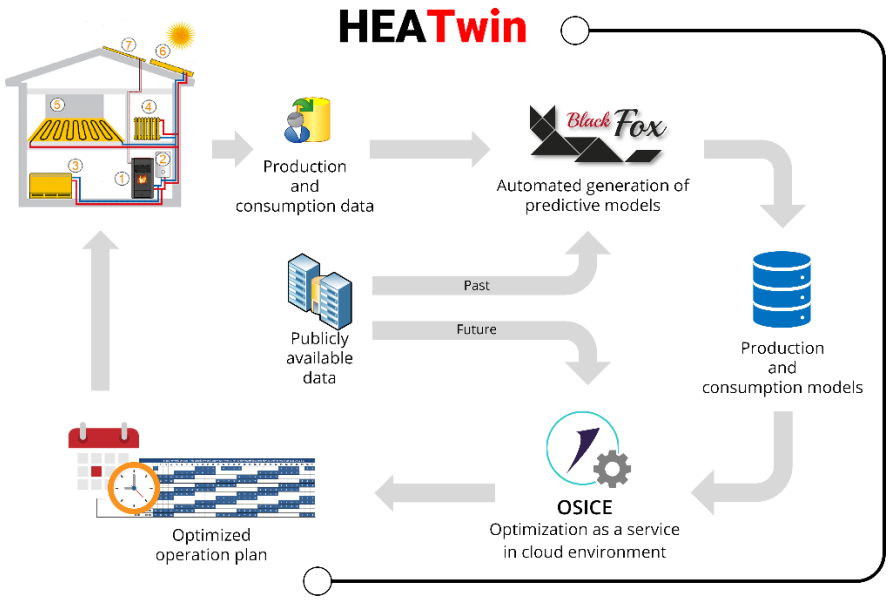
Technical Specification Double-side Page

1. TECHNICAL SCOPE:

Buildings are responsible for around 40% of energy consumption and 36% of CO_2 emissions in the EU, making them the single largest energy consumer in Europe. Heating systems are highly heterogeneous including both central heating and distributed facilities, and at the same time clients have varying abilities to control ambient conditions at their buildings. To save power, increase reliability, get ready for changing conditions, cut costs and provide better customer service, energy providers need to improve their predictive analysis methods.

In order to enable energy providers to predict heating demand accurately and to optimize heat production and distribution, we will develop HEATwin, an automated platform for energy production and consumption management.



Based on the data acquired during the building exploitation, a new solution, HEATwin will automatically create the most adequate predictive models of the internal energy production and consumption, which will enable simulation of the data chain for any hypothetic operation plan. The results obtained from the simulations, along with all other micro-grid features and external factors, will be subjected to an optimization process in order to find the energy management pattern that will result with the most economical usage of energy under the given conditions. This solution will be offered to end users in the form of SaaS, thus enabling them to optimize energy savings without investment in scarcely available data science and optimization experts, or in the necessary computing infrastructure.

2. ALGORITHMS, TOOLS AND CONCLUSIONS:

As a prerequisite for the optimization of the operation plans, HEATwin automatically creates machine learning models of external and internal energy production and consumption, based on data acquired during the building exploitation. These models can be further improved by using publicly available data on weather, working and non-working days, price of electricity and natural gas in case of modular heating systems with boilers and thermal pumps, solar radiation in case of thermal solar cells, etc. To secure that the generated predictive models are always genuine digital twins of the installed equipment and the residents' habits, the models are recreated periodically, thus evolving together with the building and the environment.

