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Title: **The Building Energy Efficiency Marketplace**

Author: **Athanasios Volikas**

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Supervisor: **Associate Professor Athanasios Dagoumas**

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DECLARATION OF AUTHORSHIP

I, Mr. Athanasios Volikas – MEN19013

confirm that the report entitled

“The Building Energy Efficiency Marketplace”

is part of my assessment for module **MSc in Energy: Strategy, Law and Economics**

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Athanasios Volikas

Piraeus, January 13, 2025

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This is for my son, for finally letting me finish it.

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ABSTRACT

This thesis presents the conceptual design of a platform, the Building Energy Efficiency Marketplace, developed with a holistic approach to intersect the needs of diverse user groups and stakeholders within the energy efficiency market. The Marketplace, which has been developed by the Regulatory Authority for Energy, Waste and Water of Greece, aims to provide a facilitating interface for all interested parties within the wider energy efficiency market including Consumers (such as households and commercial/ office building owners) and Providers (such as Energy Service Companies, contractors/ suppliers of energy efficient solutions and financiers) with the main objective to overcome market shortcomings through simplifying, aggregating and effectively accelerating the implementation of energy saving projects. Simplification of key technical principles has been at the epicenter of the Platform's design to improve consumer awareness which is further enhanced with the provision of tailored prefeasibility assessments (via an intuitive interface, the Consumer module) for specific types of energy saving solutions that have been transformed into standardized service products. The Marketplace also produces valuable insights for policymakers, industry stakeholders, and the wider community, helping sector actors to identify and locate actual needs for technical solutions as well as to quantify investment requirements and prioritize actions to inform national planning and strategies for enhancing energy efficiency policies and measures. The Building Energy Efficiency Marketplace ultimately aims to contribute to the creation of a more cohesive and proactive energy efficiency market.

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ACRONYMS AND ABBREVIATIONS

A/C	Air-Conditioning
ACL	Annual Cooling Load
AHL	Annual Heating Load
AHU	Air Handling Unit
BAS	Building Automation System
BDF	Building Density Factor
BESS	Battery Energy Storage System
BMS	Building Management System
BT	Base Temperature (BT_H: Heating BT; BT_C: Cooling BT)
BTU	British Thermal Units
CEC	Electricity consumption for cooling
CF	Contact Factors
DD	Degree Days (CDD: Cooling DD; HDD: Heating DD)
DHW	Domestic Hot Water
DOF	Daily Operation factor
EC	European Commission
EE	Energy Efficiency
EF	Elevation Factor
EPS	Expanded polystyrene
EPBD	Energy Performance of Buildings Directive
ESCO	Energy Service Company
EU	European Union
GHG	Greenhouse Gas
GUI	Graphical User Interface
HEC	Electricity consumption for heating
HP	Heat Pump
HVAC	Heating, Ventilation, and Air Conditioning
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technologies
NUTS	Nomenclature of Territorial Units for Statistics
OF	Operating Factor
PV	Photovoltaic Plant
PVC	Polyvinyl Chloride
PF	Performance Factor
SPT	Set Point Temperature (SPT_H : SPT for Heating SPT_C : SPT for Cooling)
TBA	Total Building Area
MS	Member State(s)
NECP	Member State(s) National Energy and Climate Plans
RES	Renewable Energy Systems
kW	Kilowatt (kWh: Kilowatt-hour)

VAT	Value Added Tax
WOF	Weekly Operation factor
XPS	Extruded polystyrene

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I. INTRODUCTION

1.1. Background

Conflicting geopolitical interests and constantly growing energy demand challenge the availability and affordability of energy and introduce significant risks and uncertainties in the global economy. Many governments and markets around the world acknowledge that climate change is factual and admit that economic activities need to abandon conventional emission intensive technologies as a decarbonized future is the only viable solution for human prosperity in the long run. The strategy of such a transition needs to focus on resource efficiency and promote innovative concepts and practices that mitigate climate change and address economic and environmental sustainability. In this regard, Energy Efficiency ("EE") plays a pivotal role by reducing greenhouse gas emissions, lowering energy costs, enhancing security and reliability of energy systems and should constitute a fundamental component of the contemporary efforts for a cost-effective transition to a global decarbonized economy.

Historically, the concept of energy efficiency gained prominence during the oil crises of the 1970s, when nations faced significant energy supply constraints and fuel prices soared. This period marked the beginning of a concerted effort to develop technologies and practices that could reduce energy consumption across various sectors, including industry, transportation, and residential uses and led to a technological bull run in the energy efficiency sector across the wider spectrum of economic activities. Since then, advancements in technology, energy and climate policies regulation, and public awareness have significantly improved energy efficiency standards and practices. In more recent years, the focus on energy efficiency has been more intense due to the growing concerns about climate change. The Intergovernmental Panel on Climate Change (IPCC) is consistently highlighting the importance of energy efficiency as a cost-effective strategy to reduce carbon emissions and achieve international climate goals. In 2015, the European Commission (EC) adopted energy efficiency as a pillar of the Energy Union (EU) and the "Energy Efficiency First" principle underpinning it, is guiding energy policy and investment decisions to prioritize energy efficiency and lower production costs. Governments around the world are implementing policies and incentives to promote energy efficiency, such as energy labeling, performance standards, and subsidies for building renovation. Furthermore, incorporation of digitalization concepts and practices within the energy sector especially designed to promote best practices, outreach, replicability and scalability are important to accelerate the transition. Moreover, the synergies between rapidly developing renewable energy systems with storage and energy efficiency technologies are creating new opportunities for integrating energy saving measures into the broader energy spectrum. Such applications are

crucial for creating a sustainable energy future, through maximizing the application of clean energy solutions while optimizing utilization of resources and minimizing waste.

It is widely recognized that the greatest potential for energy saving lies in the building sector being the largest energy consumer in Europe (and in most cases in the rest of the world), both in terms of residential and non-residential buildings. Energy-renovation rates have been estimated to 1% annually, while deep renovation rates at 0.2%[1]. These rates reveal the insufficiency of current policies / practices and indicate the pressing need for more properly designed approaches to overcome persisting barriers and especially those finance related such as split incentives, high upfront costs and long paybacks (see also initial/preset values in ANNEX I, barriers to the EE1st[2]).

According to the revised Energy Performance of Buildings Directive (EPBD)[3], Member States need to adopt appropriate strategies to reduce the average primary energy use of the residential building stock at least by 16% by 2030 and 20-22%% by 2035. These ambitious targets seem highly challenging and imply the need for substantial investments in energy-efficient applications, to overcome market barriers and behavioral inertia, and enable equitable access to energy-efficient technologies for all socio-economic groups through a just transition.

