysis.

The energy savings determination process is based on the comparison of measured use or demand before and after implementation of ECM, making suitable adjustments for changes in conditions. Figure 12 illustrates the energy-usage history and shows the adjustment process principle.

[5] International Performance Measurement and Verification Protocol

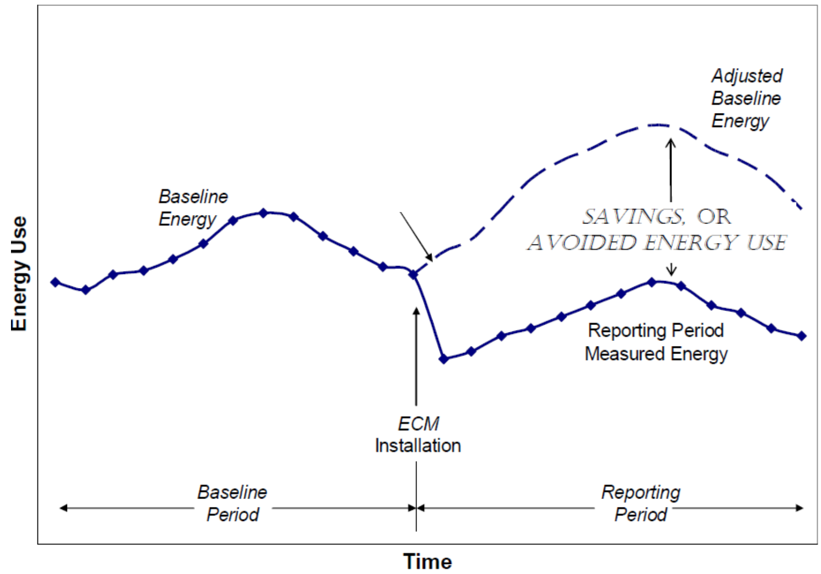


Figure 12: Principle of energy savings evaluated

The baseline was established over the years 2012, 2013, and 2014 (Gras et al., 2014a). The monitoring period conducted during the year 2015 also constitutes a baseline to which some of the data are compared in the rest of the document.

In the frame of the French pilot site, the number of occupants of the site is supposed to be unchanged between the baseline and the reporting period. Only the occupancy associated to holidays (depending on years) is considered as a static factor and used in the adjustments.

Weather (outdoor temperature) is considered as an independent variable allowing the adjustment of heating consumptions. In the frame of IDEAS demonstration, a simple HDD adjustment is used for the energy savings assessment associated to heating consumptions. The HDD base considered in the analysis is 19°C.

4.1.2 Energy opportunity detection

A complementary quantitative analysis has been conducted on the data in order to detect the energy opportunities of the IUT site in relation to the specific occupation of the site and its specific energy use.

This analysis has been conducted by investigating the consumptions profiles and detecting anomalies and unnecessary energy use.

4.1.3 Optimisation scenarios

The optimisation process produces values for storing/retrieving energy (heat and electricity) to/from storage and for selling/buying electricity to/from grid over next 24 hours.
The two optimisation criteria are the following:

- Optimisation with respect to economic cost (profit)
- Optimisation with respect to CO_2 emission cost (reduction).

Optimisation can be configured to favour a particular criterion by setting the value of the input γ. The input parameter γ can take values between 0.0 and 1.0, where 0.0 denotes optimisation with respect to economic cost only and 1.0 denotes optimisation with respect to CO_2 emissions cost only and any value between 0.0 and 1.0 denote optimisation with respect to a weighted combination of two criteria.

In order to determine a favourable value of the γ parameter for the French site with current electricity buying and selling price, the optimisation is configured to run with following combination of Gamma (γ) parameter and electricity buying and selling price:

Scenario	γ	Electricity buying price (€/kWh)	Electricity selling price (€/kWh)
1	0	0.046 (Peak hours) and 0.029 (Off peak hours)	0.0662
2	0.5	0.046 (Peak hours) and 0.029 (Off peak hours)	0.0662
3	1	0.046 (Peak hours) and 0.029 (Off peak hours)	0.0662

Table 5: Costs considered for the different γ value

To determine the effect of decreasing feed-in-tariff compared to the electricity buying price (as expected in future), the following scenarios are run with reduced electricity selling price. These scenarios are run with γ parameter set to 0 i.e. optimisation based on profit.

Scenario	γ	Electricity buying price (€/kWh)	Electricity selling price (€/kWh)
4	0	0.046 (Peak hours) and 0.029 (Off peak hours)	90% of buying price
5	0	0.046 (Peak hours) and 0.029 (Off peak hours)	0.0595
6	0	0.046 (Peak hours) and 0.029 (Off peak hours)	0.0503

Table 6: Definition of the optimisation scenarios tested during the demonstration of IDEAS

These different scenarios were tested for the three sets of experiments described in chapter 2.2:

- PV 367kWp/2880m² + biofuel CHP 600kW
- PV 367kWp/2880m² + biofuel CHP 1200kW
- PV 367kWp/2880m² + biofuel CHP 2000kW

For the last set of experiments (PV 367kWp + CHP 2000kW), only scenario 4 was calculated.

Based on the analysis of the results, the two most promising or realistic scenarios to move the neighbourhood towards energy positivity were identified (scenario A and scenario B) and selected for the KPIs calculation (see chapter 4.1.4).

4.1.4 KPIs calculation

The KPIs defined in relation to the EPN concept and definition have been listed in D3.1 chapter 5.3 (Ala-Juusela et al., 2014) and are reminded in annex A (chapter 9.1). In the frame of the demonstration for the French pilot site, the most important KPIs (OER, AMR, MHS, MHD, RPL, CO_2 emissions and energy positivity level) have been evaluated for the selected scenarios previously identified (A and B). The results have been compared to the KPIs evaluated for the baseline period (before implementation of IDEAS).

The scheme illustrated in the figure below is therefore employed to test the EMS.

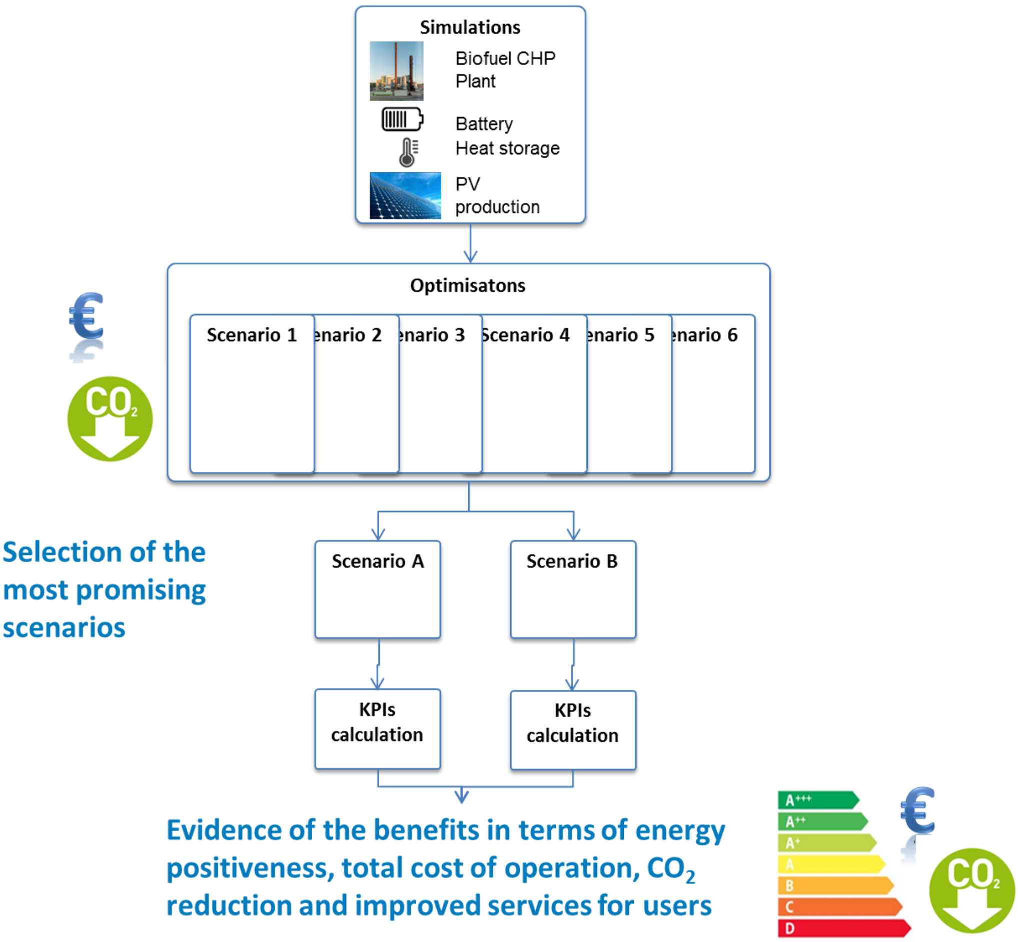


Figure 13: Scheme used to test the EMS

4.2 Qualitative evaluation approach

4.2.1 Interviews/Surveys: tools for the evaluation of behaviour changes

In the frame of an IPMVP approach, some dependent variables related to the behaviour of the site end-users are not measurable. They may involve changes in equipment and uses. A good way to get information about them is the use of questionnaires aimed at users. These are valuable tools especially when the target of the interventions is the user behaviour and when some variables describing uses must be included as independent variables. This approach has been highlighted in the monitoring methodology developed within previous projects (E3SOHO, eSESH, 3e-Houses) (Salmon et al., 2012).
In order to collect the feedbacks from the end-users of the deployed tools as well as occupants of the site, some interviews were conducted at the end of the project (Jérôme MALVESTIO, Laurence PERRIER, Laurent MORA, 02/10/2015).

Besides, a questionnaire (provided in annex B, chapter 9.2) has been submitted to all the occupants of the IUT site via a general emailing.

4.2.2 Log activity on the 3D Virtual World and the awareness interface

The login and logout times for each user of the 3DVW have been measured by UoT on the server where the 3DVW is hosted. The parameters related to the date and time of each connection, duration of each connection, and IP address used for each connection are

registered.
Moreover, a google analytics has been implemented by CSTB in order to monitor the connexion to the website used to feed the large screen interface.
These two monitoring tools are used to analyse the activity on the interfaces.

4.3 Fine tuning of the tools during the evaluation

This section aims at documenting the last actions performed in the French pilot site in order to finalize and correct problems detected in the interfaces as well as the communications infrastructure used as part of the IDEAS solution.

Minor additional modifications and/or bug fixes have been implemented, according to the feedback received from the end users during the initial stage of the pilot phase.

This includes modifications in the large screen interface such as adapting font size and colours on some pages to improve readability according to the exact screens location. Moreover the dynamic pages displaying near real-time data related to the site consumptions have been placed as the first pages of the website in order to get a more attractive home page that is changing at each connexion.

Some slight adjustments have also been made on the EPNSP interface in order to take into account the end-users’ feedbacks collected after the presentation of the tool to the virtual facility managers of the IUT site. For instance, these people were interested in having the mean daily energy consumption value calculated from the beginning of the year displayed in the interface.

5 MAIN RESULTS

This section provides the results obtained according to the methodology developed in the previous section. It also answers point by point to the action plan proposed after the second review meeting.

5.1 Analysis of energy consumptions evolutions compared to the baseline data

This chapter provides an in-depth comparison between the data collected during the demonstration phase (after implementation of the IDEAS tools) and the baseline period (before implementation of the IDEAS tools) in order to identify some potential energy savings. The comparison is conducted for electricity and gas consumptions.

5.1.1 Electricity consumptions evolution

The following graphs illustrate the evolution of electricity consumptions for different periods of time for the whole IUT site. These results are not adjusted with the occupation rate of the site (depending on the years).
Note that for the results presented in Figure 14, the 2015 yearly consumption has been obtained by extrapolating the data collected from January until end of September to the whole year by considering the consumption breakdown over the year for the previous three years.

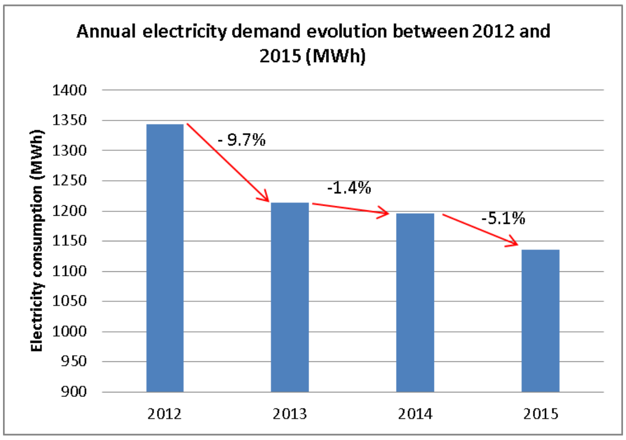


Figure 14: Annual electricity demand evolution between 2012 and 2015 for the whole IUT site

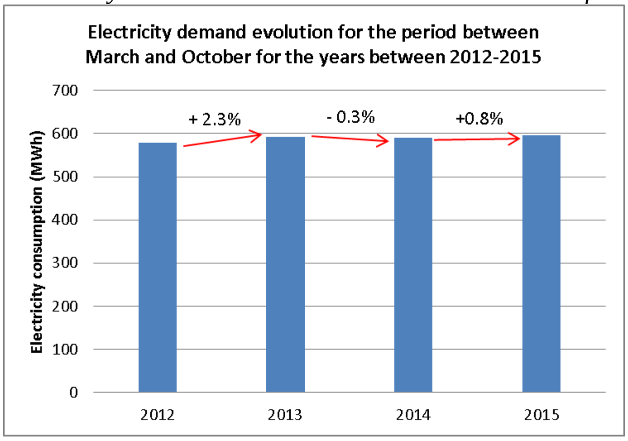


Figure 15: Electricity demand evolution for the period between March and October for the years between 2012 and 2015 for the whole IUT site

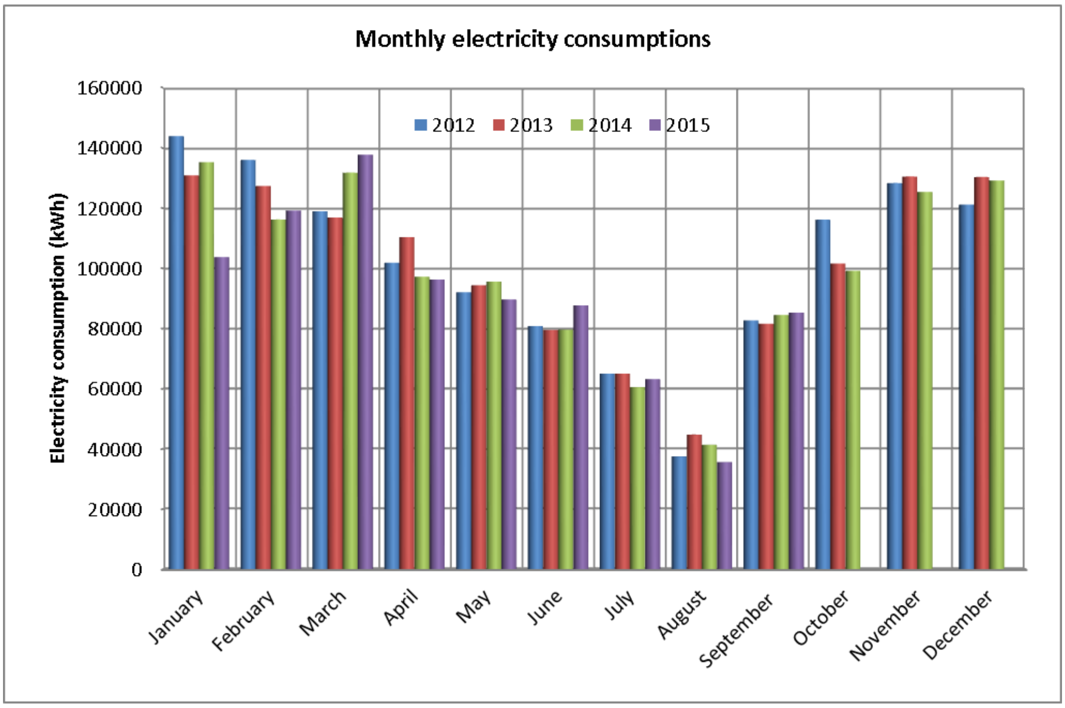


Figure 16: Monthly electricity consumption evolution between 2012 and 2015 for the whole IUT site

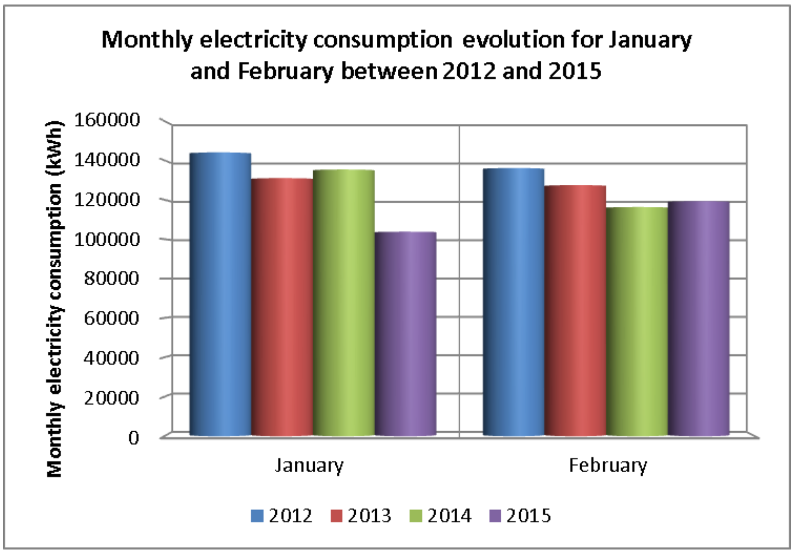


Figure 17: Monthly electricity consumption evolution for the months of January and February between 2012 and 2015 for the whole IUT site

All these graphs show an overall decrease of electricity consumption in 2015. Even if this decrease is not entirely due to the effect of the IDEAS tools, these results reflect the engagement of the IUT people in managing and optimizing their energy use and the positive impact of the measures they have implemented during the past four years.

