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Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology

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D7.2 DEVELOPMENT OF INTELLIGENT MODELS FOR REAL-TIME PERFORMANCE ASSESSMENT OF NZE SETTLEMENTS

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Executive Summary

Under the framework of the task "*Intelligent models for performance assessment and reliability-centered maintenance*" intelligent data processing models have been developed. The models are intended to be incorporated in the Web-GIS platform for performance assessment and increased reliability of the ZERO-PLUS case studies' implementation.

The development of the intelligent models constitutes the Deliverable 7.2 "*Development of intelligent models for real-time performance assessment of NZE settlements*". The purpose of the present document is to provide an overview of the various types of intelligent models that have been developed for each level of the Web-GIS platform along with their selected method of development.

The detailed description of the work performed for the development as well as for the implementation of the models is provided in the report D7.3 "*Development of a framework for reliability-centred maintenance of NZE settlements*".

This is the first version of the report. A second updated version will be released in June 2019.

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1. Introduction

The monitoring and evaluation of the settlements' performance is an essential part of the ZERO-PLUS project. To this end a monitoring and performance analysis platform has been created. The Web-GIS platform has been designed in four levels for each case study, as follows:

Level 1: Indoor Environmental Quality of Buildings' Users.

Level 2: Energy demand profiles for buildings and district (public lighting).

Level 3: Energy production technologies' monitoring level.

Level 4: The Case Studies Integrated Resources Management Level and Dashboard.

A detailed description of the Web-GIS platform and the levels is provided in the report "*Design of a Monitoring Framework for Performance Assessment during Operation*".

For each of the aforementioned levels a series of intelligent data processing models have been developed under the framework of the task "*Intelligent models for performance assessment and reliability-centered maintenance*". The models are intended to be incorporated in the Web-GIS platform for performance assessment and increased reliability of the ZERO-PLUS case studies' implementation.

The present document provides an overview of the various types of intelligent models along with the method of development of each model. A detailed description of the work performed for the development as well as the implementation of the models is provided in the first release of the report "*Development of a framework for reliability-centred maintenance of NZE settlements*".

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2. Intelligent Models

For each level of the platform the following models have been developed:

- Models for Level 1: Real-time synchronization of all indoor environmental quality indices; Extraction of PMV and PPD; Setting the indoor comfort set-points and requirements; Fault detection of the various sensors.
- Models for Levels 2 and 3: Statistical and probabilistic analysis of energy demand and energy production profiles; Prediction of energy demand and production 24 hours ahead; Linking of the energy demand and production profiles with specific subsystems (such as advanced ventilation systems, WindRail, etc.) to support effective predictive maintenance of the ZERO-PLUS technologies; Fault detection of the various subsystems to be maintained.
- Models for Level 4: Development of integrated resources' supervisor models which manage the most complex functionalities, such as user interface, database and the control logic that can be applied to the entire system (e.g. the whole building or a section of settlements). The reliability of these models is tested in proper simulation environments.

In the following sections the models and the respective method of development are presented.

2.1 Intelligent models for level 1: Indoor Environmental Quality

The models that have been developed in relation to the first level of the platform are intended to support monitoring and evaluation of the IEQ (Table 1). In order to correctly calculate the IEQ indices the correct time stamp of the related measurements is of crucial importance. This is achieved through real time synchronization of all IEQ indices. Thermal comfort evaluation will be achieved through extraction of PMV and PPD values. Furthermore, acceptable indoor comfort set points and requirements have also been defined to further support thermal comfort evaluation. Finally, fault detection of sensors has been designed so as to support effective monitoring.

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Table 1: Level 1 intelligent models and method of model development

MODELS	METHOD
Real-time synchronisation of all indoor environmental quality indices	This has been done as part of the database design
Extraction of PMV and PPD	PMV and PPD calculation. Parameters for calculation: 1.Metabolic rate Fixed value (throughout the year) 2.Clothing insulation: Fixed value (different for each season) 3.Mean Radiant Temperature: Determined through spot measurements 4.Ambient air temperature: Monitored 5.Relative humidity: Monitored 6.Relative air velocity: Determined through spot measurements
Setting the indoor comfort set-points and requirements	Algorithms for the evaluation of the thermal comfort for the different groups will be determined after needs and requirements of the different user groups (tenants, case study owners, technology providers etc.) are collected 1. Dynamic models: -Setting of acceptable temperature ranges for living rooms according to [1] -Category II (new buildings and renovations) PMV-PPD limits suggested by [2] 2. Conventional approach: - Category II temperature, PMV-PPD limits suggested by [2]

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Fault detection of the various sensors	Definition of acceptable range of measurements

2.2 Intelligent models for levels 2 and 3: Energy demand and production

The intelligent models that have been developed in relation to levels 2 and 3 of the Web-GIS platform (Table 2) are intended to support the statistical and probabilistic analysis of energy demand and energy production profiles as well as the predictive maintenance of the ZERO-PLUS technologies. Prediction of energy demand and production 24 hours ahead has also been designed. Finally, fault detection of the various subsystems is intended to support maintenance of the various subsystems.

Table 2: Level 2 and 3 intelligent models and method of model development

MODELS	METHOD
Statistical and probabilistic analysis of energy demand and energy production profiles	Statistical analysis: Descriptive statistics. Probabilistic analysis: Cumulative frequency and its distribution should be used in order to further analyze the data in respect to the frequency of occurrence of measurements less than a reference value.
Prediction of energy demand and production 24 hours ahead	Mathematical models of the various energy production technologies, based on the technical specifications of each technology, will link the production of the technologies with environmental variables (temperature, solar radiation, wind speed) Artificial Neural Networks (ANN) will be used for the prediction
Linking of the energy demand and production profiles with specific subsystems to support maintenance	Error calculation for predicted and actual energy from the various RES. If error is over the specified threshold, a

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	notification to be sent.
Fault detection of the subsystems	Definition of acceptable range of measurements

2.3 Integrated resources supervisor models for level 4

The level 4 is the Web-GIS platform. The platform includes an interactive Dashboard that allows overall monitoring of each case study. All the previous developed models are integrated into the platform. The intelligent models for this level are intended to manage interaction of users with the platform and interaction among various components of the platform (Table 3).

Table 3: Level 4 intelligent models and method of development

MODELS	METHOD
Integrated resources' supervisor models which will manage the most complex functionalities, such as user interface, database and the control logics that can be applied to the entire system.	Level 4 models will be developed along with the development of Level 1, 2 and 3 models and setting of thresholds.

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3. Conclusions

A series of intelligent models have been designed for each level of the Web-GIS platform. The development of the intelligent models is the subject of this report. The document provides an overview of the various types of intelligent models that have been developed for each level of the Web-GIS platform as well as the selected method of development of each model.

The specifics of the development and implementation of the intelligent models are included in the report D7.3 "*Development of a framework for reliability-centred maintenance of NZE settlements*".

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4. References

[1] L. Peeters, R. de Dear, J. Hensen, W. D'haeseleer, Appl. Energy 86 (2009) 772–780.

[2] CEN, EN 15251: Indoor Environmental Input Parameters for Design and Indoor Air Quality , Thermal Environment , Lighting and Acoustics, Bruxelles, 2007.

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