In Greece, the building sector is particularly energy-intensive and has a significant energy and environmental footprint. This is mainly attributed to the age of the largest share of the building stock and the obsolete and inefficient technologies (electromechanical equipment) still used. Common factors are indicatively summarized below:

- Lack of (or partial) thermal insulation: The majority of the building stock has significant cooling needs (electricity) as not adequately insulated, while not allowing for optimal living conditions throughout the whole year (during the heating season as well),

[1] Buildings Performance Institute Europe - Report on the evolution of the European regulatory framework for buildings efficiency (2022). Available: https://www.bpie.eu/publication/a-guidebook-to-european-buildings-efficiency-key-regulatory-and-policy-developments/. Accessed: 117/11/2024

[2] Commission Recommendation (EU) 2021/1749 of 28 September 2021 on Energy Efficiency First: from principles to practice — Guidelines and examples for its implementation in decision-making in the energy sector and beyond

[3] Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)

- Electromechanical (E/M) installations are in many cases obsolete and inefficient. This is usually the case especially for conventional heating systems where inadequate maintenance and poor/ damaged insulation of networks is also frequently observed.
- Windows of outdated technology (frames without thermal break / single glazing / high infiltration rates),
- Incomplete information of building managers and/or tenants on issues relevant to rational energy use and proper management.

In Greece, energy use in the wider building sector averages 40% of total energy demand while the residential sector (households) accounts for up to 30%. These figures highlight the significant potential for improvement through investments in energy efficiency but also properly designed policies and measures addressing key challenges.

This thesis presents the design of a Marketplace platform developed with a holistic approach to intersect the needs of diverse user groups and stakeholders within the energy efficiency market of Greece. This tool aims to contribute to the creation of a more cohesive and proactive EE market, ultimately supporting the transition to a more sustainable energy future.

1.2. Rationale

Despite significant advancements in energy efficient technologies and the growing awareness of their importance, the energy efficiency market faces several critical challenges that hinder its full potential. One of the primary shortcomings is the lack of effective communication and coordination among the various stakeholders, including policymakers, investors, energy service companies, and end-users. Such market inefficiencies often result in missed opportunities for collaboration ultimately leading to under-investments in energy-saving technologies and half measures. Another issue is the limited accessibility and usability of information related to energy efficiency. Many existing resources and guidelines for energy efficiency are either too complex or not sufficiently intuitive and user-friendly, making it difficult for non-experts to navigate and utilize them effectively. This creates a significant barrier for stakeholders who may lack the technical expertise to engage with these resources, thereby limiting their ability to make informed decisions about energy efficiency investments. Furthermore, there is a notable gap in the integration of dynamic interactions between the different parties involved and absence of progress / results reporting mechanisms which hamper the ability to share best practices, track progress and respond promptly to emerging opportunities or challenges within the energy efficiency market.

The problem is compounded by the varying levels of awareness and engagement among stakeholders. While some entities are highly proactive in pursuing energy efficiency initiatives, others remain unaware of the potential benefits or are hesitant due to perceived risks and

uncertainties. This inconsistency in engagement levels leads to disjointed and disorganized approaches to energy efficiency, undermining the overall impact of collective efforts.

To address these challenges, there is a need for developing means and mechanisms to enhance awareness and facilitate better coordination among all parties involved within the energy efficiency market. This can be achieved through tools that aim to simplify access to relevant technical and financial information, provide friendly, intuitive and non-technical interfaces for any interested user, and integrate comprehensible methods to support informed decision-making. By promoting transparency, collaboration, and engagement, these tools can help unlock new potential in energy efficiency and drive more effective implementation of energy-saving investments.

This thesis presents the design of such web-based technical tool developed with a holistic approach to intersect the needs of diverse user groups and stakeholders within the energy efficiency market of Greece. This tool aims to contribute to the creation of a more cohesive and proactive EE market, ultimately supporting the transition to a more sustainable energy future.

1.3. Objectives

This study provides a detailed design of a web-based platform, the "Building Energy Efficiency Marketplace" hereinafter "the Platform", developed from the Regulatory Authority for Energy, Waste and Water "RAAEY" of Greece. The Platform is an online tool bringing together all interested parties within the wider energy efficiency market including Consumers (i.e. residential and commercial/ office building owners, individuals, companies) and Providers (i.e. Energy Service Companies "ESCOs", contractors/ suppliers of Energy Efficient "EE" equipment and/or services, financiers, etc.) with the main objective to overcome market shortcomings through simplifying, aggregating and effectively accelerating the implementation of energy saving investments. Such investments can be, for example, the installation of or replacement with new – energy-efficient technologies and applications (insulation of building envelope elements, heat pumps, smart systems and automation systems, mechanical ventilation systems, heat recovery, etc.) as well as residential and/or office buildings integrated photovoltaic plants "PV" with or without an electricity/ battery storage system "BESS" (and connected to the Distribution Network). The Platform also focuses on awareness-raising through a user-friendly and intuitive environment, supports interactive communication and collaboration among stakeholders and provides valuable insights for policymakers, industry stakeholders, and the academic community, helping sector actors to identify and locate actual needs as well as to inform strategies for enhancing energy efficiency policies and measures.

II. PLATFROM STRUCTURE AND DESIGN

2.1. Operational Concept

The operational structure of the Platform is based on the concept of "matchmaking" between Demand and Supply sides of the energy efficiency market, integrating and providing for both sides the necessary information of techno-economic nature. The following graph represents in a simplified manner the actions and mechanisms required for the creation of Requests and Offers as necessary steps to enable match-making conditions. The whole process is described in detail in Chapter III.

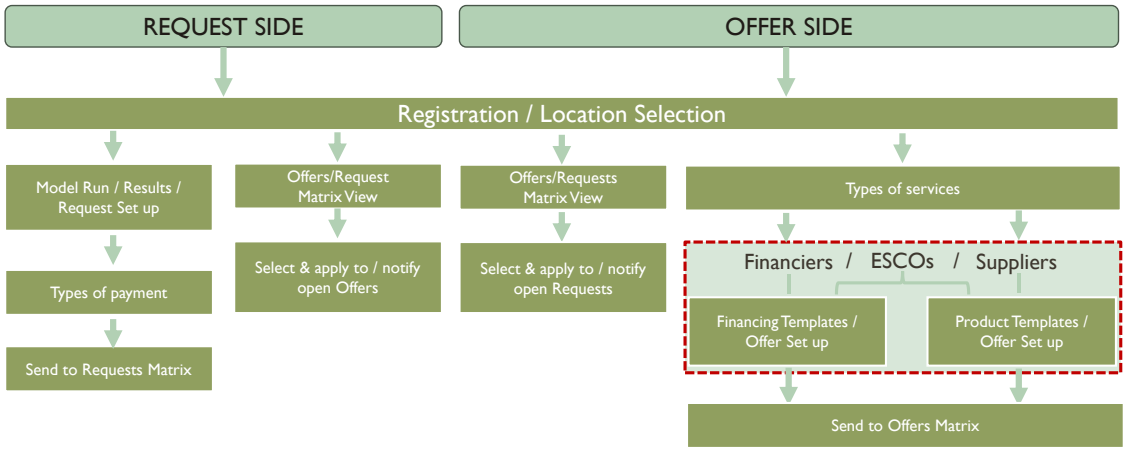

Figure 1. Conceptual design of the Platform

The application aggregates requests into uniform groups to create standardized portfolios in order to match them with open offers. Such requests consist of specific "Services" that are supported by the Platform which concern common/ conventional interventions (from a technical perspective), while also include financing options (either as grant or loan) as a separate Service.