Figure 14 shows that the yearly electricity consumptions slowly decrease along the years between 2012 and 2015 for the whole site. This decrease can be attributed to the improvement measures implemented by the IUT staff in each building of the site. For example, some improvements have been conducted on the lighting systems:

- the old lamps have been replaced by new performing lighting bulbs,
- an automatic extinction of the lighting system is now activated at the end of each day,
- an automatic switch-on of the lighting system is based on presence detection.

Few years ago, the lighting consumption was the main share of the electricity consumption at the IUT site. The improvements measures have been implemented gradually in the buildings and this may explain the progressive decrease of electricity consumption of the whole site along the years.

5.1.1 Gas consumptions evolution

Figure 18 illustrates the gas consumptions evolution between the years 2012 and 2015. A decrease of 17% is observed between the 1st quarter of 2014 and the 1st quarter of 2015 and a decrease of 13% between the 2nd quarter of 2014 and the 2nd quarter of 2015.

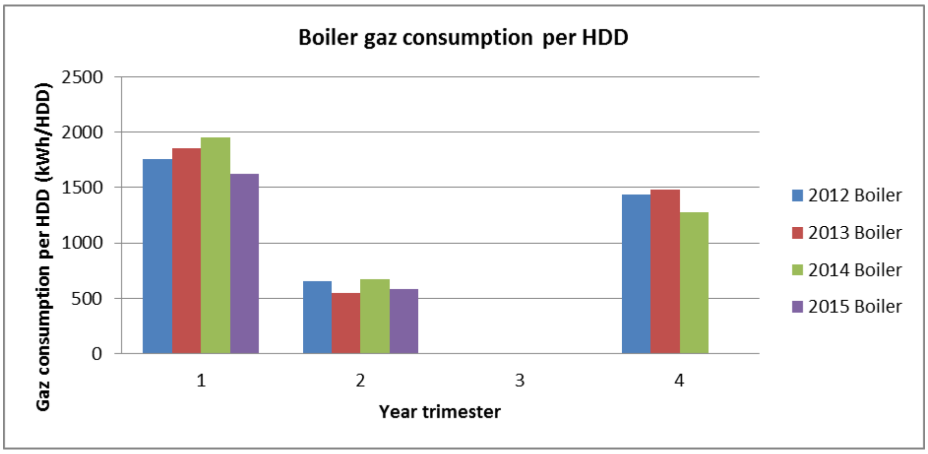


Figure 18: Quarterly gas consumptions evolution per HDD for the years between 2012 and 2015 for the whole IUT site

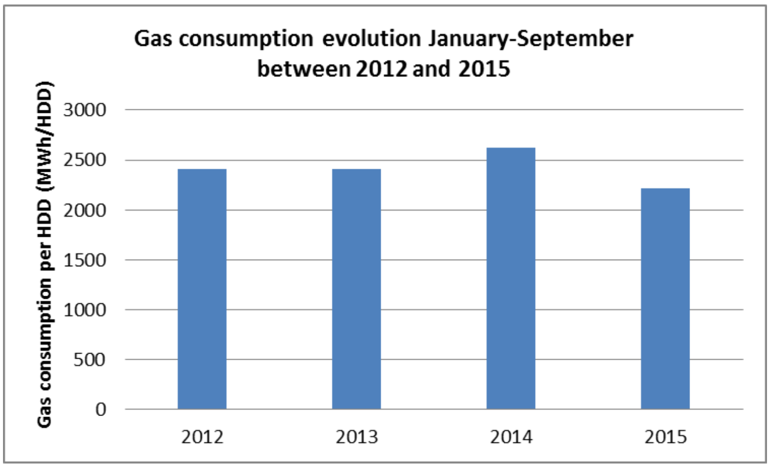


Figure 19: Gas consumptions evolution per HDD for the period between January and September for the years between 2012 and 2015 for the whole IUT site

The same kind of explanation as above for the electricity can be provided here to explain the energy use decrease regarding heating. Some improvements in the heating distribution systems have been implemented by IUT and the positive consequences of these improvements are visible through the progressive decrease in gas consumptions.

5.1.2 Conclusions

It should be emphasized that the comparison between the reporting period and the baseline period is not straightforward because the tools implementation has been late and does not allow a strong demonstration of the IDEAS tools impact on the overall energy consumptions

of the site.
Nevertheless, the results indicate that a decrease in energy use (gas + electricity) appears along the years since 2012, indicating the commitment of IUT in the energy management of the site. The stakeholders' awareness raised by the IDEAS project has contributed to this positive trend.

5.2 Analysis of energy consumptions profiles: is there any change? Is there any energy opportunity?

This section focuses on the profiles and trends of energy consumptions in the IUT site. The energy savings are not characterized only by the consumption values integrated over a period (week, month, and year). They must also be evaluated in terms of reduction of maximum instantaneous power demand (peak shaving). Indeed, the efficiency measures for energy in general but especially for electricity, are intended to avoid or at least shift in time a part of the consumption that occurs during peak demands (Demand Response or Demand Side Management). These peaks usually occur regularly at the same time in the same region or country (around 19:00 p.m. for France, 22:00 for Spain). In the case of the IUT site which is a university campus, the peaks occur around 10:00 a.m. or 15:00 p.m.

5.2.1 Electricity

Figure 20 illustrates the hourly electricity consumptions as a function of time for a nine months period. This graph highlights the high amount of electricity which is consumed during the periods of inoccupation of the site (nights, week-ends and holidays).
For instance, the electricity totalised during the night represents 45% of the total electricity consumption of the whole site. And the electricity consumed during all the periods of inoccupation (nights, week-ends and holidays) represents 33% of the total electricity consumptions (Figure 21).

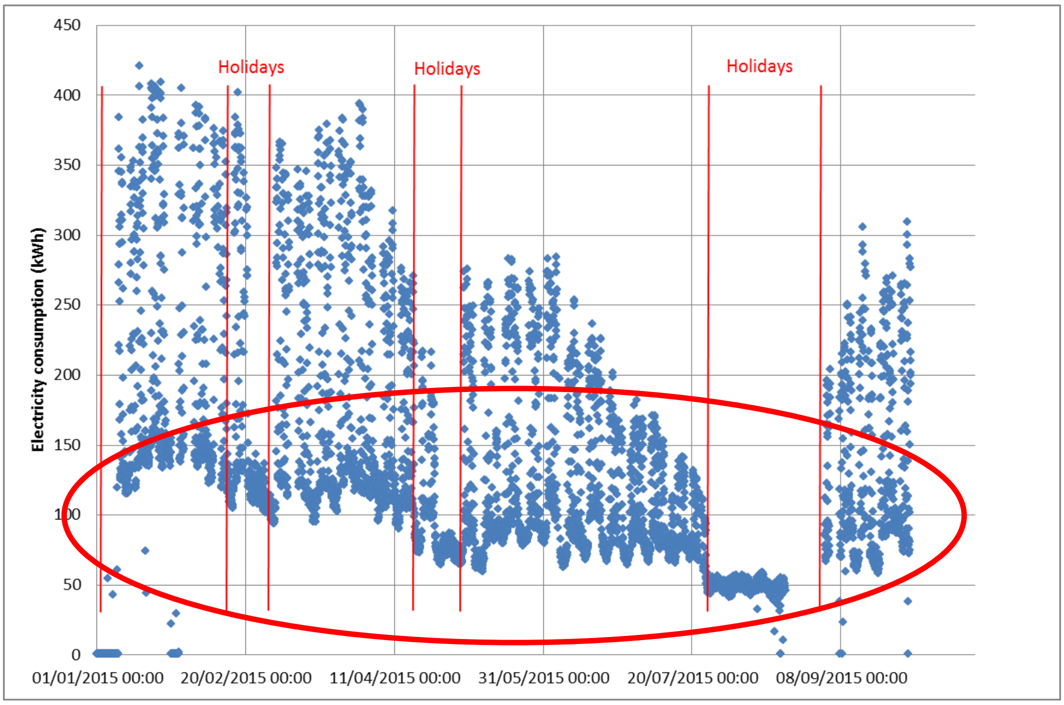


Figure 20: Hourly electricity consumptions versus time for the whole IUT site

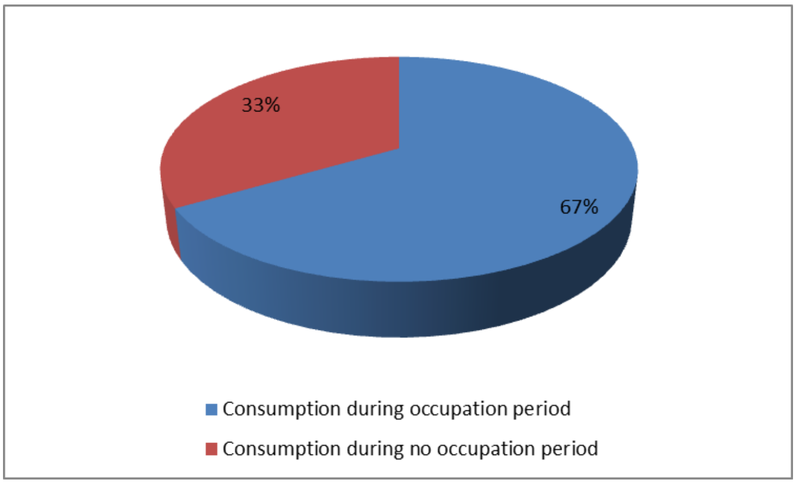


Figure 21: Electricity consumption breakdown between occupation and inoccupation periods

This observation has been highlighted and detected by the virtual facility managers of the IUT site thanks to the EPNSP interface. The following graph shows the electricity consumption profile for two consecutive days shown in the EPNSP interface. The level of consumptions during the night is about half the level of consumption during the day which constitutes a huge opportunity for decreasing the energy bill at the IUT.

Figure 22: Hourly electricity consumptions versus time for the whole IUT site – EPNSP interface

Figure 23 shows the electricity consumption per building measured from the 20th of February 2015 until the 1st of October 2015. This graph highlights the highest consumer of the whole IUT site (building 9A) which is the building where all the IT servers are located. Even if this consumption cannot be completely avoided, a smart way of managing it by introducing renewable electricity sources on site can be envisioned.

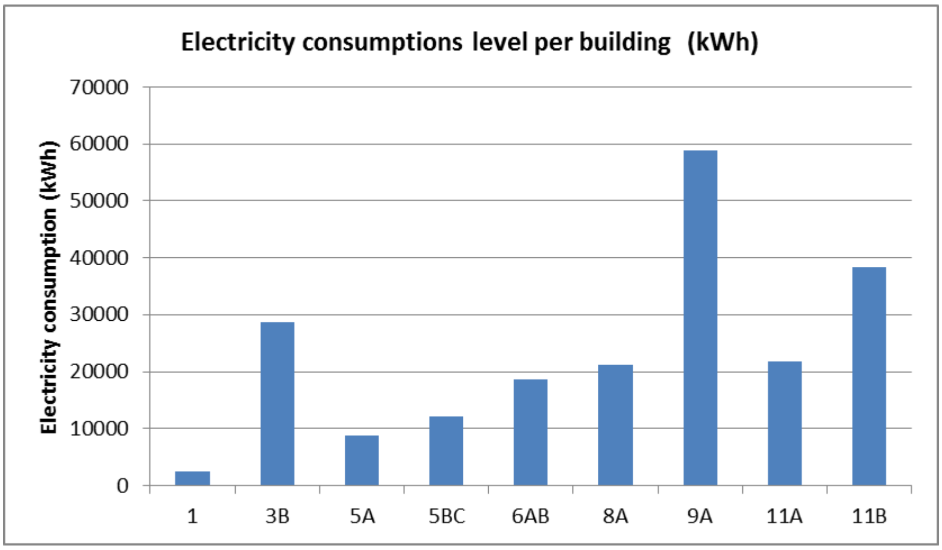


Figure 23: Electricity consumptions per building from 20th of February until 1st of October 2015

Figure 24 shows the electricity consumption of the IUT site per usage: lighting and other uses. This graph highlights that the lighting system consumption represents less than 20% of the total electrical consumption of the IUT site. This result confirms the positive impact of the improvement measures implemented during the past few years on the lighting system and management. Now some efforts have to be turned toward improving and reducing the other usages consumptions.

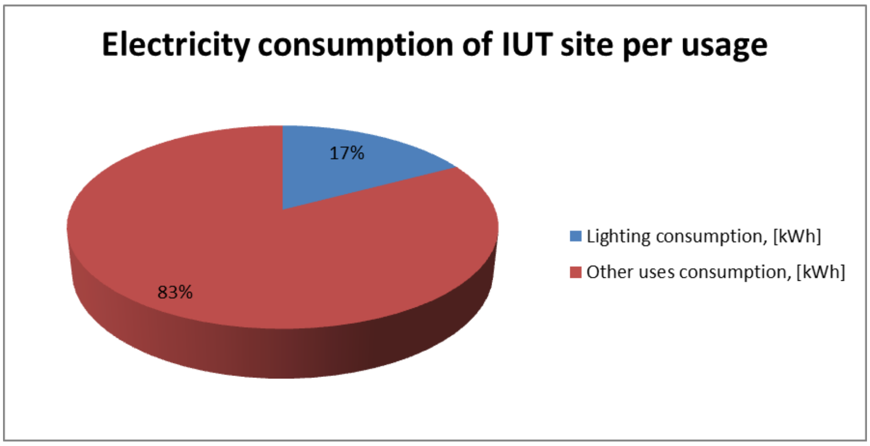


Figure 24: Electricity consumption per usage from the 20th of February until 1st of October 2015

5.2.2 Gas (general boiler only)

An optimised management of the heating features is observed through the gas consumptions measurements performed in the IUT site.

The heating regulation is almost perfectly optimised at the IUT at two levels: general boiler level and sub-station level and this regulation is mainly based on the outdoor temperature.

Figure 27 shows the increase in heating demand perfectly correlated with the decrease in outdoor temperature. Moreover, there is a heating restart around 7:00 AM in order to get a comfortable indoor temperature at 08:00 AM when the students arrive on site. At 18:00 the heating consumptions seem to be minimal.

A reduced temperature set-point is used during the nights and the week-ends but it do not seem to be used for the holidays periods. This observation could constitute an energy use

reduction opportunity.
Therefore except by conducting a refurbishment focused on buildings insulation, there is no other important means to reduce the heating consumption of the whole IUT site.

