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OrbEEt

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Public Summary

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1. EXECUTIVE SUMMARY

This report details the validation of the OrbEEt framework and the components incorporated therein, including energy efficiency, business performance, cost-efficacy, user acceptance, behavioural change, and persistence of effect. The deliverable builds upon the work presented in D4.4 "Report on Pilot Operation and Validation of OrbEEt Framework", submitted in M24. Reflecting the methodology presented by D4.4, it consists of several main sections: Methodology, Deployment and Validation, Comparative Analysis, and Cost Benefit Analysis.

The methodology section extends the work presented in D1.6 "User Engagement and Behavioural Change", to outline specific elements of the validation through the mixed-methods approach. Attention is given to multiple validation components, as through mixed-methods various sources of data are considered, ranging from energy KPIs through business indictors and usage statistics, to user feedback. Furthermore, the overarching stages of validation, as presented in D4.2 "OrbEEt Validation Framework", are applied as means to separate the mixed-methods and their application throughout the validation period to establish a clear timeline of activities.

The Deployment and Validation section presents the bulk of the analysis, data presentation and validation activities. As described, to give an appropriate timeline of events, this section is broken down into the stages of validation. This consists of three core periods; Calibration and Baselining, First Trial, Optimization and Second Trial Phases, and Persistence of Change.

- The Calibration and Baselining subsection covers the first stage of validation, with a focus on the hardware and software infrastructures put in place at each pilot site, as well as pre-intervention activities such as questionnaires and baselining efforts.
- The First Trial & Optimization and Second Trial Phases subsection covers the main two trials conducted as part of the intervention for each individual pilot site. This fully incorporates the mixed methods approach, with analyses presented for energy data, system usage data and behavioural change indictors.
- The Persistence of Change subsection covers the final stage of validation, projecting the data and self-reports to highlight the viability that positive behavioural change can be maintained past the intervention. In addition, specific attitudes and behavioural indictors are identified towards OrbEEt's gamified features to advise applicability within similar future interventions.

The Comparative Analysis and Cost Benefit Analysis sections provide a comparison between the different pilot sites to highlight the most impacting factors that are of importance to the project. In particular, the cost of OrbEEt is evaluated against the potential energy that can be saved through improving occupant behaviour. By comparing the diverse pilot sites and their business process, elements relevant to similar public buildings with potentially diverse needs and environmental factors are identified, to support exploitation and OrbEEt's future beyond the project duration.

2. SUMMARY AND CONCLUSIONS

D4.6 is the final version of the OrbEEt framework validation deliverable, having built upon the foundation set by D4.4 to evaluate the OrbEEt ecosystem with its behavioural feedback and gamified elements. Focus is given to behavioural change, and more specifically the facets of design that best supported positive transitions through the OBCF leading to improved energy efficiency within the workplace. Insights analysis, end users feedback and impact assessment are among the aspects that consist of the OrbEEt evaluation analysis.

Measures for future exploitation of OrbEEt components as commercial products are considered that address real market and user needs. Compliance of results to the user requirements of WP1 is undertaken in this deliverable, with reports on impact assessment further contributing to the evaluation of OrbEEt framework.

In summary, we provide below a brief comparative analysis of the different pilot sites through the analysis of system data vs result of user surveys (Behavioural characteristics vs savings, self-efficacy, awareness and engagement vs savings). The final results per load type and pilot site are presented in the following table (reporting results in the last project period –following persistence of effects period- are slightly different from the 2nd optimization period).

	Energy Savings			
Load Type	**Asparrena**	**Erlangen**	**BHOE**	**Pernik**
Heating	19.50%	16.98%	21.44%	19.23%
Lighting	30.37%	20.42%	17.41%	15.76%
Other	7.14%	7.86%	7.12%	8.06%
Total	**21.28%**	**17.00%**	**18.97%**	**16.88%**

Table 1 Energy Savings

Complementary to the results from impact assessment analysis, end users feedback also provides insights towards better understanding the impact of OrbEEt framework at the different pilot sites. The main outcomes of this analysis are presented:

- The overall OrbEEt framework and each specific application may lead to significant energy savings
- **Analysis per load type** is very important in order to contextualize and further estimate the impact of the framework to the different load types:
    - HVAC is the load type with a high potential for savings
    - Lighting is also an important load to be examined. Especially within OrbEEt, by combining information about contextual conditions and (near) real time notifications we managed to achieve significant savings
    - Reducing vampire loads consumption is always an objective, nevertheless the total impact is rather low.
- **Pilot context** is the main parameter affecting the evaluation of the framework. We have to carefully evaluate the pilot specificities prior to any deployment of the OrbEEt framework in premises.
    - In Asparrena pilot site, the potential was higher for lights consumption reduction due to the non-optimal operation of lighting in premises
    - In Erlangen pilot site, the potential of savings is less (compared to the rest of the pilot sites), mainly due to the user profile characteristics and the type of activities performed in premises

- In BHOE pilot, the potential for heat consumption reduction is high considering the available infrastructures (TCR available in premises) and the interest of end users to adjust the consumption in their personal thermal preferences
- In Pernik pilot site the potential is higher for heat consumption, nevertheless a better adjusted demonstration of OrbEEt in premises may lead to significant savings in other load types

- Pilot **user profile characteristics** are the leading factor that affects the final impact of OrbEEt framework - personalization is at the heart of the overall framework