2.2. Design of the Request Side

2.2.1. Description of basic functions

Each Consumer, (User representing the Request side), following registration, is invited to fill in the necessary information provided through the "Consumer Module" of the Platform. This process enables the creation of an open "Request" for the desired services of the Consumer. The Consumer is also possible to create multiple Requests for different properties and services. In the last step and before final submission, the Platform provides a financial evaluation of all recommended services (based on reference/ specific prices and indicative capital expenditures

fed in the Module), giving the opportunity to the Consumer to select the best performing as well as the option of finance as a service to cover partially or in full the selected EE investments.

All published Requests become available in the "Requests Matrix" of the Marketplace and are grouped by location. In this way, the Platform develops homogeneous portfolios formulating ready-made investment packages to better indicate consumer needs while enabling the creation of properly designed offers (providing also the option to be combined with different financing options) from the “Providers” side. To enable Energy Efficiency financing and accelerate implementation by exploiting economies of scale, the Request packages are also evaluated in terms of their financial performance by the Consumer Module. In this way ESCOs (Energy Service Companies) as well as other potential Providers (such as financiers and equipment suppliers) can tailor their Offered services and adapt provided financial support options (such as through selecting the best performing projects to be combined with loans and the worst performing to be combined with grants). This is achieved through the “Provider Module” of the Platform which is a tool that will be described in the following Chapter under the “Providers” section.

2.2.2. Consumer types

The types of users supported on the Request side are representatives of the building sector (residential or tertiary). In the case of the residential sector, the Platform supports all types and sizes of houses, from a single apartment to a multi apartment building, while in the case of the tertiary sector respectively, the facilities supported include typologies ranging from a single office space within a building, or an entire building complex. Thus, appropriate sizing, classification and evaluation of the requested equipment and/or related construction works is necessary. For example, in the case of a residential facility the Consumer needs to insert the number of residents hence consequently their number will differ if the facility is a single apartment compared to a multiapartment building while in the case of an office building the corresponding parameter affecting occupational routines is the (weekly and daily) operation profile.

For this purpose, the Platform provides the “Consumer Module”, a user-friendly interface – tool providing these options, to enable the creation of tailored "Requests" for each different Consumer profile and select the desired energy saving interventions/ investments from a range of different options of varying technical complexity and economic requirements, while also estimating their performance in terms of energy and cost savings.

2.2.3. The Consumer Module

2.2.3.1. Data entry and selection of desired Services

The necessary information is collected through the Consumer Module through a series of direct and simple questions regarding the basic characteristics and current condition and operational routines of the building. To simplify this process and maintain a user-friendly design, the Graphical User Interface (GUI) of the application is developed in a wizard environment. The process involves the Consumer entering data about the current state of the building, such as (but not limited to):

- Type of building (residential/tertiary sector building)
- Number of residents / Usage profile
- Building location/altitude
- Building density
- Number of floors
- Total heated area
- Building elements areas (walls, windows, roof, basement)
- Type of openings (thermal brake/ glazing)
- Type of thermal insulation
- Element in contact on each façade of the building
- Heating & cooling system(s) operating conditions (setpoint temperatures)
- Type of heating/cooling equipment
- Annual building consumption (for two consecutive years) - Optional
- Unit cost of energy source(s)

Following input of the above parameters, the Consumer is asked to choose from a set of possible applicable interventions, in elements of the building envelope and electromechanical equipment, entering the investment cost for each desired intervention (optionally and/ or if already known from possible offers received) which is otherwise calculated through assumptions and taking into account the input data from the user's side from the Module. The desired services supported by the application and included in the options for submitting a request are presented as follows:

P1. Thermal insulation of walls/ roof/ basement
P2. Replacement of single- or double-glazed frames with new PVC, or aluminum with thermal break and double or triple glazing
P3. Heat pump (options: i) Heating only; ii) Heating and Domestic Hot Water; iii) Heating, Cooling & Domestic Hot Water)
P4. Mechanical Ventilation with Heat Recovery
P5. Solar Water Heater
P6. Smart Building Automation Systems

P7. Rooftop Photovoltaic system
P8. Electricity storage system (Battery and/or Electric vehicle)
P9. Insulation of heating and cooling networks
P10. Project Financing (through grant or loan)

2.2.3.2. Calculation of Cost, Energy and Investment Savings

Through applying basic rules of thermodynamics, the tool quantifies savings, in terms of energy and cost, achieved by each intervention separately and aggregated, by combining all inputs submitted by the user.

For P1 and P2 interventions: through the input data specified in the previous steps and taking into account the heating/cooling degree days of the selected location (at the NUTS 3 level of regions in Greece, see ANNEX II), the tool estimates the Thermal Transmittance Coefficient to determine thermal losses for each individual building element, as well as the total thermal load of the building (before and after the implementation of the interventions in the building envelope). In addition, the thermal energy demand and the total annual energy – electricity and/or thermal – consumption as well as associated energy costs are estimated depending on the envisaged energy savings scenario (future situation).

For the installation of a heat pump system (P3) and mechanical ventilation with heat recovery (P4), the savings calculations take into account bibliographically accepted values of efficiency factors while giving the user the opportunity to further modify them (through the "advanced user" option).

For the installation of Solar Water Heater (P5) as well as Smart Building Automation Systems (P6) the energy savings are calculated considering the type/ use of the building/ facility and assuming specific parameters on the basis of common energy savings factors based on the literature.

The production of electricity from the installation of rooftop photovoltaics (P7) is estimated according to the location's total annual solar radiation index (W/m^2) and taking into account the available roof area, corresponding to the input data submitted by the Consumer, while in the case of installation of an electricity storage system (Battery and/ or via Electric vehicle) (P8) the calculations relate to cost savings (not energy) and are calculated in the case of a dynamic tariff (inactive function at the initial edition of the Platform since such scheme is not available yet in Greece). The last service related to technical works is the insulation of HVAC networks (P9) and indicative savings from this measure are being estimated based on factors based on the literature (considering that an actual inspection at the facility would be required to estimate in more accuracy the damages/ wear and tear of the insulation materials of the HVAC systems).

Finally, the provision of Financing (P9) through a grant or loan is treated as a separate Service from the Platform as it aims to further promote supporting schemes for energy saving projects.

Calculation of investment costs: The investment cost of each intervention is carried out according to predetermined indexes based on the Greek market, which however may be modified by the user.

2.2.3.3. Creating a Request

This section summarizes step by step the actions required to effectively use the Consumer Module and create a Request for the selected Services. Each step incorporates the transposition of User inputs into values (initially set by the author, but subject to changes by the Administrator through the back-office interface) that contribute to the calculation of the parameters presented in the following Section (2.2.4). The initial (preset) vales of each factor described below are also presented in Annex I in tables.