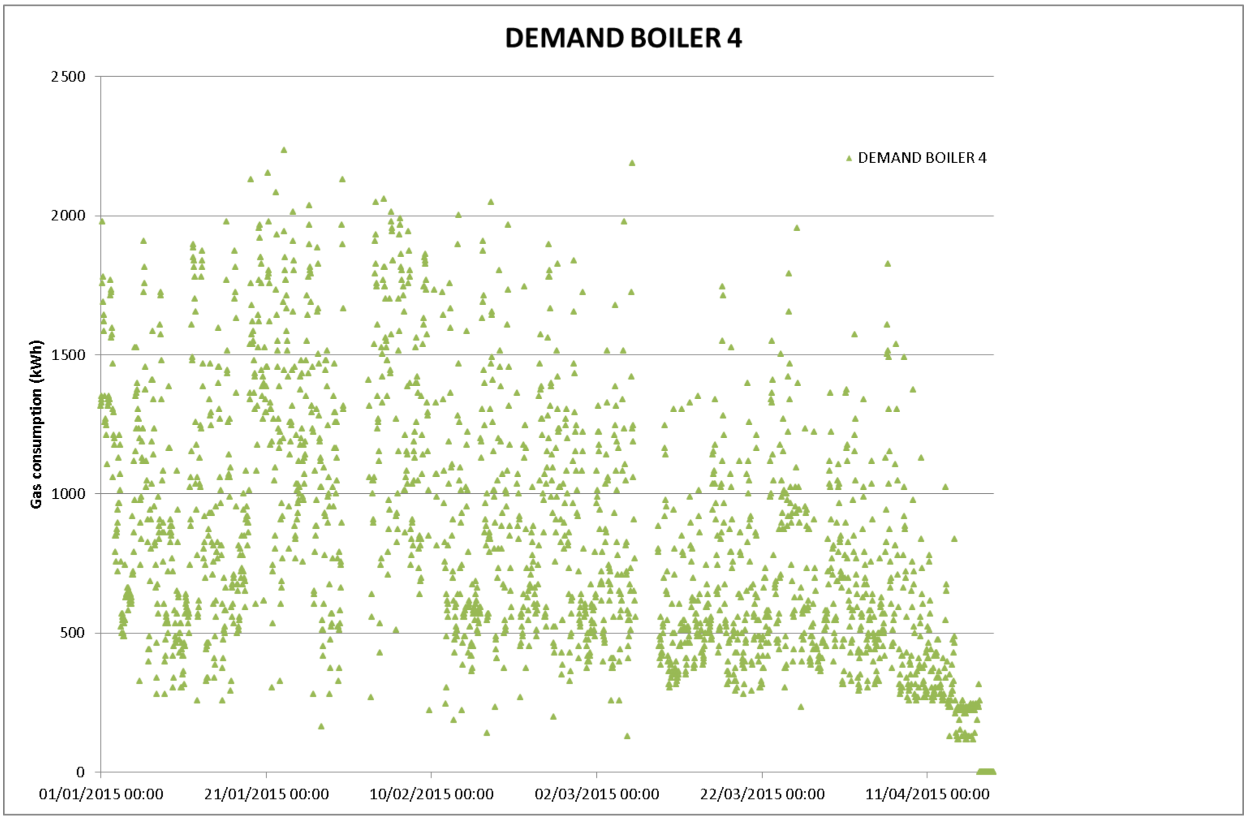


Figure 25: Hourly gas consumption versus time for the whole IUT site

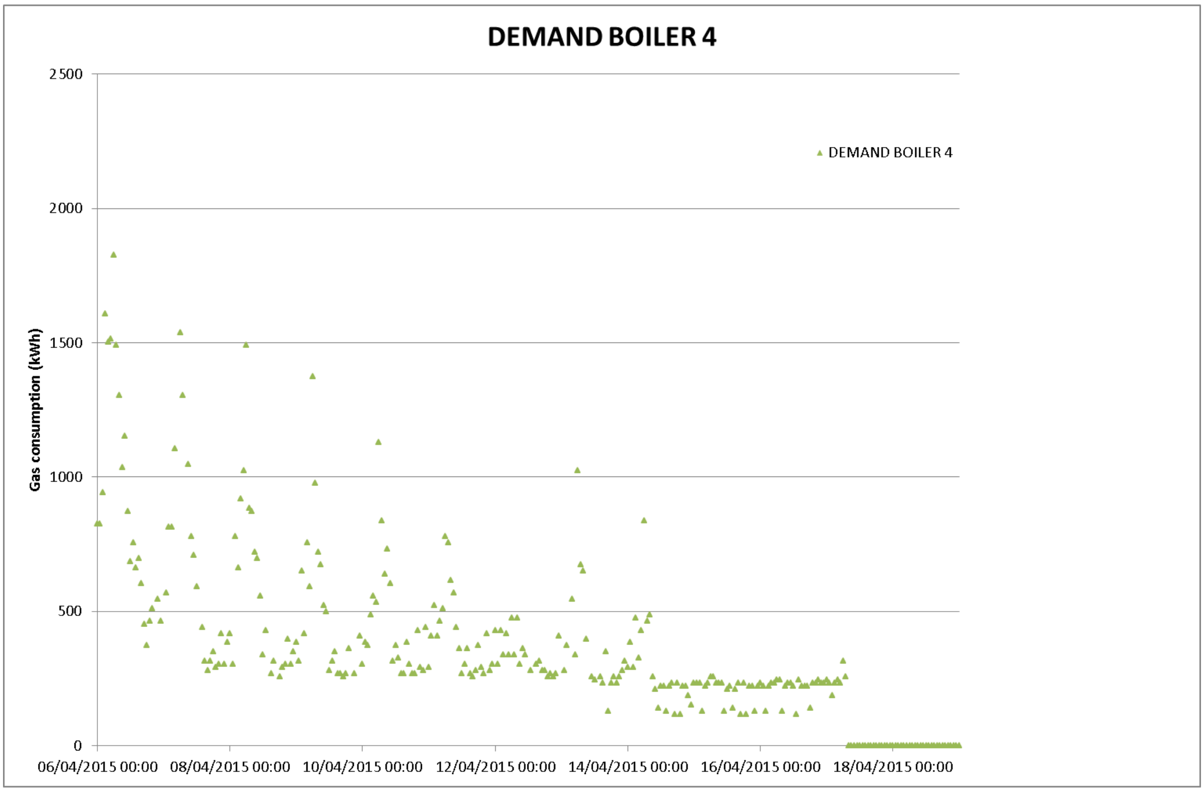


Figure 26: Hourly gas consumption versus time for the whole IUT site during the Easter holidays of 2015

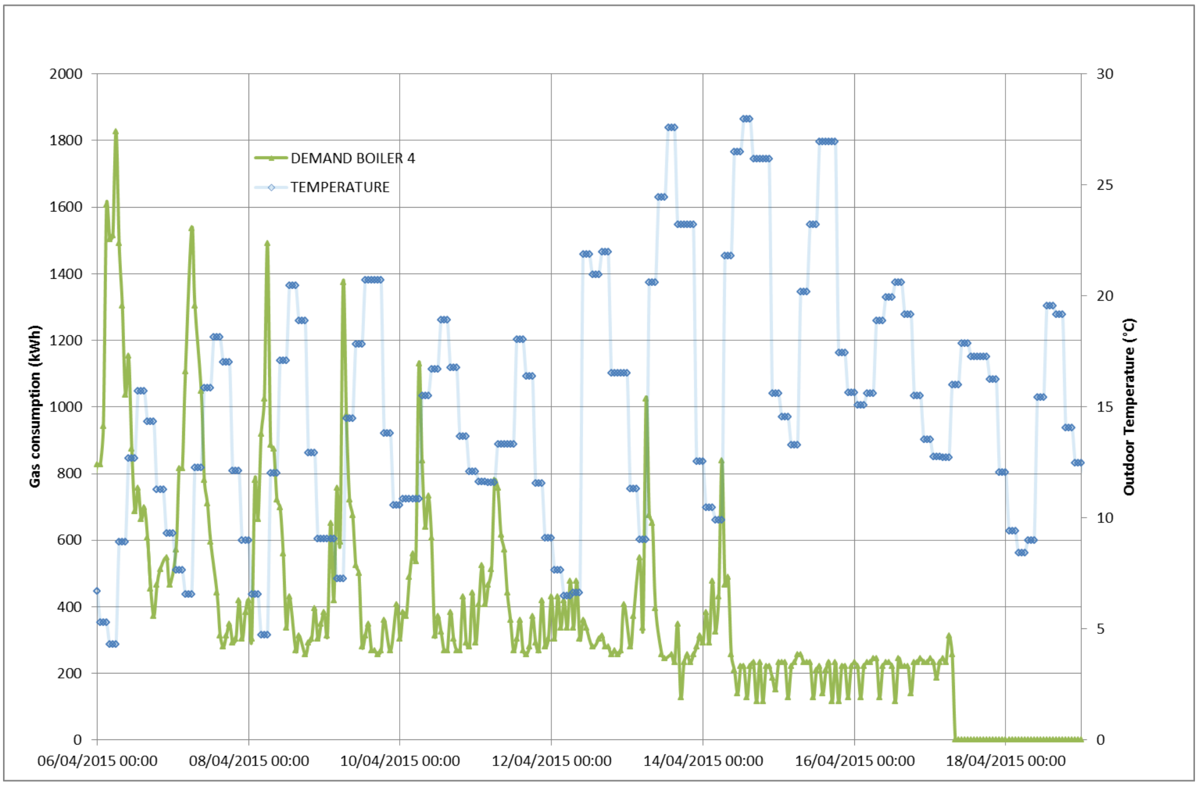


Figure 27: Hourly gas consumption versus time for the whole IUT site and outdoor temperatures

5.1 EMS impact – Optimisation scenarios

The following table summarises the results obtained for all the scenarios defined in chapter 4.1.3 in terms of energy costs and CO_2 emissions and calculated over the considered period (from 19/02/2015 until 07/10/2015).

CASE 1 **CHP Sizing 600**	**Energy costs - simulated situation[6] (€)**	**Energy costs - Baseline situation[7] (€)**	**Gain got from the simulated scenarios (%)**	**CO_2 emissions- simulated situation (kgeqCO_2)**	**CO_2 emissions - baseline situation (kgeqCO_2)**	**Gain got from the simulated scenarios (%)**
Scenario 1	25378.12		57.8	151676		33.6
Scenario 2	25378.12		57.8	151676		33.6
Scenario 3	44501.89	60157	26	225451	228615	1.4
Scenario 4	44524.38		26	138849		39.3
Scenario 5	31030.98		48.4	151676		33.6

[6] Costs for energy related to the simulated scenarios are defined as follow: Total cost of solar PV generation + Total cost of CHP electricity generation + total cost of buying electricity from grid + total cost for CHP heat generation + total cost of buying heat from grid - total income by selling electricity to the grid

[7] Costs for energy associated to the baseline situation = total cost of buying the whole electricity from grid + total cost of buying the whole gas from grid for heating for the same period (19/02/2015 until 07/10/2015)

Scenario 6	38793.12		35.5	151676		33.6
CASE 2 **CHP Sizing 1200**	**Energy costs - simulated situation (€)**	**Energy costs - Baseline situation (€)**	**Gain got from the simulated scenarios (%)**	**CO_2 emissions- simulated situation (kgeqCO_2)**	**CO_2 emissions - baseline situation (kgeqCO_2)**	**Gain got from the simulated scenarios (%)**
Scenario 1	-8711.02	60157	114.5	138822	228615	39.3
Scenario 2	-8705.49		114.5	138822		39.3
Scenario 3	59361.27		1.3	225705		1.3
Scenario 4	37071.06		38.4	102759		55
Scenario 5	4044.12		93.3	138822		39.3
Scenario 6	21572.72		64.1	138822		39.3
CASE 3 **CHP Sizing 2000**	**Energy costs - simulated situation (€)**	**Energy costs - Baseline situation (€)**	**Gain got from the simulated scenarios (%)**	**CO_2 emissions- simulated situation (kgeqCO_2)**	**CO_2 emissions - baseline situation (kgeqCO_2)**	**Gain got from the simulated scenarios (%)**
Scenario 4	35709.51	60157	40.6	96201	228615	57.9

Table 7: Results of optimisation scenarios for the three sets of experiments

Results of the six optimisation scenarios for the case#1 indicate that there is net monetary loss (this also the case for scenario 4 case #3). The scenario with minimum losses is scenario 1 for which the γ parameter is set to 0 (maximize profit) and for which the electricity selling price is highest (0.0662 Eur/kWh). In this scenario the CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period.

The case #2 gives the highest net profit of 8711 Euros over the whole period for scenarios 1 and 2.

Scenarios 5 and 6 indicate the cases where the goal of optimisation is to maximize profit and electricity selling price is lower than scenario 1 but still greater than electricity buying price. The CHP operation in these cases is also similar to scenario 1. Moreover, the economic profit decreases with decreasing electricity selling price in these cases.

In scenario 4, the electricity selling price is lower than electricity buying price. In this case the CHP plant is turned on intermittently to meet the energy demand of the IUT site. When the electricity demand of the IUT site is low then it is not in the best economic interest to run the CHP plant at full capacity in order to sell electricity to the grid.

Scenario 3 has one of the least benefits in terms of economic profit. In this scenario, the optimisation is set to minimize CO_2 emissions. Since the source of local CO_2 emissions is the CHP plant, hence in this case CHP plant is not turned on at all. It is also assumed in this scenario that the CO_2 emissions corresponding to operation of CHP plant is the same as buying energy from the grid.

It should be emphasized that whatever the scenarios tested, the energy costs are lower in the simulated cases than in the current situation. The reduction in terms of cost goes from 26% up to 114%. Regarding the CO_2 emissions reductions, they go from 1.5% up to 58%.

The two scenarios that were retained for the KPIs' calculations are the following:

	Scenario A CASE 3/Scenario 4	Scenario B CASE 1/Scenario 1
CHP sizing (kW)	2000	600
PV sizing (surface//power peak)	2880m^2/367kWp	2880m^2/367kWp
Optimisation scenario	4 (γ=0, maximize profit and selling price set to 90% of buying price) The CHP plant is turned on intermittently to meet the energy demand of the IUT site	1 (γ=0, maximize profit, with current selling price) The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period
Energy costs reductions in comparison to the baseline situation	40.6 %	57.8 %
CO_2 emissions reductions in comparison to the baseline situation	57.9 %	33.6 %

Table 8: Scenarios retained for the KPIs calculations

Scenario A has been selected because it entirely covers the whole energy demand of the IUT site and corresponds to possible future evolutions of the energy selling prices. Moreover it corresponds also to the business models case that has been studied in D2.2 in the frame of the specific business models definition for demo cases (Crosbie et al., 2014). Nevertheless, the initial investment for such a system (estimated at 914850€ including auxiliary boiler + thermal store + fuel store) that can be too large for the IUT and not realistic in terms of implementation in a near future.

Scenario B has been selected because it is more realistic in terms of initial investment for the IUT site (406850€ for the CHP) and corresponds to a profit based approach with a continuous running of the CHP plant.

5.2 KPIs evaluation

This section aims at providing the indicators values calculated during the demonstration phase of the IDEAS project and comparing them to the same indicators that were evaluated for the baseline period (before the implementation of the IDEAS tools). For the demonstration, these calculations have been made for the two scenarios (A and B) that were selected in the previous section.
The most relevant KPIs calculated for the IUT site are provided in the following sections for each scenario.

5.2.1 Scenario A

5.2.1.1 On-site Energy Ratio

In the case of scenario A, the OER is **98 %** for the period from February 2015 to October 2015.

5.2.1.2 Annual Mismatch Ratio

In the case of scenario A, the AMR_{ELEC} is **25 %**. This value indicates that 25 % of all electrical energy demand is imported from the electrical grid. Therefore the local renewable energy supply meets almost entirely the IUT electrical demand at the right time (during the occupation hours and the peaks of demand). For the baseline period the AMR_{ELEC} value was 100%. Figure 28 shows the AMR indicator versus time and indicates that the production time is very well correlated with the electricity demand.

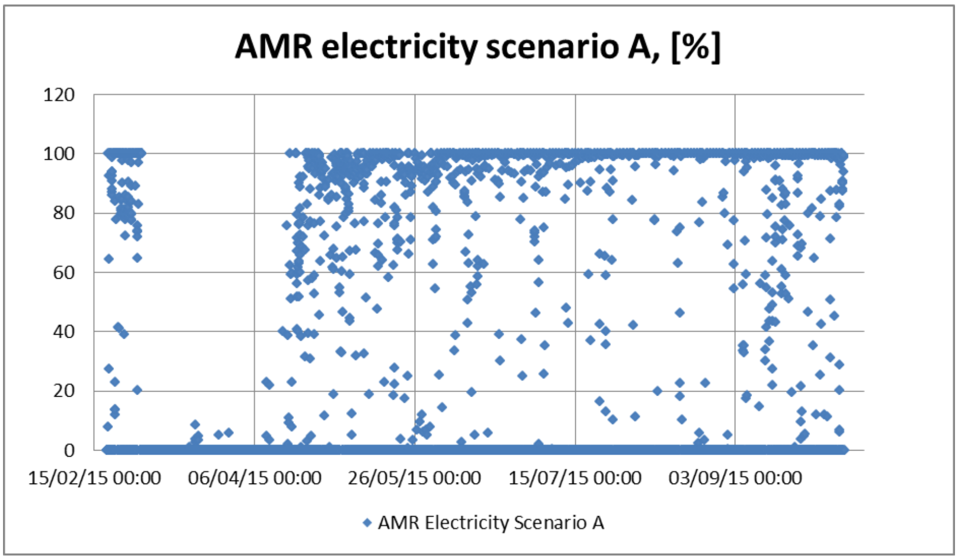


Figure 28: Hourly ratio between electricity local supply (PV+CHP) and electricity demand during the same hour

Concerning the Annual Mismatch Ratio of heating energy (AMR_{HEAT}), it is **16.51 %**. It indicates a good heat self-sufficiency of IUT campus: 83.49 % of the overall heat demand is covered by CHP plant production at the right time (during the occupation hours and the peaks of demand) and the rest which is 16.51 % is provided by the gas boiler fed by the national gas grid. For the baseline period the AMR_{HEAT} value was 100%. Figure 29 shows the AMR indicator versus time and indicates that the production time is well correlated with the heating demand during the heating period. This figures also shows that the heating system of IUT site has been shut down on the 17th of April, as the hourly mismatch ratio falls down to zero at this date.