To create and maintain these models, HEATwin will use Blackfox, our Cloud service for automated generation of optimized machine learning models, based on Deep Neural Networks, Random Forest or XGBoost. Blackfox performs genetic algorithm (GA) optimization of all elements of the machine learning model with the aim of generating a model that best describes input data. In the case of DNN models, elements subjected to optimization are the number of hidden layers, number of neurons per layer, activation functions, learning algorithms and learning rules. Throughout an evolutionary process, the system automatically performs adjustment of DNN architecture according to a present dataset. The optimization methodology is based on the iterative strategy of evolutionary algorithms, where individuals represent neural networks with different architectures. The obtained predictive models are used for simulation of the

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energy data chain and evaluation of number of hypothetic operation plans under given conditions. The optimal operation plan will be obtained on a daily basis through simulation-based optimizations performed on our portable cloud service OSICE - Optimization as a Service in the Cloud Environment. OSICE performs complex evolutionary algorithm-based optimization efficiently thanks to its microservice design and inherent scalability.

3. SCALABILITY AND FLEXIBILITY OF THE SOLUTION:

Scalability and flexibility of the HEATwin solution is inherently ensured by the implementation of Blackfox platform.

Usage of predictive models in energy management is well-known, but with the rising complexity and heterogeneity of energy systems, application of traditional modeling methods is no longer feasible. Ever-growing availability of IoT devices and increasing datasets creates environment for development of very detailed operational digital twins that rely on a multitude of machine learning models of the energy system elements, which is impossible to do manually. The goal of Blackfox is to automate and dramatically simplify the process of building and maintenance of deployment-ready predictive models.

Blackfox consists of two core modules: the module for automated machine learning (AutoML) and the module for machine learning operations (MLOps). The model creation is just the beginning of the implementation process. ML models must be constantly monitored and adapted to changes that occur in the real-world environment, e.g., data drift, detection and adjustment of changes in the properties of independent variables, or concept drift, detection and adjustment of changes in the statistical properties of the target variable that models are predicting. Blackfox's MLOps module enables automated management and deployment of a number of predictive models on industrial scale for usage in real-world settings. Generated predictive models are constantly observed for the occurrence of data drift or concept drift, and when their accuracy falls below a given level, the procedure of model retraining or regeneration is automatically started.

Scalability and flexibility of Blackfox platform in automated creation and simultaneous handling of thousands of predictive models has been already proven within EDI and HUBCAP H2020 projects.

4. DATA GOVERNANCE AND LEGAL COMPLIANCE:

Our solution does not collect or process personal data, so the GDPR does not apply. In the variant in which the solution is implemented on the client's infrastructure, security will be guaranteed by the security policies and protocols implemented by the client. In case the solution is located on the public Cloud, the security of the data storage is guaranteed by the Cloud service provider, and communication between the client's and the Cloud software solution will be protected by the regular SSL/TLS. Within the Cloud provider itself, VPC (Virtual Private Cloud) will be employed with strict firewall rules. Sensitive users' data will be stored using strictly encrypted block storage and object storage, compliant to contemporary data encryption standards.

5. QUALITY ASSURANCE AND RISK MANAGEMENT:

The internal quality of predictive models is imposed by standardization procedures implemented in Blackfox. Every ML model is unique and needs to be managed according to its own model life cycle (MLC). But effective governance of models in an enterprise requires a consistent approach to defining, implementing, monitoring, and reporting on MLC. Blackfox imposes standardization, and enables the unique development, deployment, operationalization and governance aspects for each model and its MLC to be fully captured and automated in a consistent, efficient, and transparent manner.

The most important foreseeable risk is inadequate or insufficient data supplied by the data provider, which will not allow the development of high-quality predictive models. Mitigation measures, in this case, will be enhanced communication with data provider personnel and implementation of publicly available data sets. Other risks, such as difficulties in installing HEATwin solution on the client's infrastructure if such a request is made, and inadequate algorithms used by Blackfox to solve optimization problems are categorized as low. We have already successfully conducted the installation of the Blackfox and OSICE modules on Vodafone Ireland and Electric Power Industry of Serbia infrastructures. On the other hand, Blackfox relies on the industry proven ML methods and algorithms, which minimizes the risk of low prediction performance. It also makes use of industry standard ML model formats (such as ONNX) and industry standard ML model registry and lifecycle management (MLFlow), proving it interoperable with other software solutions.

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