Step 1. Building type and operational profile

In the first step, two (2) options are provided in order to characterize the type of building use. The Consumer will be asked to choose between (a) residential or (b) commercial building. In addition, in case a type of residence is selected, it will be required to enter the number of residents (in total for the case of a multiapartment building), while in the case of a commercial building, the user will be asked to declare additional information regarding the operational profile though indicating the number of working hours/days. Indicatively for a tertiary sector building, the operational profile options are as follows:

1. Weekly Operation factor “WOF” (days/week): 4 or 7 (see also initial/preset values in ANNEX I, Table 6)
2. Daily Operation factor “DOF” (hours/day): 4, 8, 12, or 24 (see also initial/preset values in ANNEX I, Table 7)

According to the above, the tertiary building's Operating Factor (hereinafter “OF”) is determined as follows: OF = WOF x DOF. The OF for a residential building is calculated based on the number of residents selected, ranging between 35% and 90%.

Step 2. Location and topography

At this stage, the Consumer selects the necessary elements in order to determine the basic topographic characteristics of the wider area where the building is located. More specifically,

the Consumer is asked to provide information regarding the location at NUTS-3 level[4], the elevation which is characterized through the Elevation Factor "EF" (see also initial/preset values in ANNEX I, Table 8) (above or below 500m) and the building density characterized through the Building Density Factor "BDF" (see also initial/preset values in ANNEX I, Table 9), where:

- High density corresponds to clustered/ dense built-up area and a protected building
- Medium density translates to a sparse built-up area and partially protected building,
- Low density corresponds to a minimum (or non) built up area around an exposed building

Step 3. Building elements surface areas surface areas

In this step, the Consumer defines the total areas of the building's structural elements and more specifically:

1) Number of building floors/ storeys
2) Total conditioned/ heated area
3) Rooftop/ roof surface (total)
4) Free roof/roof surface (available for photovoltaic system)
5) Wall area (including openings)
6) Total area of openings

To enable a better user experience, the Tool automatically derives/ estimates the area (A_i) of each remaining building element from (3) to (6) of the list above automatically, based on the given floor number (1) and overall heated surface (2). More specifically the values of the rest parameters – essentially walls and openings – are estimated on the basis of common architectural indicators (expressed as percentages) (see also initial/preset values in ANNEX I, Table 10) corresponding to the different categories of number of floors and multiplied by the total conditioned/ heated area of the building. The User, however may insert measured dimension to achieve an increased level of accuracy that will also benefit the Provider to have a more detailed building profile.

Step 4. Thermal properties and elements in contact

In this step, the Consumer submits the characteristics of the building envelope as well as the external elements surrounding it. The User needs to determine if the structural elements are adequately insulated (based a common Consumer's subjective requirements or through inserting the present thermal transmittance value in the case of an "advanced user" – through selecting

[4] See: Eurostat, Nomenclature of territorial units for statistics (NUTS) – Overview. Available: https://ec.europa.eu/eurostat/web/nuts

accordingly form the slider button provided) to enable the estimation of the corresponding U-values (U_i) of building elements (see also initial/preset values in ANNEX I, Table 11) as well as the external elements they come into contact with (characterized as Contact Factors "CF_i"), over the largest part of the corresponding building sides/ façades (see also initial/preset values in ANNEX I, Table 12), as follows:

Table 1 Building envelope features and elements in contact

Building Element	Building Elements Characteristics – options	External Elements (in contact with Building Elements) – options
Roof/ Ceiling	Insulated/ Non (adequately) insulated	Air / Other, non-air-conditioned area of the building / Other, air-conditioned area of the building (e.g. other apartment) / Slab under roof / Roof
Wall	Insulated/ Non (adequately) insulated	Air (free side) / Other, non-air-conditioned area of the building (eg storage room, staircase) / Other, air-conditioned area of the building (eg other apartment) / Ground (Basement wall)
Floor/ Basementr	Insulated/ Non (adequately) insulated	Ground (Basement) / Other, non-air-conditioned area of the building (eg warehouse, closed parking area) / Other, air-conditioned area of the building (eg other apartment) / Air (Open space)
Openings (Frames and glazing)	Single glazing - window without thermal break/ Double glazing - window without thermal break / Energy efficient window with thermal break	N/A (same as walls)

Step 5. Heating & cooling setpoint temperatures

In this step, the desired indoor temperature conditions (set points) during the winter and summer period are determined by the Use, where .

1. SPT_H: Set Point (desired) Temperature for Heating
2. SPT_C: Set Point (desired) Temperature for Cooling

Step 6. Heating and cooling systems

At this stage the User selects the technologies currently used for heating and cooling from a predefined list, however it is also possible to add new/ different technologies for heating and/or cooling. This enables the selection of an appropriate Performance Factor "PF" (efficiency) of each technology (see also initial/preset values in ANNEX I, Table 13); however, the Consumer is given the capability to insert different values of efficiency/ performance ratios by selecting the "Advanced User" button.

Table 2 Technologies / sources of heating and cooling

Heating source(s)	Energy product
Heat pump	Grid Electricity
Split type air conditioning units (A/C split units) with inverter	Grid Electricity
Split type air conditioning units (A/C split units) without inverter	Grid Electricity
Electric heater (convector, fan, halogen, etc)	Grid Electricity
Condensing Natural Gas Boiler - autonomous system	Natural Gas
Condensing Natural Gas Boiler – central system	Natural Gas
Conventional oil boiler	Heating Oil
Old oil boiler	Heating Oil
Biomass boiler	Wood Pellet
Fireplace - Closed Combustion	Firewood
Fireplace - Open fire	Firewood

In case more than one technology has been selected for a given use case (heating and/or cooling), the Consumer further specifies the main source / technology (i.e. used on a regular basis).

Step 7. Total consumption and recent supply price

In this step, on the basis of the data and information already submitted by the Consumer, the estimated energy consumption (electrical and thermal – if any) is calculated (in the units invoiced – using appropriate conversion factors) in accordance with the available heating and cooling systems performance ratios. The User, however, may also indicate the actual consumption figures for the energy products considered.

In addition, the corresponding indicative (average) energy cost(s) are presented depending on the energy products used, while the Consumer may also provide a specific energy price per energy source (see also initial/preset values in ANNEX I, Table 14).

Finally, it is possible to include regulated charges in the electricity cost calculations in the cases of electricity and natural gas.

Table 3 Energy products and supply prices

Energy product	Consumption	Specific Cost
Grid Electricity	kWh_e	€/kWh_e
Natural gas	kWh_{th}	€/kWh_{th}
Heating oil	Lt	€/lt
Wood pellets	Kg	€/kg
Firewood	Kg	€/kg

Step 8. Selection of desired energy saving measures

Finally, a series of applicable energy savings measures (Services P1 to P8) are proposed by the Module concerning the building envelope as well as its equipment, based on the inputs provided by the Consumer in the previous steps.