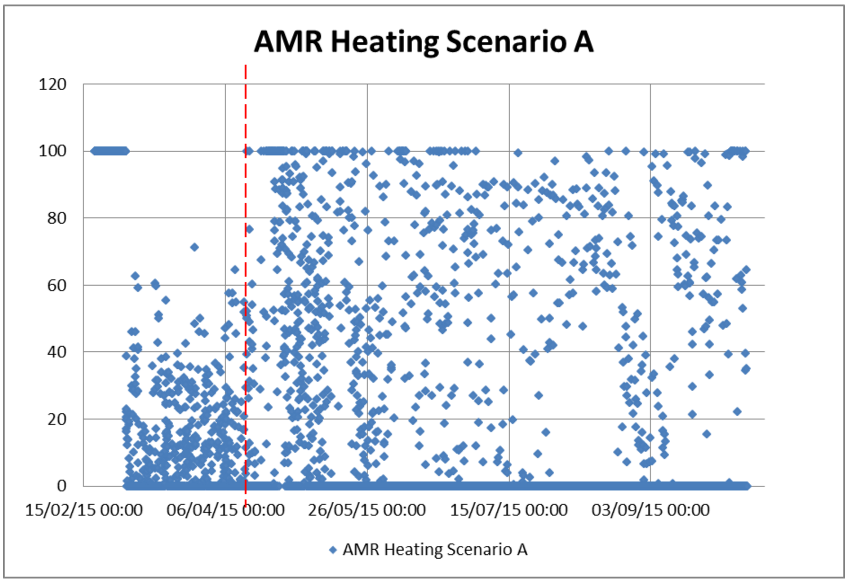


Figure 29: Hourly ratio between heat local supply (CHP) and heating demand during the same hour

5.2.1.3 Maximum Hourly Surplus

In the case of scenario A, the MHS_E is **12.72** and the MHS_H is **578.28**.

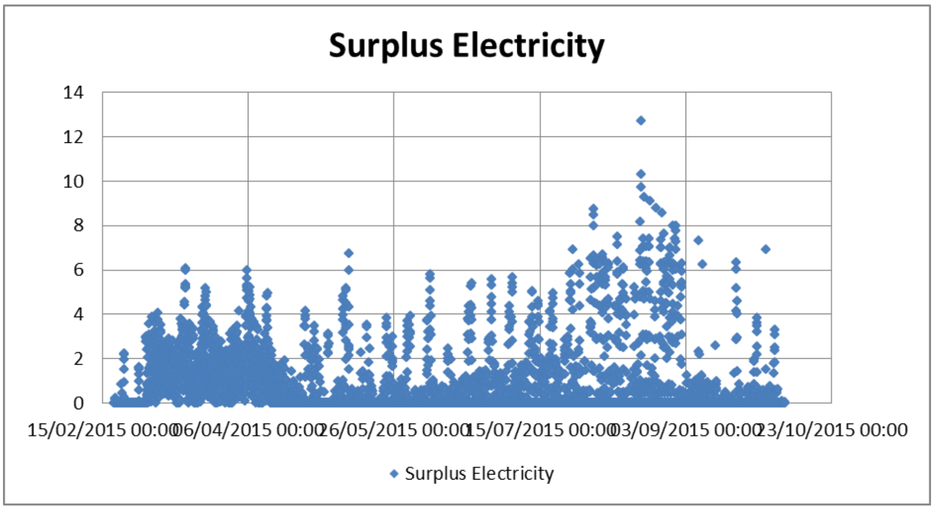


Figure 30: Hourly electricity surplus between local electricity supply and site electrical demand on the same hour

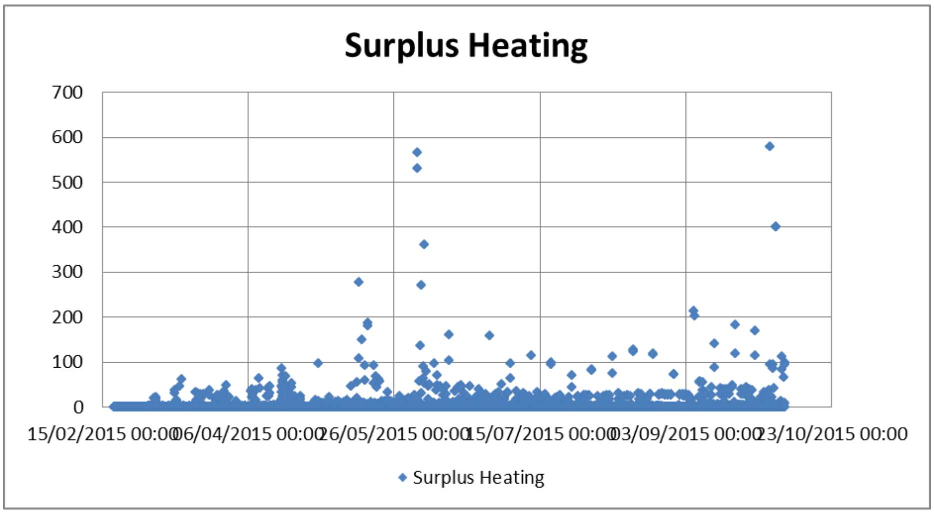


Figure 31: Hourly heating surplus between local heating supply and site heating demand on the same hour

5.2.1.4 Maximum Hourly Deficit

In the case of scenario A, the MHD_E is =**3.84** and the MHD_H is **173.7**.

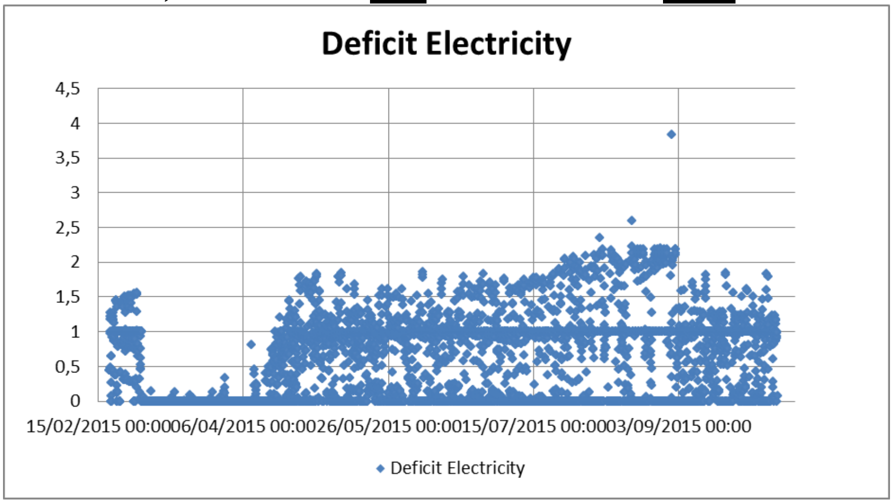


Figure 32: Hourly electricity deficit between local electricity supply (PV) and site electrical demand on the same hour

The maximum value of MHD_E appears at the end of March when the PV production is not very high.

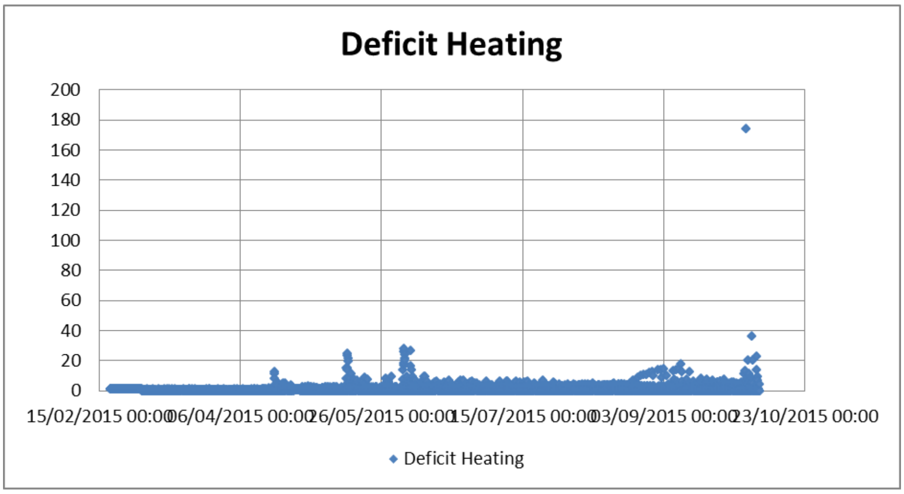


Figure 33: Hourly heating deficit between local heating supply (CHP) and site heating demand on the same hour

5.2.1.5 Monthly Ratio of Peak hourly demand to Lowest hourly demand (RPL)

The measured values of extremum hourly demand (high and low) for electricity and heating are presented in table 8.

	The biggest value for hourly Electricity demand (kWh)	The biggest value for hourly Heating demand (kWh)	The lowest value for hourly Electricity demand (kWh)	The lowest value for hourly Heating demand (kWh)
February	355	2030	96	16
March	394	2250	93	13
April	331	1881	64	0,2
Mai	282	23	59	0,2
June	284	25	62	0,2
July	182	4	43	0,2
August	58	4	10	0,2
September	309	23	10	0,2
October	318	105	67	0,2

Table 9: The measured values of extremum hourly demand for electricity and heating

The RPL values corresponding to the biggest and lowest values above are presented below:

	RPL Electricity	RPL Heating
February	3,7	127
March	4,24	173
April	5,17	9405
Mai	4,78	115
June	4,58	125
July	4,23	20
August	5,8	20
September	30,9	115
October	4,75	525

Table 10: RPL values electricity and heating

5.2.1.6 Little environmental impact (CO_2–eq emissions mainly, compared to similar

areas, radioactive waste could be also included)

In order to compensate for the lack of environmental impact data from similar areas to be compared with those of IUT site, we propose to compare the baseline and reporting period data without any intervention in site with:

- Measurement data with a simulated introduction of PV generation;
- Measurement data with a simulated introduction of PV generation and CHP biofuel plant.

These 2 scenarios have been chosen to demonstrate the environmental benefits of going towards the energy positive neighbourhoods.

Due to data's availability in the EMS, the period from 19th of February to 07th of October 2013 has been considered as baseline period and the period from 19th of February to 07th of October 2015 has been considered as reporting period for this calculation.

The following table provides the results of this comparison.

	19/2/13 to 07/10/13	19/2/15 to 07/10/15 No intervention	19/02/15-07/10/15 (with a simulated introduction of 367 kWp of PV)	19/02/15-07/10/15 (with introduction of a simulated PV and CHP (2000 kW) plant generation)
CO_2 emissions (g CO_2 eq/m^2)	8109,4	5715,3	5574,9	2405,1
CO_2 emissions avoided (g CO_2 eq/m^2)		2394,1	140,4	3310,2
CO_2 emissions avoided (%)		29,5 %	2,5 %	57,9 %
CO_2 emissions associated to the electricity consumption (g CO_2 eq/m^2)	637,3	264,6	124,2	251,9
CO_2 emissions associated to the gas consumption (g CO_2 eq/m^2)	7472,1	5450,7	5450,7	2153,2

Table 11: Environmental impact of IUT energy consumption during the baseline and reporting periods

5.2.1.7 Energy positivity level indicator

Considering the simulated extensions of the French pilot site described by scenario A, **<u>the energy positivity label reached is nearly A.</u>**

5.2.2 Scenario B

5.2.2.1 On-site Energy Ratio

In the case of scenario B, the OER is **235 %** for the period from February 2015 to October 2015.

5.2.2.2 Annual Mismatch Ratio

In the case of scenario B, the AMR_{ELEC} is **1.13 %**. This value indicates that only 1.13 % of all electrical energy demand is imported from the electrical grid. Therefore the local

renewable energy supply meets almost entirely the IUT electrical demand at the right time (during the occupation hours and the peaks of demand).
For the baseline period the AMR_{ELEC} value was 100%.

Figure 34 shows the AMR indicator versus time and indicates that the production time is very well correlated with the electricity demand.

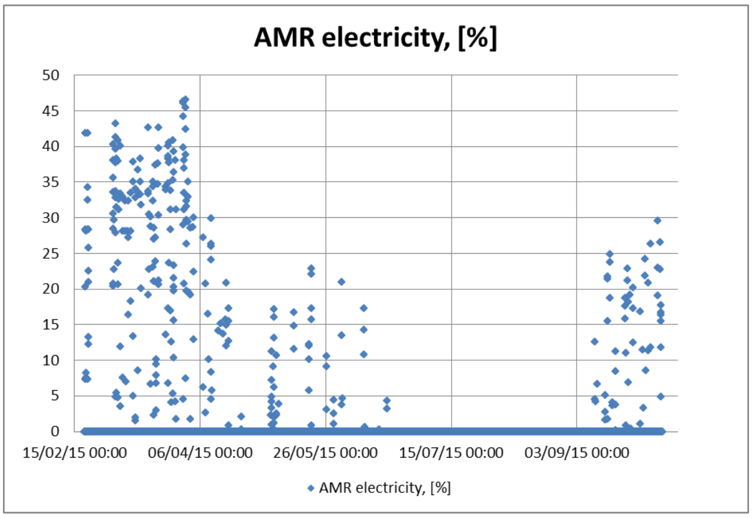


Figure 34: Hourly ratio between electricity local supply (PV+CHP) and electricity demand during the same hour

Concerning the Annual Mismatch Ratio of heating energy (AMR_{HEAT}) for the IUT site, it is **<u>31.38 %</u>**. This value is higher than AMR_{ELEC}. Nevertheless, it indicates a good heat self-sufficiency of IUT campus: 68.62 % of the overall heat demand is covered by CHP plant production at the right time (during the occupation hours and the peaks of demand) and the rest which is 31.38 % is provided by the gas boiler fed by the national gas grid.
For the baseline period the AMR_{HEAT} value was 100%.
Figure 35 shows the AMR indicator versus time and indicates that the production time is well correlated with the heating demand during the heating period, but don't meet entirely the heating demand of the site. This figures also shows that the heating system of IUT site has been shut down on the 17th of April, as the hourly mismatch ratio falls down to zero at this date.

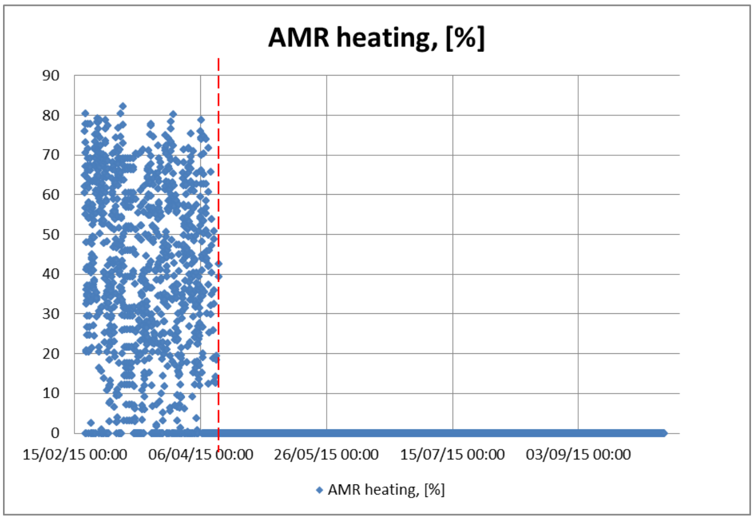


Figure 35: Hourly ratio between heat local supply (CHP) and heating demand during the same hour

5.2.2.3 Maximum Hourly Surplus

In the case of scenario B, the MHS_E is **30.2**. This value indicates that the electricity generation is 30.2 times more than the electricity demand. This situation occurs by the 18th of August from 15:00 to 16:00 and is due to small electrical demand during non-occupation period of the site.