  - In Asparrena, active engagement of end users in applications (in office display, intranet portal and game app) leading to significant savings; (near) real time notifications as the preferred means of users interaction with the platform- availability of in office displays in all zones.
  - In Asparrena, lights consumption reduction was high; impact of (near) real time notifications and provision of personalised savings
  - In Asparrena, end users willing to reduce also heat consumption; main boundary was the lack of individual thermostats (individual control) per building zone
  - In Asparrena, the (small) size of the pilot is affecting the level of engagement of end users in the project

  - In Erlangen, (heat consumption) savings was higher in single occupant offices (e.g. Researcher's office I, Manager's office) compared to multi - occupancy zones
  - In Erlangen, end users prefer to adjust their lights consumption (in contrary to heat consumption): the location of pilot site and business activities performed affects the final impact of the OrbEEt framework
  - In Erlangen, the level of engagement of end users in project activities is affecting the final results (Researcher's office I, Manager's office);
  - (Near) real time notifications as the preferred way for users engagement- end users familiar with the technology and the provision of personalized apps.
  - The deployment of the applications affect the final results; large screen display in meeting room affecting the impact of OrbEEt in this specific zone.

  - In BHOE, significant savings at heat consumption of 1st floor; end users engagement level and the site location affecting the impact of OrbEEt framework
  - The level of controllability (depicted also in the triggering/notification messages) is a main factor affecting the final impact; (technology enabled energy savings) the impact on heat consumption was higher than lighting or office/plug devices;
  - (Technology enabled energy savings) - availability of bi-switches is a main a factor to achieve significant light consumption savings
  - The level of knowledge/interest for the domain affects the final results; technicians vs. administrative personnel and the level of engagement and commitment in project activities
  - End users level of commitment is rather low; end users prefer to receive summary notifications about their performance.

  - In Pernik, the impact of OrbEEt framework is affected by the type of business processes performed: higher consumption reduction in Accounting Office (early engaged in the project, higher interest for the project, non-externals).
  - In Pernik, building intrinsic characteristics affect the final impact → centralized heating, low energy circuits, lack of bi-switches affecting the potential of the

framework; pilot audit analysis is very important for the best fitted demonstration of OrbEEt framework
- In Pernik, the gender synthesis of end users linked with the potential of savings (e.g. heat consumption reduction potential is rather low – gender related parameter)
- In Pernik, the level of commitment is directly linked with the final results; (near) real time notifications was not the best way to interact with end users.
- In Pernik, non-familiar with ICT and energy applications; prefer to receive summary notifications about their performance

As a general comment, we highlight the impact of external weather conditions in total energy savings. The next table presents the aggregated (monthly) number of degree days at the different pilot sites (baseline vs. deployment).

Pilot	Asparrena		Erlangen		BHOE		Pernik	
Month	Baseline	Demonstration	Baseline	Demonstration	Baseline	Demonstration	Baseline	Demonstration
September	38	70	42	105	46	116	39	38
October	125	117	222	149	198	184	142	151
November	244	260	350	316	322	368	298	277
December	315	326	447	409	514	502	501	404
January	401	303	590	348	630	439	690	459
February	234	334	330	482	335	489	370	371
Total	**1357**	**1410**	**1981**	**1809**	**2045**	**2098**	**2040**	**1700**

Table 2 Heating Degree Days

Some remarks:

- No significant deviations (< 5 %) to be reported between baseline and demonstration period; Pernik site has the major deviations depicted also in the heat consumption results
- January/February are the months with significant deviations, impact depicted also in the total amount of heat consumption reported per month

Along with thermal aspect analysis, visual aspects are also examined to evaluate the potential of savings at the different pilot sites. Overall, the potential for lights savings is high in Asparrena pilot site where the amount of sunlight is significant. This is not the case in Erlangen and BHOE pilot sites where the amount of natural light is rather low.

We presented above the summary results and the main remarks for OrbEEt framework addressing issues related to pilot site comparability and externalities (conclusions on technology enabled energy savings, pilot context, pilot user profile characteristics and engagement). It is clear that a thorough analysis of the contextual environment (building characteristics, weather conditions, etc...) is a main prerequisite for the demonstration of OrbEEt framework but also this contextualization and personalization is the main factor leading to significant energy savings as reported in this document.

3. ACRONYMS AND TERMS

eDECs..... enhanced Display Energy Certificates

FM ..... Facility Manager

KPI ..... Key Performance Indicator

OBCF ..... Organizational Behavioural Change Framework

SEOR..... Systemic Enterprise Operational Rating

WP..... Work Package

ICT ..... Information Communication Technologies

OrbEEt ..... Organizational Behaviour improvement for Energy Efficient administrative public offices

IOD..... In office Displays

CBA..... Cost Benefit Analysis

STD ..... Standard Deviation

DoA ..... Description of Actions

UI..... User Interface

NPV..... Net Present Value

IRR ..... Internal Rate of Return

O&M ..... Operational and maintenance

BaU..... Business as Usual

ToU..... Time of Use

IoT ..... Internet of Things

4. REFERENCES

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[2]. D1.6 User Engagement and Behavioural Change
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[6]. D4.4 Pilot Operation and Validation of OrbEEt Framework
[7]. EC Commission, 2014, Guide to Cost-Benefit Analysis of Investment Projects