P1. Insulation of walls / roof/ floor

P2. Replacement of single- or double-glazed frames with modern PVC, or aluminum with thermal break, with double or triple glazing
P3. Heat pump installation
P4. Mechanical ventilation with heat recovery
P5. Solar Water Heater
P6. Smart Building Automation Systems
P7. Rooftop photovoltaic systems
P8. Electricity storage system (Battery and/or Electric vehicle)
P9. Insulation of heating and cooling networks

An “Advanced user” may also insert the envisaged values of thermal transmittance for the building envelope interventions (if applicable/ envisaged), by selecting the "Advanced User" button. In addition, the Consumer may either deselect a proposed measure or add a new one. In the latter case, however, a new measure will concern electricity use exclusively and uses other than air-conditioning. The user should also provide the estimated/ expected percentage of electricity savings.

Step 9. Results preview

After performing the necessary calculations, the application displays the results in a simple and concise manner, capturing key indicators of each intervention, in order to enable the user to evaluate them in terms of their energy saving and economic performance, identify the best options and prioritize the most cost optimal investments accordingly. More specifically, for each intervention, the following indicators are presented:

- Energy savings
- Cost savings
- Investment costs (see also initial/preset values in ANNEX I, Table 15)
- Simple payback time

The above indicators are also presented for the whole group of interventions, as a package. In addition, the results are presented in table and graph(s) in order to easily identify best options and map an optimal investment strategy.

Step 10. Creation of Request

Following the findings of the previous step, the Consumer is now prompted to select the most effective services (economic performance-wise) that will comprise a package of one single

Request. The service of project finance becomes available for selection too, in this final step[5]. After completing all necessary steps of the Consumer Module and filling all necessary information, the Consumer is given two possibilities for the created Request:

- Save as draft (for future editing/ revising and / or deletion) and
- Final Submission to the Platform.

Once submitted, a Request may remain active in the system depending on the time limits set by the Administrator.

2.2.3.4. Submission of a Request

Following submission, the Request is added in the Marketplace to the corresponding side "Request Matrix", for the given location. During the completion of the Consumer Module, the Consumer may save his progress as draft at any stage so to continue editing in the future. Upon completion of the steps of the Wizard, the Consumer can proceed to final submission (Publish). Otherwise, the Consumer has still the option to temporarily save the completed Request as draft for future editing (for example until verification/ correction of input data).

Through the back-office interface, administrators are given the tools to update the necessary parameters and the databases of the Consumer Module (such as degree days, investment costs, performance ratios, etc.). Such updates / modifications of specific rates and values can be achieved through relevant import and export files, structured in standard "template" formats (excel or text txt, csv). In addition, through the same system, it is possible to modify access rights and to designate (enable/ deactivate) administrators of the application.

2.2.4. Computational Methods

The present section summarizes the basic principles of the approach followed to calculate present energy consumption and establish standardized consumption benchmarks for each building type across the Marketplace to achieve a common level of comparison between them, preventing User's bias and interference to the results (through non-normalized/ subjective consumption inputs).

[5] Upon creation of the Request, the User, having an approximate idea of the cost of the desired interventions, is also asked to indicate whether a "Financing" Service (P8) (through a possible grant or loan) is also desired.

2.2.4.1 *Calculation of two-year heating / cooling degree days*

Degree Days (hereinafter referred to as "DD") Heating ("HDD") and Cooling ("CDD") data for all EU countries, are extracted from the relevant Eurostat dataset[6]. The total yearly values (at a NUTS-3 level) corresponding to the selected location from Step 2 of the previous section "Input Data" are collected and the average per DD type (HDD_{annual} and CDD_{annual}) of the two most recent years is calculated. Then, taking into account the Elevation factor determined in step 2 of the previous section, the HDD and CDD for that specific location ("$\mathbf{DD_{Adjusted}}$") are adjusted for higher altitudes. The adjustment of the degree days is carried out as follows:

$$\mathbf{HDD_{Adjusted} = HDD_{annual} \times (1 + EF)}$$

$$\mathbf{CDD_{Adjusted} = CDD_{annual} \times (1 + EF)}$$

2.2.4.2 *Calculation of thermal transmittance coefficient of heat losses*

In order to make the application user-friendly and to limit the Consumer's commitment time (for data entry purposes) to an optimal minimum, a simplified method is used for the calculation of the thermal transmittance coefficient of building thermal losses (hereinafter referred to as "ΣUA"). For this purpose, the simplified expression for calculating this coefficient will be used (in its general form):

$$\mathbf{\Sigma UA_{total} = \Sigma UA_{walls} + \Sigma UA_{windows} + \Sigma UA_{roof} + \Sigma UA_{groundfloor} =}$$
$$\mathbf{[A_{walls} \times U_{walls} \times (1+CF_{walls}) \times (1+BDF)] + [A_{windows} \times U_{windows} \times (1+Average\ CF_{walls}) \times (1+BDF)] +}$$
$$\mathbf{[A_{roof} \times U_{roof} \times (1+CF_{roof}) \times (1+BDF)] + [A_{groundfloor} \times U_{groundfloor} \times (1+CF_{groundfloor}) \times (1+BDF)]}$$

Where:

A_i: The surface area of each individual building element as defined in step 3 of the previous section

U_i: The value of the thermal transmittance factor of each individual structural element of the building as determined in step 4 of the previous section

CF_i: The contact factor with external elements of each individual structural element of the building as determined in step 4 of the previous section

BDF_i: The building density factor of the building area as determined in step 2 of the previous section.

[6] *Cooling and heating degree days by NUTS 3 regions - annual data (nrg_chddr2_a)*

2.2.4.3. Estimation of thermal energy demand – Calculation of heat load

The following formula is applied (in its general form) for the calculation of the thermal load of the building and estimate the demand of the required total / annual thermal energy (for heating and cooling):

$$\mathbf{AHL = 0.024 \times \Sigma UA_{total} \times OF \times HDD_{Adjusted} \times \Delta TF_H}$$

$$\mathbf{ACL = 0.024 \times \Sigma UA_{total} \times OF \times CDD_{Adjusted} \times \Delta TF_C}$$

$$\mathbf{AL = AHL + ACL}$$

Where:

AHL: Annual Heating Load

ACL: Annual Cooling Load

OF: Building Operating Factor as defined in step 1 of the previous section and

ΔTF: a correction factor incorporated to reflect User's choices in step 5 (where internal set point temperatures are selected) and is calculated as follows:

$$\mathbf{\Delta TF_H = |SPT_H - BT_H| \times 0.07 + 1}$$

$$\mathbf{\Delta TF_C = |SPT_C - BT_C| \times 0.07 + 1}$$

Where:

SPT_H: Desired space heating temperature as determined in step 5 of the previous section

SPT_C: Desired room cooling/cooling temperature as defined in step 5 of the previous section

BT_H: Heating base temperature (BT_H=15ºC)

BT_C: Cooling base temperature (BT_C=26ºC)

2.2.4.4. Annual energy consumption estimation

The estimation of total annual electricity consumption is carried out primarily to establish a consumption benchmark of different buildings through common principles among the different types envisaged.