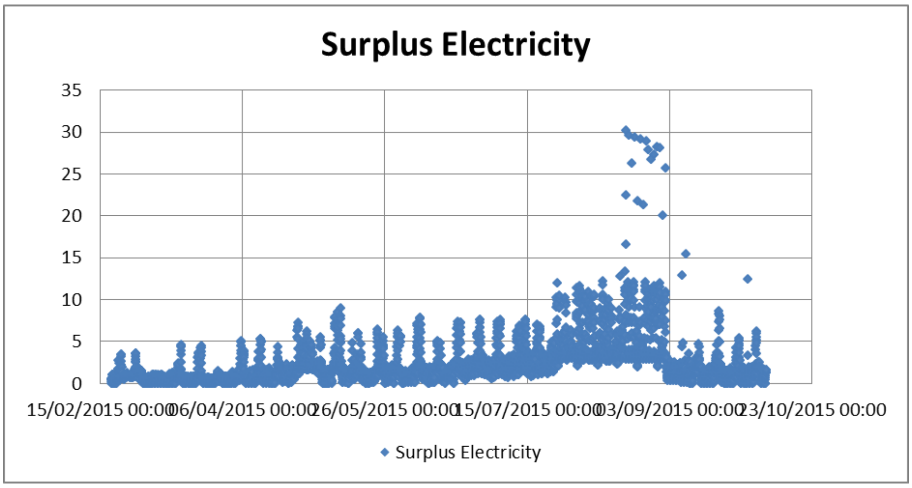


Figure 36: Hourly electricity surplus between local electricity supply and site electrical demand on the same hour

In the case of scenario B, the MHS_H is **2624**. This value seems to be high, but in fact, it's due to the heating demand close to zero after the 17th of April (when the local heating production has been shut down) and the constant heat generation from CHP plant during spring and summer.

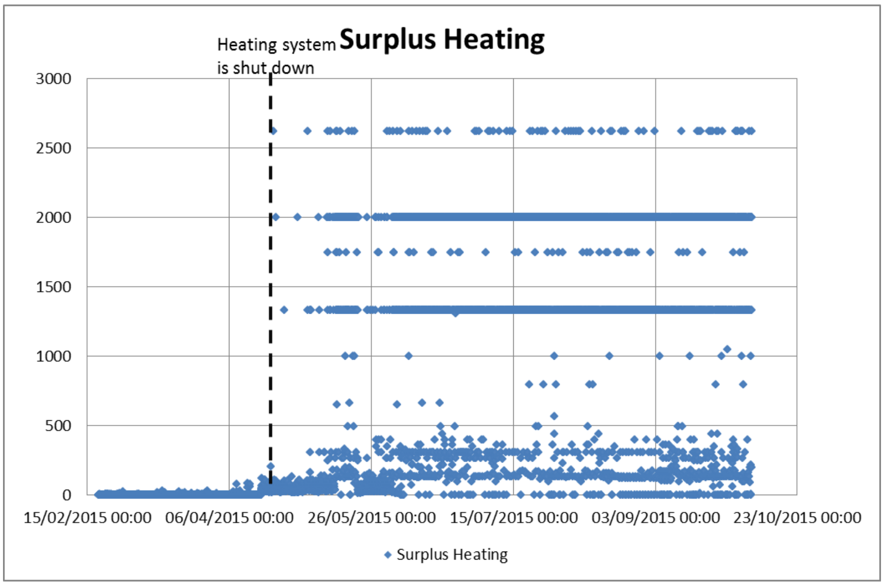


Figure 37: Hourly heating surplus between local heating supply and site heating demand on the same hour

5.2.2.4 Maximum Hourly Deficit

In the case of scenario B, the MHD_E is =**0.44**.

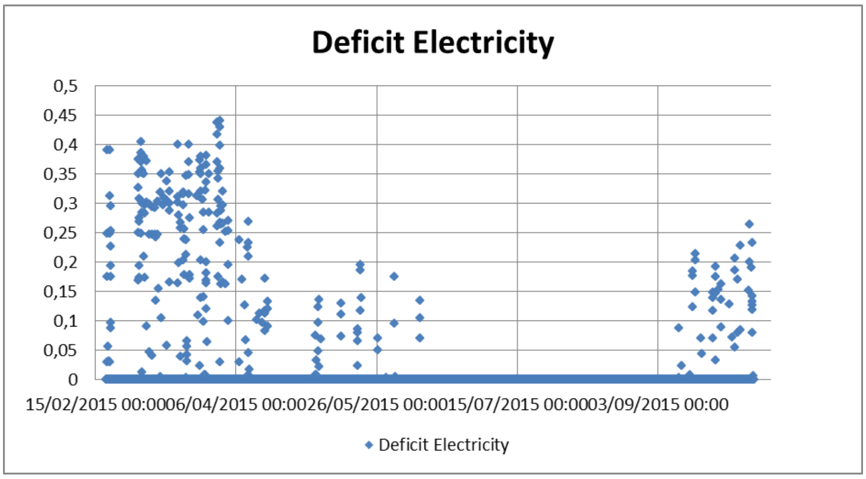


Figure 38: Hourly electricity deficit between local electricity supply (PV) and site electrical demand on the same hour

The maximum value of MHD_E appears on the 31st of March at 8:00 when the site occupants arrive at the site and the PV production is not still very high. The CHP generation remains stable at this moment.

The Monthly Hourly Deficit for heating MHD_H is **0.82**. This maximum value appears on the 6th of March at 6:00 when the site heating demand is at its maximum over the considered period.

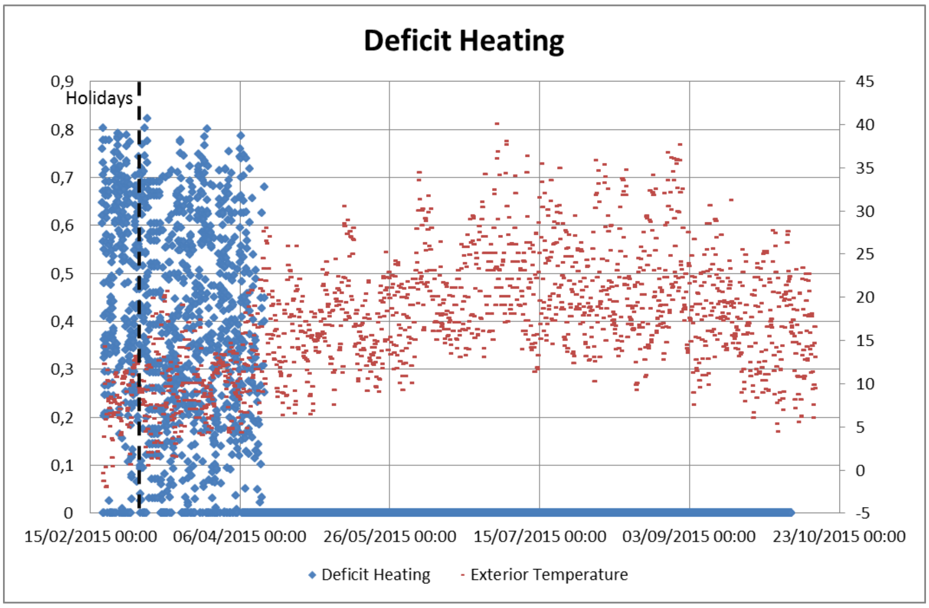


Figure 39: Hourly heating deficit between local heating supply (CHP) and site heating demand on the same hour

5.2.2.5 Monthly Ratio of Peak hourly demand to Lowest hourly demand (RPL)

As the RPL indicator only depends on energy demand, the same values are obtained as for scenario A.

5.2.2.6 Little environmental impact (CO2–eq emissions mainly, compared to similar areas, radioactive waste could be also included)

The same approach as described in 5.2.1.6 is used here.

The following table provides the results of this comparison.

	19/2/13 to 07/10/13	19/2/15 to 07/10/15 (without intervention in the IUT site)	19/2/15 to 07/10/15 (simulated introduction of 367 kWp of PV)	19/2/15 to 07/10/15 (introduction of a simulated PV and CHP (600 kW) plant generation)
CO_2 emissions, (g CO_2 eq/m^2)	8109,4	5715,3	5574,9	3791,9
CO_2 emissions avoided (g CO_2 eq/m^2)		2394,1	140,4	1923,4
CO_2 emissions avoided (%)		29,5 %	2,5 %	33,7 %
CO_2 emissions associated to the electricity consumption (g CO_2 eq/m^2)	637,3	264,6	124,2	450,7
CO_2 emissions associated to the gas consumption (g CO_2 eq/m^2)	7472,1	5450,7	5450,7	3341,2

Table 12: Environmental impact of IUT energy consumption during the baseline and reporting periods

According to the values provided in Table 12, the introduction of PV generation allows avoiding **5614 kg equivalent CO_2** or **140.4 g eq CO_2/m^2** during 7.5 months for IUT site. Interpolating these values on a full year, **10779 kg eq CO_2 per year** or **269.5 g/m^2 equivalent CO_2 per year** can be avoided.
The introduction of both PV generation and CHP plant allows avoiding more CO_2 emissions during 7.5 months period: 76939 kg or 1923.4 g/m^2 equivalent CO_2.

5.2.2.7 Energy positivity level indicator

Considering the simulated extensions of the French pilot site described by scenario B, **the energy positivity label reached is A+++**.

5.2.3 Conclusions

The following table summarises the KPIs results for the French pilot site and compares the values obtained after the implementation of the IDEAS approach to the initial values (without implementation of the IDEAS approach) and for the different tested scenarios.

The calculated indicators provide empirical evidence of the benefits of the IDEAS approach for control management in terms of energy 'positiveness' and CO_2 reduction. Scenario B consists of sets of parameters that allow the site to make profit but whatever the scenario considered, the energy costs are considerably reduced considering the optimisation scenarios. As the heating represents the largest share of the energy demand, the impact of a PV system alone is not very high in comparison to the CHP plant impact. The OER reached using this PV scenario is 26% which allows the IUT site to change its energy positivity level by one level.

Scenario A which considers a CHP plant turned on intermittently to meet the energy demand of the IUT site gives an energy neutrality to the IUT site and does not generate profits but generates energy costs that are 25% decreased in comparison to the baseline situation.

Scenario B which considers a CHP plant running continuously during summer months gives level A+++ on the energy ‘positiveness’ scale and generates profits for the IUT site. Nevertheless the question related to the means to dissipate all the heating produced during the summer months should be addressed in order to make this scenario more realistic.

KPI	Value for the baseline situation (2015 with no evolution)	Value after the implementation of IDEAS (simulated PV only)	Value after the implementation of IDEAS Scenario A (2000kW biofuel CHP plant+PV 2880m^2+scenario 4)	Value after the implementation of IDEAS Scenario B (600kW biofuel CHP plant+ PV 2880m^2+scenario1)
On-site Energy Ratio	0 % (no local Energy Supply)	26 %	98 %	235 %
Annual Mismatch Ratio (electricity)	100% (no local Energy Supply)	5.11 %	25 %	1.13 %
Annual Mismatch Ratio (heating)	100 % (no local Energy Supply)	100 % (no local Energy Supply)	16.51 %	31.38 %
MHS electricity	0 for baseline (no local supply so no surplus)	17.22	12.72	30.2
MHS heating	0 for baseline (no local supply so no surplus)	0	578.28	2624
MHD electricity	1	1.81	3.84	0.44
MHD heating	1	1	173.7	0.82
RPL electricity	Min= 3.7 Max= 30.9			
RPL heating	Min= 20 Max= 9405			
CO_2 emissions (g CO_2 eq/m^2)	5715.3	5574.9	2405.1	3791.9
Energy positivity label	D	C	Nearly A	A+++
Energy costs	60157	47585.8	35709.51	25378.12

Table 13: EPN KPIs values for the French pilot site

5.3 Impact of the interfaces developed within IDEAS

5.3.1 EPNSP influence / EMS impact

Even if they really appreciated the design and graphics of the EPNSP interface, the IUT stakeholders have mentioned that more information related to the tools and calculation methods used within the EPNSP interface would have been useful. The description which has been made in the frame of D5.3 detailing the features of each indicator displayed in the interface has helped the end-users to overcome this issue.

Moreover, some historical displays of energy consumptions are missing in order to have a more powerful tool for facility manager of such a site. Besides, as a decision support tool, the EPNSP interface could also include a benchmark analysis of the data provided in the tool (comparison with existing building or site, comparison with the previous years…).

Lastly, a data diagnostic tool could also be useful in order to detect when data acquisition problems are happening (alerts system…).

The stakeholders have also highlighted the fact that the costs savings and CO_2 savings do not constitute a strong lever for the decision making people at the IUT but these are useful information to be used in the frame of courses for pedagogical purposes.

Another notification could have been interesting: the annual energy cost to be compared to the value of 7-8€/m².year which is a reference for the FM of the IUT site in terms of targeted energy costs.

Therefore some ways of improvements have been suggested to increase the EPSNP interface impact and usability. These improvements could also be inspired by the existing FM interfaces available on the market and those that are already provided by the energy providers for instance. The web application for electricity consumptions management that is provided by EDF which is the energy provider of the IUT site (Figure 40) is for instance a good example of technical interface associated to the electricity consumption management of a whole site. Nevertheless, the EPNSP interface has numerous advantages over this kind of tool and among them the ability to gather various energy types and also the ability to provide predictions data allowing a piloting support for a FM.

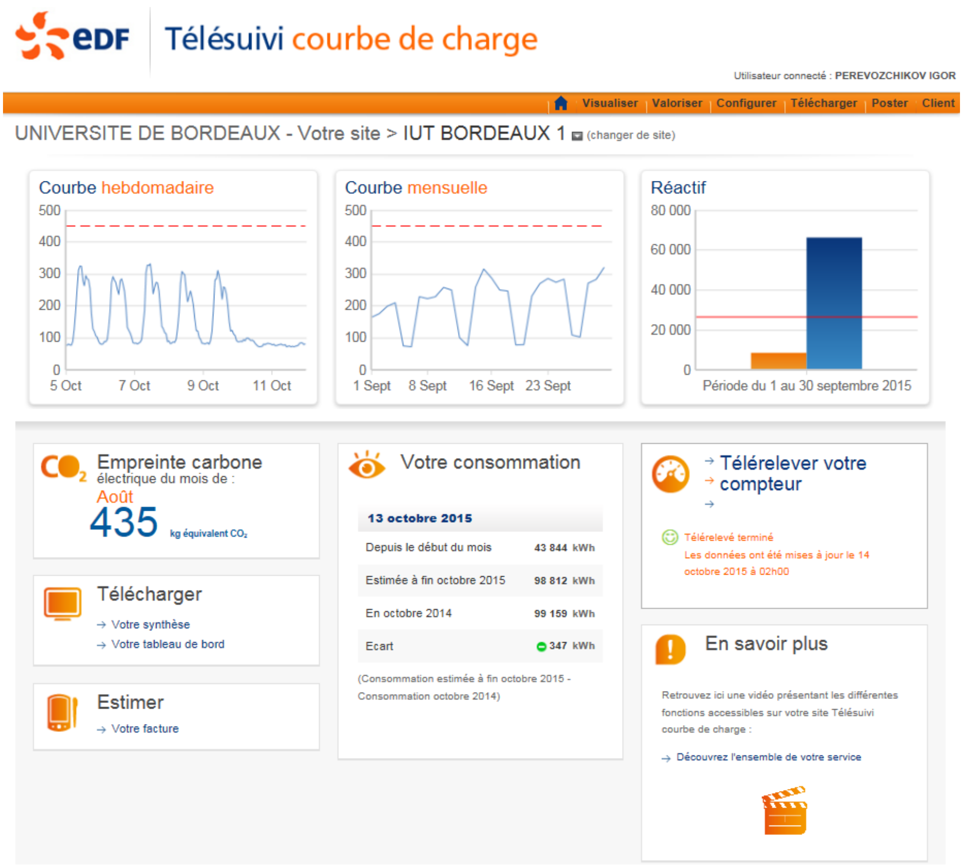


Figure 40: EDF web application interface

5.3.2 Awareness increase through large screens and web portal influence: questionnaires/survey analysis and interviews report

The teachers of the IUT site have observed a decreased interest of the students after the first visualisation of the large screen interface. According to them, the website is really good whereas the transition of the same interface to the large screens is not successful. The large screen interface content should have been customised according to the location of its installation (place where people are simply in transit or cafeteria). Moreover, in order to be more concerned and engaged, students would have prefer a more detailed information in close relation with themselves (for instance an information related to the building in which they are working). The information provided at the site scale is not the good lever to raise awareness and it requires a local correspondent making the bridge between the neighbourhood level and the building level. The implementation of a competition based on targets for energy savings at the building level and the ranking of the buildings participating in the competition could be an efficient mean to obtain better results in the occupants' commitment.

A remark has been made during the demonstration phase by a person from the IUT. An automatic switch-off of the screens should have been implemented in order to remain coherent with the energy management approach advocated by the IDEAS project and its interfaces.

To corroborate the lack of impact of the information disseminated in the awareness website, the google analytics results have been analysed. It allows tracking the number of visitors of the website.

From April until October 2015, 362 sessions have been opened on the website.