From the Consumer's side the estimation aims on the one hand on enabling an indicative in brief assessment of the different factors affecting current situation (awareness) and on the other hand to allow for a preliminary evaluation of estimated versus actual consumption data to identify appropriate/ reasonable justifications in cases of significant differences.

A. Estimation of annual electricity consumption

The total annual electricity consumption estimate corresponds to seasonable (for space heating and cooling) needs and "fixed" consumption from various other temperature-inelastic uses of electrical and electronic appliances (such as for DHW with electric boiler, cooking, lighting, IT, CCTV, data rooms/centers, etc.). While "fixed" uses are rather dependent on the type/ usage of

the building, the space heating and cooling demand/ needs can be estimated with some generally acceptable level of accuracy, through the method described in the following paragraph.

i) Electrical Heating (space and DHW) and Cooling component

The part of existing consumption related to space heating and cooling through (grid) electricity (HCEC – "Heating / Cooling Electricity Consumption"), is calculated from data already determined after a "check" regarding the (basic) energy product and corresponding technology used for heating, as follows:

Check:

Energy product for heating before = Electricity (Grid)

YES

$$HCEC_{before} = (HEC_{before} + CEC_{before}) \times \frac{HDD_y + CDD_y}{HDD_{annual} + CDD_{annual}}$$

NO

$$HCEC_{before} = CEC_{before} \times \frac{HDD_y + CDD_y}{HDD_{annual} + CDD_{annual}}$$

Where:

HEC_{before}= Electricity consumption for heating (before):

$$HEC_{before} = \frac{\mathrm{AHL}_{before}}{\mathrm{PF}\ (of\ basic\ technology\ for\ heating\ before)}$$

CEC_{before}= Electricity consumption for cooling (before):

$$CEC_{before} = \frac{\mathrm{ACL}_{before}}{\mathrm{PF}_{before}\ (of\ basic\ technology\ for\ cooling\ before)}$$

ii) Fixed uses component

For the estimation of electricity consumption related to fixed uses, a distinction shall be made between the type of use of the building, hence for residential buildings the Fixed Energy Consumption (FEC) is horizontally set at 35 kWh/m^2, while for buildings of the tertiary/ services sector the value is set at 25kWh/m^2.

iii) Total electricity consumption

Finally, fixed uses component (ii) values are multiplicated with the overall building conditioned area and added on top of the (i) component described above, to indicate the total electricity consumption of the building. Hence, the estimate for the total annual electricity consumption (EC) is calculated as the sum of the above, as follows:

$$EC_{before} = HCEC_{before} + FEC_{building\ type} \times TBA$$

Where:

TBA: The total air-conditioned area of the building as defined in step 3 of the previous section.

B. Estimation of annual thermal energy consumption

The estimation of total annual Thermal Energy Consumption "THEC" corresponds exclusively to consumption resulting from heating needs. It is therefore calculated as follows:

Check:

Energy product for heating before = Thermal Energy

YES

$$THEC_{before} = (HEC_{before}) \times \frac{HDD_y + CDD_y}{HDD_{annual} + CDD_{annual}}$$

NO

$$THEC_{before} = 0$$

2.3. Design of the Offer Side

2.3.1. Description of basic functions

Upon registration, Providers (Users representing the Offer side) are required to disclose the types of Services they provide as well as the locations/ regions in which they are active. The maximum allowable number of Services offered, and locations served are set by the Platform Administrator. Creation of offers is achieved through the "Provider Module" where the necessary information of technical, qualitative and economic nature, is submitted through ready-made templates. The Module allows for the creation of either a "Single Service Offer", i.e. an offer for one specific Service, or a "Bundled Service Offer", i.e. an offer package including multiple Services, while it is also possible to create multiple Bundled Offers for different combinations of Services or equipment variations of similar technologies.

All published Offers become available in the "Offers Matrix" of the Marketplace and are categorized under each Provider's location/ region of activity. In this way, the Platform aggregates all individual Offers published, to enable direct evaluation by interested Consumers. Upon registration, each Provider of Services (including funding) can view the Request Matrix for the supporting locations and Services that he has declared to form a complete understanding of local market needs and adapt the offers accordingly.

2.3.2. Provider Types

Types of users supported by the Offer side may include Energy Service Companies (ESCOs), Financiers[7] and Private Professionals[8]. The registration of Providers of any type is carried out as legal entities, using TaxisNet credentials, and the relevant VAT Identification Number. Subject to Administrator's changes, each Provider, upon registration, is required to declare:

- Up to six (6) possible locations of activity if it is an Energy Service Company (ESCOs), while there is no limit on the number of service types provided, including project financing (P10 – through grant or loan)).
- Up to five (3) possible locations of activity if it is a private professional, while all service types (P1 to P9) but project financing (P10) are allowed.
- Unlimited locations if it is a Financier, while the type of service provided is exclusively project Financing P10 (through grant or loan).

As already mentioned, the creation of an Offer, is achieved through the submission of predefined templates containing necessary qualitative, technical and financial information for each offered Service, while it is also required to submit relevant documentation such as technical data sheets and specifications, certifications, warranty, etc. to ensure that Consumers are sufficiently informed and in the position to compare and evaluate open Offers from different Providers for the same Service(s). For Financiers, Energy Efficiency Financing may be provided separately as a Service while in the case of Energy Service Companies (ESCOs), such service shall be offered within a Bundle (package) and must have, inter alia, a lower and upper limit in terms of the total available budget as well as a Financing Service with a maximum amount that can be provided if and to the extent that it is offered along with other Services of technical nature (from P1 to P9).

It is expected that the creation of open Offers from the Providers will attract Consumers assuming that prices of offered Services will be more competitive compared to those outside of

[7] Users included in this category can be either financial institutions or any form of companies (including energy suppliers). In such case, the Service provided is Financing (funding in the form of grants or loans) and it becomes available separately. However, it cannot be received as a standalone Service from the Platform as it has to be combined with specific energy saving Services either based on criteria set by the Provider of the financial service or by the Platform according to the overall investment needs.

[8] Private professionals are defined as those registered entities who can cover technical works (measures P1 up to P9) but not the Financing (Service) of the projects they undertake.

the Platform's Marketplace. The Platform offers efficiency and effectiveness given that Providers (ESCOs or private professionals) will be able to procure – and secure – comparatively larger volumes of products, materials and equipment, delivering them locally, in shorter timeframes without necessarily having to rent the required storage capacity, thus significantly reducing associated expenses.

2.3.3. The Provider Module

2.3.3.1 Basic Offer types and characteristics

When preparing any type of Offer, the Provider is required to insert the qualitative/ technical and economic elements of the respective Service(s) as well as the period of its validity/ availability. The requirement of a "Targeted Budget" is also an additional option provided through the Platform. If such requirement is selected, the Provider needs to indicate for each Service included in the Bundle, the budget that is required to be covered in-advance ("Targeted Budget") by Consumers' matching requests before the former is committed to initiate project implementation, as well as the maximum budget "Maximum Budget Limit" that once fulfilled, the matching of new consumer requests gets automatically deactivated.

2.3.3.2 Offers templates

Any Offer template consists of two distinct sections; one fixed section with common information that needs to be submitted for each case and a customized-per-Service section with specific information of mostly technical nature. The templates fixed and customized-per -Service content is presented separately and in detail as follows.

Offer Templates – Fixed Section and Information

The table below summarizes the information required to be submitted by the Providers when preparing any Offer for any given Service (except for Project Financing where due to its specifications, the template will be presented separately in the end of Table 5).

Table 4 Offers templates – fixed section and information

Title	Input type
Offer Type	Select: Single / Bundled
Service Type	Select: P1 up to P9
Make / Model	insert text
Technical data sheet	file upload
Guarantee	insert value (years)
Availability from	insert value (date)
Valid until	insert value (days)
Targeted Budget	insert value (€)
Maximum budget limit	insert value (€)

Offer Templates – Customized Section and Information per Service

The table below summarizes the information required to be submitted by the Providers when preparing the Offers for envisaged Services.

Table 5 Offers templates – customized sections and information

Service	Input type
P1. Thermal insulation	
Building type	Residential / Commercial / All
Placement	Walls / Roof / Floor
Material	Expanded polystyrene (EPS) - White / Expanded polystyrene (EPS) - Graphite / Extruded polystyrene (XPS) / Mineral wool / Other (please specify)
Material thickness	insert value [mm]
Coefficient of Thermal Conductivity, λ	insert value [W/K]
Corner bead	With mesh and water drip / With mesh
Indicative specific costs (including procurement, transport and installation works)	insert value (€/m2)
P2. Replacement of windows	
Building type	Residential / Commercial / All
Placement	Door / Window / Ceiling / Patio Door
Material	Aluminum (with thermal brake) / PVC / Wood / Other (with thermal brake)
Type	Hinged / Sliding / Fixed / Other (please specify)
Glazing	Double / Triple
Indicative specific costs (including procurement, transport and installation works)	insert value (€/m2)
P3. Heat pump	
Building type	Residential / Commercial / All
Operation	Heating / Heating & DHW / Heating & Cooling / Heating & Cooling & DHW
Capacity	insert value [kWe]
Thermal Power (Heating)	insert value [kWth]
Seasonal Coefficient of Performance (SCOP)	insert value
Thermal Power (Cooling)	insert value [kWc]
Seasonal Energy Efficiency Ratio (SEER)	insert value
Water storage capacity	insert value [lt]
Operating temperature	Low (up to 55°C) / Medium (up to 65°C) / High (up to 80°C)
Indicative unit cost (including procurement/supply, transport and installation)	insert value (€)
Fan coil unit	

Position	Wall / Floor / Cassette / Channel / Other (specify)
Thermal Power (Heating)	insert value [BTU]
Thermal Power (Cooling)	insert value [BTU]
Indicative costs (including procurement, transport and installation works)	insert value (€)
P4. Mechanical ventilation with heat recovery	
Building type	Residential / Commercial / All
Thermal Power	insert value [kW]
Indoor area covered	insert value [m2]
Indicative costs (including procurement, transport and installation works)	insert value (€)
P5. Solar collector	
Building type	Residential / Commercial / All
Absorber type	Flat Selective / Vacuum Tubes
Rate of yield	insert value [%]
Collector surface	insert value [m2]
Hot water storage capacity	insert value [lt]
Indicative collector cost (including procurement, transport and installation works)	insert value (€/m2)
Indicative tank cost (including procurement, transport and installation works)	insert value (€/Lt)
P6. Smart and automation systems	
Building type	Residential / Commercial / All
Product type	Replacement with LED / Sensors / Smart device / Energy Monitoring, Management (BMS), Automation (BAS) / Energy Star appliance / Other (specify)
System features / description	insert text
Indicative specific costs (including procurement, transport and installation works)	insert value (€/m2)
P7. Rooftop photovoltaic system	
Building type	Residential / Commercial / All
Photovoltaic Panels	
Panel technology	Monocrystalline / Polycrystalline / Other (specify)
Panel type	Monofacial / Bifacial
Maximum rated power	insert value [W]
Length	insert value [m]
Width	insert value [m]
Indicative unit cost (including procurement/supply, transport and installation)	insert value (€/kW)
Inverter (required)	

Indicative costs (including inverter supply, wiring, mounts, transport and installation works)	insert value (€/kW)
P8. Electricity storage system (Battery and/or Electric vehicle)	
Building type	Residential / Commercial / All
Storage capacity/ capacity	insert value [kWh]
Indicative costs (including procurement, transport and installation works)	insert value (€)
P9. Thermal insulation of HVAC networks (duct & pipe)	
Building type	Residential / Commercial / All
Material	insert text
Material thickness	insert value [mm]
Make / Model	insert text
Technical data sheet	file upload
Guarantee	insert value (years)
Indicative specific costs (including procurement, transport and installation works)	insert value (€/m2)
P10. Financing (through grant or loan)	
Building type	Residential / Commercial / All
Financing type	Subsidy / Loan
Connected with	Single for P1 up to P2 or Bundled
Amount from	insert value (€)
Amount up to	insert value (€)
Availability from	insert value (date)
Valid until	insert value (date)

III. KEY ACTIONS AND MECHANISMS OF THE PLATFORM

The following simplified diagram schematically depicts the sequences of the key actions of the Users and the mechanisms of the Platform, from their registration and the creation of a tailored-to-the Consumer Offer until the final set up of a successful bilateral agreement between both Parties and the scheduling of relevant works. The individual Phases and respective processes are described in more detail in the paragraphs that follow.