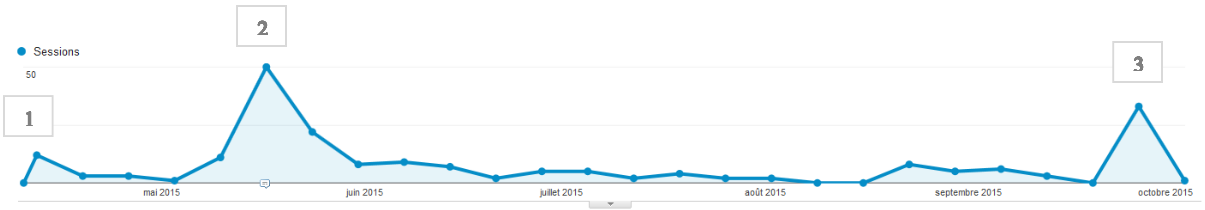


Figure 41: General website traffic

During this period, activities on the website are not linear. Three peaks of connections can be observed:

- The first is related to the installation of the five large screens in the IUT site (16/04/2015);
- The second comes in response to the emailing (20/05/2015) sent to all the occupants of the IUT site (students, teachers, staff...) with in attachment the description of the large screens approach and the link to the website.
- The third follows the questionnaire that was sent on the 1st of October to the site occupants in order to collect their feedbacks about the interface.

Between these different peaks, attendance rates are poor, especially during holidays (July and August) when buildings are not occupied. The following figure shows that nearly half of visitors come more than one time on the website, leading to say that the content or design of the interface is not attractive enough and do not engage people in connecting twice. Another conclusion could be that people consulting the website are already aware of energy and environmental issues.

Figure 42: Percentage of new and returning visitors

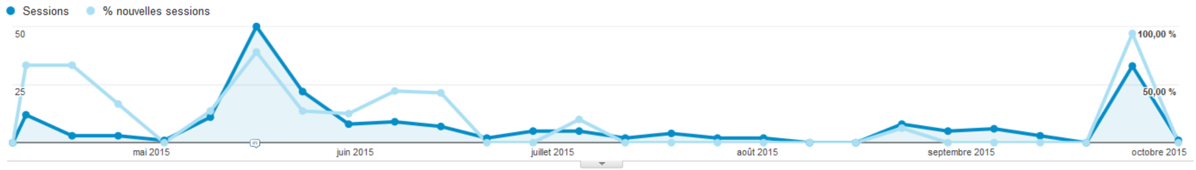


Figure 43: New sessions distribution

These graphs also show that without specific notification reminding the existence of the website, occupants of the IUT do not visit the website again (most of the connections are detected during the three peaks observed in Figure 43). Therefore in order to have a real benefit from this awareness website and have a larger amount of connections on it, it should have been accompanied by regular communication.

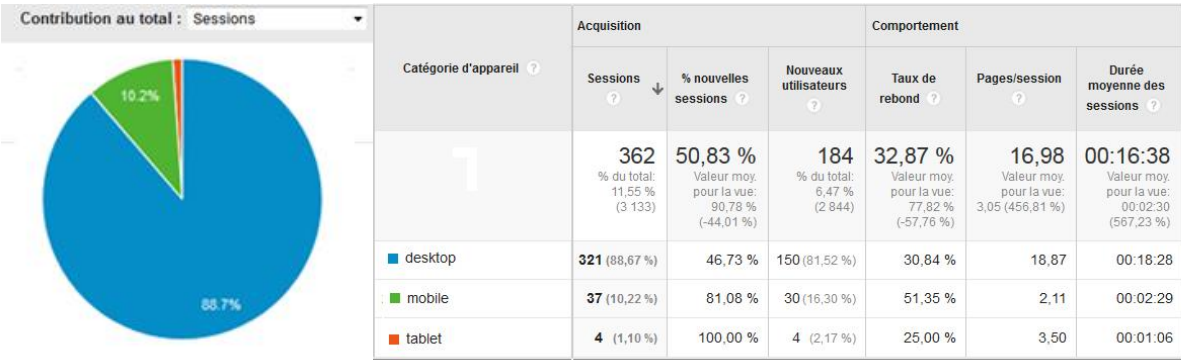
Whether it be new or old visitors, it is necessary to know if such tools create curiosity. The following table provides some indicators related to this question.

BEHAVIOUR		
Bounce rate[8]	**Number of visited pages/Session**	**Average duration of the sessions**
33%	17	00:16:38

Table 14: Website visitors' behaviour

When referring to bounce rate[8], two-third of visitors have a look at more than one page. On average, the users visit almost 17 pages (entire site) and stay for at least 16 minutes to read all the information provided.

The QR code that has been made available close to the 5 large screens installed on site enables the access to the website through a smart phone.
Figure 44 indicates that 10% of visitors connect with their phone and when they do this, the connection is very short.



Catégorie d'appareil	Acquisition: Sessions	Acquisition: % nouvelles sessions	Acquisition: Nouveaux utilisateurs	Comportement: Taux de rebond	Comportement: Pages/session	Comportement: Durée moyenne des sessions
	362 % du total: 11,55 % (3 133)	50,83 % Valeur moy. pour la vue: 90,78 % (-44,01 %)	184 % du total: 6,47 % (2 844)	32,87 % Valeur moy. pour la vue: 77,82 % (-57,76 %)	16,98 Valeur moy. pour la vue: 3,05 (456,81 %)	00:16:38 Valeur moy. pour la vue: 00:02:30 (567,23 %)
desktop	**321** (88,67 %)	46,73 %	150 (81,52 %)	30,84 %	18,87	00:18:28
mobile	**37** (10,22 %)	81,08 %	30 (16,30 %)	51,35 %	2,11	00:02:29
tablet	**4** (1,10 %)	100,00 %	4 (2,17 %)	25,00 %	3,50	00:01:06

Figure 44: Devices used for the connexion

The following two reasons can be argued:

- The information displayed on the smart phone does not encourage them to go deeper into the website. This can be due to the fact that the interface has not been adjusted to fit with the smart phone format.
- They do not feel concerned.

The quiz available on the website has allowed collecting some feedbacks from the visitors: most of the respondents feel already and increasingly concerned by energy issues but they feel they lack of means to act at the site scale. This type of tools would be more powerful in housing where users pay their bills and have some capacity to act on their own energy consumptions.

The implementation of a competition based on targets for energy savings at the building level and the ranking of the buildings participating in the competition could be also a powerful solution in order to stimulate and engage occupants of the IUT site (this approach is already implemented in the US, see LUCID Building Dashboard[9]). This approach could be more efficient than large screen interfaces that only induce passive reaction of the site occupants.

5.3.3 Awareness increase through the 3DVW influence: activity log and questionnaires/surveys analysis

[8] Bounce rate refers to the percentage of visitors to a particular website who navigate away from the site after viewing only one page.
[9] https://lucidconnects.com/

Several visits in the 3DVW have been conducted during the demonstration phase of the IDEAS project. A total of 35 people have participated to the visits and annexe C (chapter 9.3) gives the main features of these visitors.

A tutorial (in French language) aiming at providing a support for the visit has been elaborated (https://sites.google.com/site/quartieraenergiepositive/la-simulation/visite):

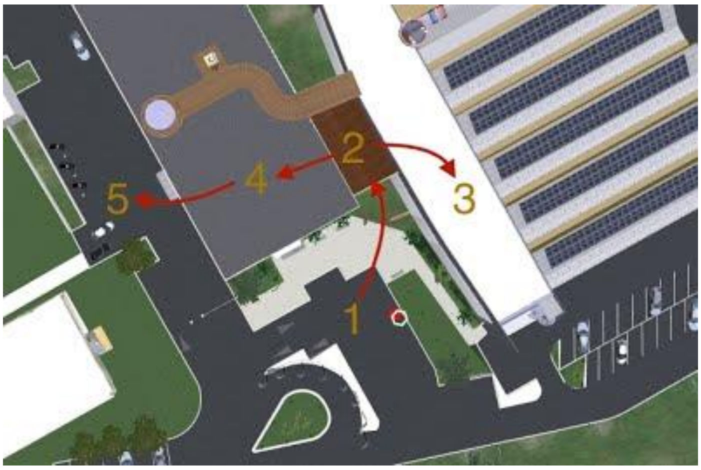


Figure 45: Tutorial of the visit

A questionnaire has been elaborated for the collection of the visitors' feedbacks at the end of the visit. It is largely based on the same questions submitted to the occupants of the IUT for the general assessment of energy awareness (see chapter 9.1).

The feedbacks from the visitors are largely positive concerning the tool but some potential improvements have been suggested by the visitors. It is important to note that most of the visitors have already some knowledge about energy and buildings.

All the visitors mention that some references to which the real values of energy consumptions displayed in the tool could be compared are missing. These references would help the end-user to better understand the quantitative data provided and have targeted values that could constitute real quantitative objectives in terms of energy consumptions.

A larger interactivity should be implemented in the tool in order to allow a concrete pedagogical approach showing the consequences of concrete actions such as increasing the temperature set-point in the buildings for example or replacing the compact fluorescent light bulbs by LED lamps. The possibility to introduce technical information related to electrical devices and energy systems at the building and site scale should be given to the visitor also.

In addition, some tips helping the end-users to adopt an eco-behaviour and follow a suitable energy behaviour related to this specific site are missing.

A more intuitive displacement within the mock-up (visit guidance, better management of the avatar displacement) would be appreciated also according to some of the visitors.

Finally, two of the visitors would have liked the possibility to visualise the simulations algorithms used for the energy consumptions predictions displayed in the tool.

On their side, the teachers see many applications of the tool within in their fields of interest:

- The 3DVW could be used as a friendly support for the courses provided that some interactive processes could be implemented in the tool. For instance, it could be useful to implement a simulation process providing the impact associated to users' behaviour or modifications of the building settings (for example, what is the impact of increasing the temperature set point by 1°C on the energy consumption of the site?

Or what is the impact of changing the PV panels' inclination on the electricity production of the site?).

- The 3DVW could also be used as a support for practical exercises aiming at providing a better understanding of renewable energies and EPNs' functioning. In order to provide a long term involvement of the users, the 3DVW should be dynamic (real-time data), scalable and interactive.
- finally, according to some of the teachers involved in the energy management of their site, the 3DVW could be used as a BMS (Building Management System) or NMS (Neighbourhood Management System) allowing the monitoring of relevant parameters at the neighbourhood scale (energy consumptions, occupations of the buildings etc.…).

One of the visitors suggested also that this kind of tool could be used for the residential sector particularly in order to raise awareness of people concerning the technologies related to Smart Homes.

Before the visits, 83% of people already applied some of the tips related to energy management that are displayed in the tool. Nevertheless, according to the questionnaires collected at the end of each visit, 55% of people have identified a positive impact of the tool on their awareness to the questions highlighted by the tool (19 positive responses over 35 participants) even if the tool serves mainly for information purposes regarding the means for energy production and for energy savings.

It should be emphasized that the work associated to the improvements mentioned above has been initiated by some of the IUT students in the frame of the IDEAS project. An additional content has been defined and initiated based on the following improvements:

- Additional content based on a link to the following website: https://sites.google.com/site/quartieraenergiepositive/la-simulation;
- Introduction of tips and simple prevention messages related to the reduction of energy consumption similar to the one displayed on the large screens interface disseminated along the visit path;

Figure 46: Tips and simple prevention messages disseminated along the visit path

- Complementary messages related to other topics than energy consumptions (environmental conditions, mobility).

According to available guidelines for the concrete actions associated to the projects management of sustainable campuses (Caisse des Dépôts, 2010 and NOBATEK, 2013), it is mandatory to integrate awareness raising tools aiming at engage end-users in a responsible attitude. For instance, Caisse des Dépôts (2010) promotes the use of virtual spaces in order to limit displacements and materiel supports. It also promotes the use of ICT in order to disseminate the ideas and best practices. The 3DVW tool developed within the IDEAS project is perfectly in line with these recommendations and should be widespread in this frame.

5.4 Interview of the local stakeholders of the IUT site

The stakeholders who have been interviewed at the end of the project highlighted the benefits related to the knowledge brought by the IDEAS project about the way to manage an energy conservation project.

Moreover, the IUT people have highlighted the positive way with which the IT issues have been managed in the frame of the ICT system implementation at the IUT site. The IT security can constitute a hard point regarding the link between the IUT and an external system. Nevertheless, in the frame of the IDEAS project, this relation with external systems was absolutely required and this has been successfully implemented during the project.

Lastly, the IDEAS project has allowed to identify energy conservation opportunities that the IUT stakeholders were not able to identify without the tools developed within the project. Indeed, the overall view of energy consumptions (mainly electricity consumptions) has allowed the identification of large electricity consumptions during the period of inoccupation of the site (nights, week-ends, and holidays). This observation led to some discussions about the possibility to introduce PV systems on site (on the Civil Engineering Building) in accordance with a necessity to renovate the roof and to smartly implement this PV system by self-consuming the electricity produced to cover this basis consumption. Therefore, the IDEAS project clearly contributed to launch these discussions within the IUT site and provided some useful information about the ROI for such an investment (through the task T5.6) and about the surface required to cover the basis electricity consumption identified during the inoccupation periods.

Moreover it should be highlighted that the IUT site is currently losing its autonomy in terms of site management because IUT depends on the University and the decisions making is now processed through the university’s decision makers. As an example, some discussions are currently taking place in order to investigate the option of hiring an external facility manager enterprise to manage the IUT site (preliminary discussions were launched with COFELY for a P3 contract). These management evolutions have appeared during the IDEAS project and they are still evolving. This could have a large impact on the way an EPNSP approach can be implemented in the future.

6 KEY LESSONS LEARNT

This section highlights the main lessons learnt during the project and proposes potential enhancements and recommendations for future actions.

6.1 Lessons learned and recommendations for future actions

6.1.1 Project consortiums

6.1.1.1 Problem identified

The IUT pilot site the owner was not a partner of the IDEAS project. Key stakeholders at the pilots were engaged and answered requests for information, provided wired infrastructures, among other services, and were generally very supportive. However they were not able to prioritise the needs of the IDEAS project above their usual busy workloads and work related to the IDEAS project had to be squeezed into their busy agendas. The lack of project funded staff for the IDEAS project at the IUT site also meant that during the summer vacation when the university is all but closed there was almost no support from staff at the pilot site. This put the IDEAS partners in a difficult position when relying on them. Overall the pilot went well, but mostly thanks to key stakeholders at the pilot being more helpful than can generally be expected of an organisation that is not a project partner.

6.1.1.2 Solution

In future similar projects, it would be advantageous to have the pilot site owner/ occupants /facility manager involved as a partner in the project.

6.1.2 Retrofitting energy monitoring systems

6.1.2.1 Problem Identified

The complexities of existing infrastructures for retrofitting energy monitoring systems in buildings and monitoring data collection errors (missing data, erroneous data etc.) and the need for automated fault detection. The latter was not built into the project funding or work plan and this caused significant problems as data interruptions and faults had to be identified in retrospect and corrected.

When considering the complexities of retrofitting energy monitoring systems wired connections are on the whole more reliable than wireless ones, however existing site constraints can necessitate the use of wireless technologies. As was the case at the IUT site where the gas meters and the general electricity meter were not accessible through the wired networks. While a working solution was found data interruptions were not completely resolved. Problems were also found in the wired elements of the system with data interruptions due to problems with connectivity and the lack of onsite staff funded by the IDEAS project to address these problems quickly.

Another complexity related to the existing network at the IUT site is that it is segmented for security reasons. A remote access to a server on the dedicated subnetwork was available for the IDEAS project but no remote web access to devices on the subnetwork. This represented a practical issue, since some devices (both on the wired and the wireless paths) are configured through a web interface, and we had to rely on the site's facilities management for tests, verifications or modifications. We sometimes ended up shooting in the dark, configuring a device in our facilities before driving to the site for installation and driving back to check it worked.

All these practical issues complicated the implementation of the IDEAS ICT infrastructure.

6.1.2.2 Solution

In future similar projects, the existing site infrastructures should be fully explored during the proposal preparation to inform the specific technical choices built into the project's design. To anticipate all the potential difficulties and simplify the implementation, it is essential that the facilities management or site manager responsible for the pilot site ICT infrastructures is involved in the proposal preparation. Therefore as discussed above site facilities management or site management if there is no facilities management as such should be a partner in a project.

The above conclusion also highlights that level of detail related to existing site infrastructures required during the project proposal phase demand a great deal of investment on behalf of those developing proposals, which brings into question how we fund future proposal development. This highlights the advantages of making funding available for project proposal development via a two phase process, in which simple phase one proposals are assessed and those that look most promising are awarded funding to support the development of full proposals.

The problems related to the data collection observed for the French pilot site are inherent to ICT systems that aim to collect real time data, particularly if these systems are to be retrofitted to existing buildings. These issues cannot be completely avoided but could be reduced by implementing several kinds of actions or tools:

1. An automated monitoring process can be implemented enabling the detection of problems or errors on the data collection (missing data, erroneous data, …) and the identification of the source of the problem (ftp server connexion failed, wrong data file name, …). This allows launching a specific corrective intervention on the site itself or on the long term, and in the case of a punctual error, to follow these errors and check if it happens again.
2. An interpolation process can be used to replace the missing data. Here several strategies can be implemented (replacing the missing data by an average of the adjacent ones, replacing the missing data by the data collected the previous day or for a similar day…). This enables the construction of a stronger database (reducing missing data) leading to more reliable results. This interpolation process can be implemented only if few data are missing (it cannot be implemented if the data of several days are missing for instance). This is why this process should be closely linked to the previous step (error detection).

6.1.3 Interfacing with existing tools

6.1.3.1 Problem identified

The data gathered at the pilot site was made accessible on an FTP server as an input to IBM's IOC. In retrospect, the IOC was too complex and cumbersome for agile prototyping in a small scale research project. Too much time was used dealing with minor issues related to data formatting and transferring data into the IOC. As such using the IOC added an extra layer of complexity (and red-tape) that hindered progress.

On the other hand, it's important to remind that the REST APIs were used not only for data access but also for energy models integration and user interfaces running on servers in different locations (demonstration sites, UoT campus, IBM Montpellier lab) and recognise that this is a powerful solution to deal with such various interactions.

6.1.3.2 Solution

The database functionality of ICT infrastructure for the EMS could have made use of one of the many commercial or open-source time series database /operational historian components and environments which are available (e.g. openTSDB available from http://opentsdb.net/ or similar). This solution would not have been as robust as the IOC for a large scale rollout of the EMS however it would have offered more agility for rapid prototyping.

On the other hand, the IOC provides a common framework for a collaborative development of multiple use cases (including User Interfaces) and is hosted in the cloud with direct internet access for all partners and end-users, and this can be a positive criterion for the justification of its selection.

6.1.4 Impact on the behaviour of building occupants

6.1.4.1 Problem identified

The energy awareness interfaces implemented in the IUT did not have the impact anticipated on the energy use of building occupants. This was partly due to the fact that the time for implementation of the tools on site built into the project timeline did not allow for the iterative improvement and the implementation of enhancements requested by the local end-users of the tools. For example, the lack of time meant that it was difficult to tailor the information supplied on the different interfaces according to the particular audiences' needs at different locations. This meant that building occupants were not as engaged as might have been possible.

6.1.4.2 Solution

If more time had been built into the project timeline, perhaps extending it for six to nine months the following could have been achieved increasing the engagement of end users:

- The tailoring of the content of the wide screen interfaces according to the particular requirements of the audiences at different locations on the IUT site.
- The addition of additional user interactivity in the 3D virtual world interface, which has a large potential but could have been improved by enabling the users to visualise the impact of different energy reduction interventions: such as replacement of compact fluorescent light bulbs by LED lamps, or a modification of the temperature set points on the heating consumptions of the whole site.

6.1.5 Need of a real Facility Manager in the EPN

6.1.5.1 Problem identified

NOBATEK has local contacts at the IUT that significantly contributed to the project but their field of actions were not as large as that of a facilities manager in an EPNSP's. The IUT staff involved in the project has different roles in the organisation. Some of them are teachers or engineers acting at building/department level; others are technical staff of the IUT acting at site level on technical aspects of the buildings but without real decision power. The IDEAS approach is strongly based on the EPNSP concept, in the current staff structures at IUT no one has this role. During the lifetime of the demonstration the role of the EPNSP manager was supposed to be taken by 'Virtual Facility Managers' that were current staff at IUT. One of the 'Virtual Facility Managers' with whom we were in contact for the EPNSP interface has retired during the IDEAS project and it was not possible to get his feedback before the end of the project.

6.1.5.2 Solution

This once again highlights that it would be advantageous in future projects to have the pilot site owner/ occupants /facility manager involved as a partner in the project. It also emphasises the need to have the key roles of partners clearly identified during the proposal development stage and the need for partners to fully understand these roles. This once again points to the need for more time and funding to be available during proposal development as discussed above.

7 Overall conclusions

This chapter discusses the impact of the IDEAS project at the French pilot and identifies the benefits derived from the implemented tools and gives some general conclusions.

7.1 Impact on the pilot site IUT

7.1.1 Future plans for energy management and renewable energy

The involvement of IUT in the IDEAS pilot has enabled this university department to benefit from the energy information gathered during the project and the discussions generated though the implementation of the different tools and interfaces at the site. This energy consumption information made available to staff through the different interfaces developed and implemented as part of the IDEAS project has underpinned new initiatives in energy management at the site.

The site energy consumption data (mainly electricity consumption) available in the interfaces developed within IDEAS has allowed the identification of high electricity consumptions during the periods that the buildings on the site are not occupied (nights, week-ends, and holidays) (for instance, the electricity consumptions during the nights represent 45% of the total electricity use). This observation led to the site administration assessing the possibility of the introduction of PV systems, on the Civil Engineering Building, as part of the currently necessary renovation of the roof. The current plans being assessed include the implementation of a smart PV system, to enable the use of electricity produced by the PV to cover this site base electricity demand. The IDEAS project not only contributed to the launch of these discussions within the IUT site but also provided useful information about the ROI for such an investment (through the task T5.6, reported in Ala-Juusela et al, 2015) and about the area for PV required to cover the basis electricity consumption identified during the non-occupation periods.

It must also be mentioned that as a result of the discussions and experience of taking part in the IDEAS project the IUT administration is currently investigating the option of hiring an external facility management enterprise (COFELY) to manage the site (P3 take care of the maintenance contract). This further illustrates the fact that the IUT is currently evolving a lot in terms of site management and this could have a huge impact on the way an EPNSP approach can be implemented in the future. As the lack of a site facilities manager was highlighted as one of the key problems during the implementation and use of the tools at the pilot site as discussed above in section 6.1.5.

7.1.2 Benefits for teaching and energy awareness

Some students have been involved in the development of the 3D virtual tool. In that frame, they developed a website which allowed them to investigate renewable technologies and try to formalize some technical content for the 3DVW. This has imposed them to make further research and improve their knowledge and understanding of these technologies. Moreover they have had to appropriate the Energy Positive Neighbourhood concept and become more familiar with the definition proposed within the IDEAS project.

7.1.3 Demonstrating the possibilities for EPNs

The KPIs that were calculated for the French pilot site equipped with simulated extensions (PV system + CHP plant) provide empirical evidence of the benefits of the IDEAS approach for control management in terms of energy positiveness and CO_2 reduction.

Moreover, the following table summarises the main features of the IUT site in terms of CO_2 emissions evolution, electricity and gas consumptions between the baseline period (2013) and the reporting period after the implementation of IDEAS tools for the following cases:

-without any evolution of the site (here, CO_2 emissions are related to electricity taken from the grid and gas taken from the gas network for the gas boiler),

-with a simulated introduction of PV in the IUT site,

-with a simulated introduction of PV + CHP plant (2000kW) Scenario A

-with a simulated introduction of PV + CHP plant (600kW) Scenario B.

Due to the natural evolution of the energy consumptions on site, a decrease of around 30% is observed for the total CO_2 emissions between the baseline period and the reporting period without any intervention on site. This percentage is calculated taking into account the adjustment due to weather conditions according to the IPMVP approach. This value reaches 2.5% when considering the simulated introduction of local energy sources (PV only) and 34% up to 58% when considering the simulated introduction of PV+CHP 600kW or 2000kW. The A+++ level is reached for an optimisation scenario where the CHP plant is running continuously in order to generate profits during the summer months by selling back the electricity produced back to the grid.

	BASELINE PERIOD 19/2/13 TO 07/10/13	REPORTING PERIOD 19/2/15 TO 07/10/15 NO INTERVENTION	19/2/15 TO 07/10/15 SIMULATED PV	19/2/15 TO 07/10/15 SCENARIO A (PV+CHP 2000KW)	19/2/15 TO 07/10/15 SCENARIO B (PV+CHP 600KW)
OER (%)	0 % (no local Energy Supply)	0 % (no local Energy Supply)	26 %	98 %	235 %
ENERGY COSTS (€)	104403	60157	47585.8	35709.51	25378.12
COSTS SAVINGS (%)			20.9	40.6	57.8
CO_2 EMISSIONS (g $eqCO_2/m^2$)	8109,4	5715,3	5574,9	2405.1	3791,9
CO_2 EMISSIONS AVOIDED (g $eqCO_2/m^2$)		2394,1	140,4	3310,2	1923,4
CO2 EMISSIONS AVOIDED (%)		29,5 %	2,5 %	57,9 %	33,7 %
ENERGY POSITIVITY LABEL	D	D	C	Nearly A	A+++

Table 15: Evolution of the main features for the IUT site

7.2 Cost and benefits analysis

This section contributes to the “lessons learnt” by providing a short analysis of the costs and benefits aspects in order to answer to the question raised in the Dow and which asks for a “Cost analysis both at project level with technical ICT providers and at site level with local stakeholders involved in facilities management in the campus comparing the cost of the solution provided to its effectiveness". The idea is to better understand the cost / benefit relationship related to the IDEAS project, before looking at future projects in Europe.

7.2.1 Cost approach

The cost analysis at the project level can be summarised as follows:

- Sum of the physical devices (meters, sensors,…) costs, including their roll-out, operations and maintenance
- Sum of the ICT software licenses costs (not considered in the IDEAS project itself)
- Sum of the custom ICT developments costs and their integration in the demonstration sites environments (use cases that implement features for different end users)
- Sum of the ICT infrastructure platforms costs (mobile devices and public screens, hardware, storage, network, administration and security management)
- Sum of the additional costs related to project management, change management, training, and data quality improvements when needed.

Regarding smart meters deployment in Europe, there are many ongoing projects. Some reports raise questions about the complexity and the cost of such deployments, like in UK (Lewis, 2014).

For the French demonstration site, the cost for the equipment installed in IUT is close to 13590 € as further detailed in Table 16:

Equipment purchased related to the ICT infrastructure installed in the French demonstration site			
Description of the devices bought	**Quantity**	**Total cost (€)**	**Remark/explanation**
11 energy meters	11	3991,13	Pulse Meters connected to the existing meters. (Adaptation of the existing meters installed on the site and system allowing to collect the measured data)
11 ethernet converters	11	1292,5	Converters used to allow the communication on the ethernet network of the IUT site (Local communication hardware equipment)
Small items of equipment for installation (raw material)	1	73,51	Raw material for installation (Local communication hardware equipment)
Cables	1	24,21	Raw material for installation (Local communication hardware equipment)
Cables	1	78	Raw material for installation (Local communication hardware equipment)
WEBDYN Gateway	2	2300	Gateways used for the wireless network used to collect wireless modules information (radio communication) (Adaptation of the existing meters installed on the site and system allowing to collect the measured data)
DISTRAME meters	3	1105,5	Wireless modules used for the gas and general electricity measurement (Adaptation of the existing meters installed on the site and system allowing to collect the measured data)
Small items of equipment for installation (raw material)	1	55,93	Raw material for installation (Adaptation of the existing meters installed on the site and system allowing to collect the measured data)
Pulse meters, Wireless repeaters wavetalk, data concentrator wave port	1	825	Wireless devices able to collect the general meters of the IUT site (gas and electricity)
Large screens for the French pilot site, associated wall or ceiling mounts, Keedox Android mini PC	5	3840	Used to display the user interfaces. Installed at strategic locations in the facilities of the French pilot site
	TOTAL	**13585,8**	

Table 16: Equipment purchased for the French demonstration site

Regarding the IBM Intelligent Operations Center, the licenses costs can only be estimated on a case by case basis as they rely on different assumptions (number of standard and premium users especially). It can be deployed on premise or in a cloud computing environment:

- packaged, priced, delivered starting points, allowing clients to generate quantified results, fast,
- solutions delivered from the cloud, with our capability sold as a service,
- a robust foundation - our Intelligent Operations Center - ready for expansion,
- specific industry services, pre-packaged and delivered on initial access.

It should be highlighted that the IBM IOC has been designed as an ICT framework that provides features that can be easily extended by customers and external partners.

The idea is that once the investment has been done on that framework (initial licence, installation and training on application development and runtime operations), there is a marginal cost only to add new features using the powerful ICT engines embedded: data acquisition, event management, portal, analytics including KPIs and optimisation capabilities.

This solution is addressing different users (end users and ICT) that can belong to multiple organizations:

If you are a...	This software can help you...
Executive	• Gain an executive level summary of events through maps, dashboards, and notifications • Determine measures of organizational success with key performance indicators (KPIs) • Identify and track issues through reports • Direct priorities and implementation of policy that is based on data that is provided
Supervisor	• Identify and act on conflicts and issues that are shown on maps, dashboards, and notifications • Manage events by adding new events, editing existing events, and cancelling events • Store and manage the execution of procedures and activities that are associated with events • Monitor KPIs • Communicate quickly and easily on matters of importance • View filtered data in reports
Operator	• Create, edit, and monitor events that are displayed in maps and lists • Receive and update status on assigned activities • Run regular and up-to-date reports • Communicate quickly and easily in emergencies and other situations that require a response
Solution administrator	• Create, update, and delete data sources • Configure the filter options that are displayed to users • Configure the geospatial map, and the location maps • Manage KPI relationships, and configure how KPIs are displayed to users • Create and edit standard operating procedure definitions

If you are a...	This software can help you...
System administrator	• Administer individual components of the system through administration consoles • Add, modify, and delete system properties • Add new users and assign them to the appropriate role-based authorization group • Ensure data security by assigning permissions to access data sources to the appropriate users and groups • Set up permissions that are appropriate to the required areas of expertise and required access to data sources • Customize pages to suit the organization

Table 17: Categories of potential end users and main benefits identified from using the IBM software

The last IBM IOC version is 5.1 announced on July 28 2015 (IBM, 2015):

National languages supported are: Simplified Chinese, Traditional Chinese, Japanese, English, French, Italian, German, Korean, Brazil (Portuguese), Arabic, Russian, Spanish, Hebrew.

It can be acquired also using different IBM programs including Passport Advantage, PartnerWorld (Business Partners including resellers, Independent Software Vendors, Consultants and System Integrators other than IBM Services teams) (IBM, 2015b):

Universities can also leverage the IBM Academic Initiative (IBM, 2015c):

The ICT platforms costs vary depending on the deployment strategy (on premise, hybrid cloud, and public cloud), the customer environment and the project type itself. The hardware requirements can be found in (IBM, 2015d).

Additional details can be found in the solution documentation and in Redbooks (IBM, 2015e, 2015f).

7.2.2 Benefits approach

The benefits for the French demonstration site associated to the implemented solution can be summarised as follow:

- Reduction in terms of energy consumption as a result of the tools deployed on site (better management by the facility manager, site occupants' actions generated by the awareness interfaces…) is not taken into account in this analysis.
- Reduction in terms of energy taken from the grid as a result of the introduction of renewable energy sources on site. The associated costs savings can be calculated based on the electricity consumption from the grid avoided as a result of the PV generation (PV production x electricity prices) plus the gas consumptions from the gas network which are avoided as a result of the CHP generation.
- Increase of benefits as a result of the electricity locally produced on site and resale to the grid when this production is higher than the demand.

Table 18 summarises the main figures associated to the costs and benefits analysis:

Case 1 / Scenario 1	
CHP 600 kW PV 367kWp $\gamma=0$, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 600 kW	406850
Heat Storage 500 kWh	20000
PV 367 kWp	734000
Battery Li-ion 150 kWh	126540
Total investment	1287390
Yearly savings	55646,2
ROI (years)	23,1
OER (%)	235%

Case 2 / Scenario 1	
CHP 1200 kW PV 367kWp $\gamma=0$, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 1200 kW	628850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1663930
Yearly savings	110188,8
ROI (years)	15,1
OER (%)	444%

Case 3 / Scenario 1	
CHP 2000 kW PV 367kWp $\gamma=0$, maximize profit, with current selling price. The CHP plant is run continuously during summer months in which the heat demand of IUT site is very low. The electricity generated by the CHP plant is sold to the grid generating an important income for this period	
	Cost (€)
ICT infrastructure	13586
CHP plant 2000 kW	914850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1949930
Yearly savings	161581,7
ROI (years)	12,1
OER (%)	722%

Case 1 / Scenario 4	
CHP 600 kW PV 367kWp $\gamma=0$, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 600 kW	406850
Heat Storage 500 kWh	20000
PV 367 kWp	734000
Battery Li-ion 150 kWh	126540
Total investment	1287390
Yearly savings	25012,2
ROI (years)	51,5
OER (%)	69%

CASE 2 / Scenario 4	
CHP 1200 kW PV 367kWp $\gamma=0$, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 1200 kW	628850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1663930
Yearly savings	36937,6
ROI (years)	45
OER (%)	96%

Case 3 / Scenario 4	
CHP 2000 kW PV 367kWp $\gamma=0$, maximize profit and selling price set to 90% of buying price. The CHP plant is turned on intermittently to meet the heat demand of the IUT site	
	Cost (€)
ICT infrastructure	13586
CHP plant 2000 kW	914850
Heat Storage 1200 kWh	48000
PV 367 kWp	734000
Battery Li-ion 300 kWh	253080
Total investment	1949930
Yearly savings	39116
ROI (years)	49,8
OER (%)	98%

Table 18: Main figures associated to the costs and benefits analysis

In Case1, the CHP plant is sized to provide baseload thermal output, with any shortfall in heat during peak winter demand being provided by a gas fired back-up boiler.

In Case 2, the CHP plant is sized to provide thermal output to meet peak winter heat demand and therefore is larger.

In Case 3, the CHP plant is sized to more than meet the heat demand of the site enabling a greater percent of the energy produced to be sold to the national grid.

The findings from the cost analysis indicate the following when employing an EMS to optimise local renewable energy production, storage and sale in the French context:

- In the current situation (selling price higher than buying price), the investment in large capacity CHP is economically justified because the ROI is the shortest for the 2000kW CHP presented in Case 3 scenario 1. However in this case all the heat generated during the summer months is wasted as the CHP is running simply to generate electricity. This suggests that future work should look at the possibilities of combined cooling heat and power (CCHP) which could reduce the ROI further.
- However it must be considered that in the future situation of the IUT site (selling price lower than buying price), it does not make economic sense to invest in larger CHP capacity to increase the OER and sell the excess electricity back to the grid as income generated in this way extends the payback period.

- These two situations correspond to extreme cases and the realistic scenario would be somewhere between the two values.

7.2.3 Lessons learnt and recommendations

The main recommendations based on the French demonstration site are the following:

- For a site which already has a CHP, PV system and energy storage installed, there is a short return on investment. The IDEAS project made the IUT more confident to study new options for the future, like deploying renewable energies production for the site.
- Smart Grid related investments are easier to justify once you've done an analysis of the benefits and savings you can get from the project.
- It's worth deploying new meters and sensors in order to reach a good spatial and temporal coverage at the site level. The site level view is key to understand the global picture, see the evolution over time and simulate scenarios before taking new decisions. It's also critical to identify high consumers and producers.
- The energy monitoring equipment need to rely on IP standards and allow an automatic data acquisition, monitoring and analysis.
- Building or asset level information is key once they've been identified to put in place dedicated actions plans including temporary or permanent monitoring and analysis.
- Multiple user interfaces enforce the energy awareness from all end users including facility managers, students, teachers and site occupants.
- It's often better to look for "quick wins" (progressive approach where new investments are funded by benefits and savings obtained from previous steps). Sometimes, this is the only possible way as funding is not available otherwise.
- Quick wins should not prevent customers to adopt an "enterprise wide" ICT architectural approach that allows the mitigation of both short and long term objectives. Quick wins should not prevent for building a consistent framework / platform that can really be extended and evolve smoothly over time. Reducing time, cost and risk while yielding expected business benefits over multiple years is often a strong requirement that needs to be addressed properly.
- Cloud computing capabilities can offer almost immediately operational capabilities while freeing customers from ICT complexities and hiring themselves ICT (rare) expertise.
- Offering an end-to-end solution integrated with the right providers is a key differentiator on the market.

7.3 Strategy to ensure the wider replicability of the piloted solutions and qualitative assessment for the progress

The strength of the IDEAS project is that it provides a holistic approach playing on multiple levers and lifecycle phases (operational phase with awareness UIs but also decision support/optimisation tools to guide future refurbishments, renewable energy installation, etc.), all combined to reach energy positivity.

Based on this approach the tools developed (except ATLAS) are all based on the EMS which in the frame of the project development consists in one single centralized system. This centralized approach can be rethought to be more efficient and more robust as well and the

EMS functionality can probably be spread among similar competitors on an open market.

The whole approach conducted in IDEAS could be replicated in all the similar sites present in France and the tools could be disseminated among this community in order to generalize the approach. In particular a simple energy opportunities detection based on an adequate energy monitoring infrastructure can be at the origin of very positive and efficient initiatives related to energy management or improvement measures on site. This process should be generalised and standardised as a very first stage in the improvement process of this kind of site and the commitment in the path towards energy ‘positiveness’. Then a more holistic process can be engaged including the whole system provided by IDEAS and all the relevant stakeholders required for a successful application.

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9 Appendices

9.1 Appendix A – KPIs definitions

9.1.1 On-site Energy Ratio

On-site Energy Ratio, OER = Annual energy supply from local renewable sources/annual energy demand (all types combined) [%].

OER represents the overall energy balance of the site.

OER < 1 neighbourhood needs imported energy

OER = 1 zero-energy neighbourhood (energy neutral)

OER > 1 energy positive neighbourhood (export possible)

OER is defined as follows:

$$OER = \frac{\int_{t_1}^{t_2} G(t)dt}{\int_{t_1}^{t_2} L(t)dt}$$

where G(t) is the on-site energy generation power and L(t) is the load power of all energy types (heating, cooling, electricity) combined, dt=1 year, 1 month, 1 hour

9.1.2 Annual Mismatch Ratio[10]

The Annual Mismatch Ratio (AMRx) is the annual average ratio of these two, for those hours when the local demand exceeds the local renewable supply:

- hourly local renewable supply (by energy type: heating & electricity) (generation)
- hourly demand (by energy type: heating & electricity) during that same hour (consumption)

It is calculated according to the following formula:

$$AMRx = \frac{\sum_{t=1}^{8760} HMRx(t)}{8760}$$

where HMR is the annual mismatch ratio and

$$HMRx(t) = \frac{\int_{t_1}^{t_2}[L_x(t) - G_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)\,dt}.$$

9.1.3 Maximum Hourly Surplus[11]

The Maximum Hourly Surplus (MHS) is the biggest value (by energy type: heating & electricity) during the year for hourly local supply per the value of hourly demand on that hour.

It is calculated according to the following formula:

$$MHSx = Max\left[\frac{\int_{t_1}^{t_2}[G_x(t) - L_x(t) - S_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)dt}\right]$$

9.1.4 Maximum Hourly Deficit

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[10] Interpretation: AMR indicates how much **energy is imported** into the area for each energy type on average. The smaller AMRx, the better the local renewable energy supply meets the demand at the right time, and the closer the neighbourhood is to energy self-sufficiency, the less energy needs to be imported into the area.

[11] Interpretation: MHSx compared to OER finally indicates the ability of the neighbourhood to balance the demand and supply on short term.

The Maximum Hourly Deficit (MHD) is the lowest value (by energy type: heating & electricity) during the year for hourly local supply per the value of hourly demand on that hour.
It is calculated according to the following formula:

$$MHDx = \mathrm{Max}\left[\frac{\int_{t_1}^{t_2}[L_x(t) - G_x(t) + S_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)\,dt}\right]$$

9.1.5 Monthly Ratio of Peak hourly demand to Lowest hourly demand (RPL)

RPL is the Monthly Ratio of Peak hourly demand to Lowest hourly demand. It is the ratio between the two following values:

- The highest value for hourly demand over the month, for each month of the demo period kWh.
- The lowest value of hourly demand over the month, for each month of the demo period kWh.

It is calculated according to the following formula:

$$RPLx,i = \frac{Max(L_{x,1},\cdots,L_{x,n})}{Min(L_{x,1},\cdots,L_{x,n})}$$

where:

$i = 1 \dots 12$ is the number of month
n is the total number of hours in the month (n = 24 * days in the month)

9.1.6 Low energy demand (compared to similar areas)

Energy demand of the area MWh/year, MWh/m^2.year, MWh/inhabitant/year.
Energy demand of similar area (the BORDEAUX 1 campus can be considered as a similar area) MWh/year, MWh/m^2.year, MWh/inhabitant.year

9.1.7 Little environmental impact (CO2–ekv emissions mainly, compared to similar areas, radioactive waste could be also included)

CO_2 equivalent emissions for the buildings - electricity (for French case EDF average, and possibly total renewable for comparison) - heat (from Gaz de Bordeaux for France) gCO_2-eq/m^2.year.
CO_2-equivalent emissions on the area - electricity - heat kg CO_2-eq/year kg CO_2-eq/inhabitant, year g CO_2-eq/m^2, year.
CO_2-equivalent emissions on similar area kg CO_2-eq/year kg CO_2- eq/inhabitant, year g CO_2-eq/m^2, year
Amount of radioactive waste related to external energy supply on the area g/year g/inhabitant, year mg/m^2,year
Amount of radioactive waste related to external energy supply on similar area g/year mg/m^2, year g/inhabitant, year.

9.1.8 Energy positivity level indicator

As described in (Ala-Juusela, M. et al., 2015), an energy positive neighbourhood (OER > 100 %) would receive label A+, and a zero energy neighbourhood would reach class A (OER=100 %). Currently it is suggested that following thresholds ae used:

A+++ = energy positive neighbourhood with very high OER, > 150 %,
A++ = energy positive neighbourhood with high OER, > 125 %

A+ = energy positive neighbourhood, OER > 100 %
A = zero energy neighbourhood, OER = 100 %
B = neighbourhood with 50 % < OER < 100 %,
C = neighbourhood with 10 % < OER < 50 %
D = neighbourhood with OER < 10 %

Figure 47: Energy Positivity level indicator defined for IDEAS

9.1.9 Energy efficiency

E-value of the buildings or energy demand of the buildings (by energy type) kWh/m^2.

9.1.10 Peak power demand (compared to similar area)

Average hourly power demand of the area kW.
Average hourly power demand of similar area kW.

9.1.11 Energy storage

Energy storage capacity by energy type depending on storage type, e.g. the storage capacity, volume, mass, temperature, long or short term storage depending on the storage type, e.g. mass (kg or t), volume (m^3), storage capacity (kWh or Ah or MW).

9.1.12 Energy demand of buildings (by energy type)

Energy demand of buildings (by energy type) kWh/m^2.year, MWh/year, MWh/month, MWh/week, kWh/day, kWh/hour.

9.1.13 Energy demand by other urban infrastructures (e.g. street lighting)

Energy demand by other urban infrastructures (e.g. street lighting) MWh/year, MWh/month, MWh/week, kWh/day, kWh/hour.

9.1.14 Building integrated renewable energy supply (for each building separately, and whole area)

Power and area of building integrated solar PV kWp, m^2
Power and area of building integrated solar collectors (by type) kW, m^2
Power and number of building integrated wind turbines kW, -
Power and number of individual hydro power plants kW, -
Power and number of the building level micro- CHP plant (for heat and electricity) kW heat and kW electricity, -
Mass/volume of wood used in fireplaces kg or m^3
Type, power, COP and number of building level heat pumps ground/rock/water, kW, -, -

9.1.15 District level renewable energy supply

Power and area of solar PV on public/common area MWp, m^2
Power and area of solar collectors (by type) on public/common area MW, m^2
Power and number of wind turbines placed on public/common areas MW, -

Power and number of district level hydro power plants MW, -
Power (possibly number, if several) of CHP plant serving the whole area (for heat and electricity) MW heat and MW electricity
Type, power and COP (and possibly number, if several) of heat pumps serving the whole area ground/rock/water, kW, -

9.1.16 Points that make the placement of the supply facilities most efficient and sustainable

Text describing the surrounding circumstances, e.g. “There is an industrial area next to the neighbourhood, with space for bio-CHP plant, so instead of placing the CHP inside the geographical limits of the area, the renewable energy is supplied from the neighbouring area.”

9.1.17 Transport distance of the biomass

Weighted average transport distance from the plant km.

9.1.18 Total cost of operation

Energy costs, maintenance costs, other costs for operation €/MWh.

9.1.19 The improvement of energy awareness level

Text describing the energy awareness level of the users.

9.1.20 The way and frequency of the energy information provided to the users

Text and possibly pictures to describe how the information is presented.
The frequency of the information times/year.

9.2 Appendix B – Questionnaire submitted to the occupants of the IUT site about the awareness interface

The questionnaire submitted to the occupants of the IUT site about the awareness interface is available at:
https://docs.google.com/a/nobatek.com/forms/d/1l6X7j2k3mm2kI8Vy_NDLaE2kXuFhv4DEm8c9r899VRk/viewform

IDEAS project: Evaluation of the awareness website

This questionnaire is devoted to the awareness tool disseminated on the 5 large screens installed in the IUT site in the following locations:
-In the entrance of the administrative building,
-In the cafeteria,
-In an entrance hall of the Electrical Engineering and Industrial Computing Department,
-In the entrance of the IT building,
-In the entrance hall of the civil engineering building.

1) Can you briefly introduce yourself? First name, Surname, professional activity (employee, teachers...) and field of activity? If you are an IUT student, please indicate the department to which you are attached.

2) Are you feeling active within the energy management process inside the IUT site?
Yes/No

3) Would you say that you are sensitive to environment protection issues and energy savings? (only one possible answer)
    a. Definitely yes
    b. Rather yes
    c. Rather no
    d. Definitely no
    e. Hard to say (do not read)

4) Could you please specify your sensitivity level to environmental issues?
1 stands for “very sensitive” and 5 stands for “not sensitive at all”

5) Are you satisfied with the level of information provided in the large screens interfaces installed in the IUT?
Yes/No

6) Which tool are you using to access the energy information of the IUT site?
    a. On the large screens installed in the IUT
    b. On the website on my computer
    c. Via the QR code connexion on my smartphone/tablet

7) How often do you consult this information?
    a. Weekly basis
    b. Monthly basis
    c. Less than once a month

d. Never

8) According to you, how relevant is the information displayed on the large screens installed in the IUT site?
   Free comments

9) How do you feel the information is organized within the website displayed on the large screens? Is the site navigation easy? Is it simple to find the information?

10) Do the electrical devices consume electricity in standby mode?
   Yes/No

11) What is the energy label of the IUT site?
   A+++/B/C/D/E//F

12) Do you feel generally, that you are better informed now on Energy issues or about energy topics thanks to these large screens information?
   Yes/No

13) Did the data displayed in the interface surprise you?
   Yes/No

14) Did the information displayed on the large screens change your behaviour concerning the energy issues? Did you change the way to use energy at home for instance? Or did you change the method of transport for getting to IUT?
   Yes/No
   Comments

15) Did you apply the tips provided in the large screens interface (such as turn off the light when leaving a room, avoid leaving the computer connected to the main power source, change your habits related to the way you travel into IUT everyday…)
   Yes/No/Already applied

16) Please rate how your energy awareness has changed, compared to before the introduction of the energy information on the large screens installed in the IUT site?

My perception of energy issues has really changed and I am now proactive in the energy management (please give examples of your actions)	My perception of energy issues has really changed but I am not proactive in that sense (my behavior did not really change thanks to the awareness interfaces)	My perception of energy issues is almost the same than before the implementation of the awareness interfaces	My perception of energy issues did not change, I already had some knowledge of this topic	My perception of energy issues did not change, the awareness interfaces had no impact on my behaviour
☐	☐	☐	☐	☐

Comments

17) Now, do you know what to do to decrease your energy use?
    Yes/No

18) Has the IDEAS project made you more aware of your energy consumption / of energy issues at the IUT site?
    Yes/No
    Comments

19) Do you think that the information displayed in the large screens interface should be more accurate or more detailed (for example, more technical content, information at building level…)?
    Yes/No

20) What kind of information would you like to be displayed on the large screens? What is missing currently?

9.3 Appendix C – List of the visitors of the 3DVW

	Date of visit	Surname	First name	Professional activity (student, teacher, IUT staff, ...)	Company, School, University	Field of professional activities, department, division	Age group between 18-25 25-35 35-45 More than 45
1	29/05/2015	GIBAUD	Robin	Student	UPPA (University of Pau	Applied chemistry and physics	18-25 years
2		VEERAMALAY	Tirouven	Student Master2	DRI Rennes1	ICT (Information and Communication Technologies) engineering for buildings	18-25 years
3	30/06/2015	Kowalski	Jaroslaw	Research Specialist	National Information Processing Institute	Interactive Technologies Laboratory	35-45 years
4		Larre	Jean-Marie	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
5		Lafargue	Thierry	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
6		MARTIN	Xavier	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
7		FABRE	Michel	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
8		GIRET	Didier	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
9		MORANCY	NICOLAS	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
10		DAL ZOTTO	PASCAL	Teacher	Lycée CANTAU	Thermal and Energy engineering	35-45 years
12	18/09/2015			23 Students ENSAM (Batchelor 2A) + 1 teacher	ENSAM (Ecole Nationale Supérieure des Arts et Métiers)	Technology training in the fields of Mechanics and energy	18-25 years
13	05/10/2015	FEBRES	Jesus	PhD student	National University of Ireland Galway	Department of Civil Engineering	18-25 years