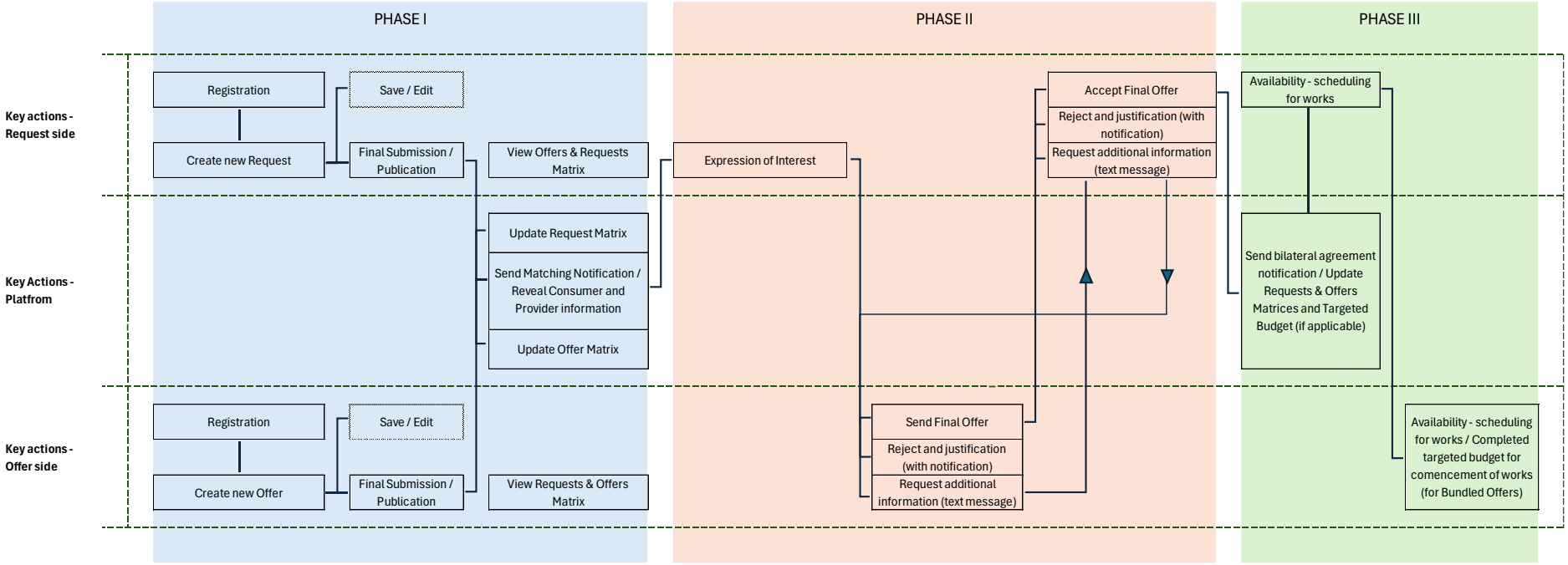

Figure 2 Simplified schematic representation of key processes and functions of the Users and the Platform to achieve matchmaking

3.1. Phase I – Creating match-making conditions

Upon registration, Consumers need to be verified via email but are not obliged to enclose any other personal information (such as address, telephone, etc.), although this will be required (and will be send to the relevant Provider) when/if Expression of Interest for a particular Offer is selected from their side. Providers, on the other side, following verification and approval from the Administrator, are required to select the appropriate profile (ESCO, Supplier, or Financier) the corresponding Services offered, the locations served and fill in company's important information, while also setting up a dedicated digital storefront. In addition, all User types can view the available/open offers and requests of the Marketplace.

Consumers and Providers, after filling in the necessary information and completing the respective Modules, by submitting, the new positions (Request/ Offer) are fed into the platform's database. Then the platform's algorithm takes over to verify matching offers with requests. In case of a match, the Interested Parties are informed accordingly, through a notification within the Platform and though email (is such notification method has been selected). Each User can then display the characteristics of the match, ie. type of Offer ("Simple" and/or "Bundled"), the Services offered/covered, their technical specifications and cost[9]. In the case of a Financing Service, exceptionally, a possible match shows the type of financing – which may be either through grant or loan – as well as the total available budget[10]. The Consumer is then in the position to decide whether intends to send an "Expression of Interest" or to reject the match by disclosing, as mentioned, the personal contact details of the to the Provider.

3.2. Phase II – Matchmaking and exploring cooperation

The Phase that follows the submission of an Expression of Interest from the Consumer, is where technical details are clarified from both sides to result into an acceptable form of an agreement from both sides. As evident from the above figure, when the Consumer selects the Expression of Interest option, the respective Provider is notified and messaging between the Parties is

[9] The cost in this phase is calculated based on the specific prices (eg. €/m^2) submitted by the Providers through the Offer and the input values given by the Consumers through the Module.

[10] A request for the provision of a Financing Service that comes from an offer of an Energy Services Company, must be accompanied by one or more Services contained in the same package, by this Company and cannot be combined with Services coming from other Suppliers.

enabled. Messaging application allows both Parties to request additional information and additional clarifications.

From the Provider's side such clarifications may refer to any additional and significant building uses not taken into account by the Consumer Module and in particular for cases of tertiary sector buildings (as technologies such as data rooms/centers, large-scale & commercial HVAC equipment including cooling towers, heat exchangers, AHUs, etc. have not been explicitly incorporated) that require more detailed evaluation and probably on-site inspection, and/or other prerequisite works such as waterproofing, masonry preparation repairs, dismantling of obsolete equipment, etc. In addition, at this point it is possible for the Provider to request a meeting/ inspection in order to prepare a more detailed offer. The Consumer may also be asked to send relevant documentation attaching in the platform's messaging application the necessary files (such as floor plans and architectural drawings) or more detailed measurements of individual building elements dimensions (in case automatic elements areas calculation was applied from the Module), etc.

From the side of the Consumer clarifications at this point may include the cost of individual works, materials, equipment manufacturer, duration and warranty coverage, estimation of works commencement and overall duration of works, etc. The exchange of information can continue at this stage until any open issues and clarifications that may arise from either side are clarified.

3.3. Phase III – Bilateral Acceptance of Matching

At this point Consumers, may either withdraw or accept the final Offer. Acceptance requires confirming their identity as natural or legal persons using TaxisNet credentials and implies the transformation of the Offer into a bilateral agreement which is followed by a relevant notice sent to both "contracted" Parties. In the case of an Offer without "Targeted Budget" the role of the Platform is essentially completed at this point, however the messaging tool will remain active, and the Users may still continue to use it in order to exchange information. In case a Targeted Budget has been selected from the Provider for the Offer:

- Implementation of works from the latter is not officially binding until the needed ("targeted") budget is reached from aggregated Requests. From that point on, the Provider should be expected to proceed to the commencement of works.
- The Platform will continue to aggregate the relevant agreements until the maximum budget limit set by the Provider, is reached.
- The targeted budget set by the Provider is automatically reduced by the amount agreed according to the contract.
- The "agreed" Consumers will need to probably expect some delays in the commencement of works until the target budget is reached.

The Administrator of the Platform will need to ensure smooth operation of the Marketplace by closely overseeing and monitoring the practices followed by the Users of each side and especially those of the Providers, with respect to their price-setting strategies, commitment to projects' delivery, communication policies, etc. The Administrator will also need to have a team of dedicated staff and proper measures in place to address/ resolve any issues raised by the Users.

IV. CONCLUSIONS

This thesis presents the design of a web-based technical tool developed with a holistic approach to intersect the needs of diverse user groups and stakeholders within the energy efficiency market. The tool conceptually intends to achieve the following targets:

- Raises awareness for technical specificities and financial feasibility of common energy saving solutions, through a user-friendly tool (the Consumer module) that simplifies technicalities and limits User commitment up to an optimal minimum level further supported by complete step-by-step guidance and support for the User. More specifically, the Consumer has the opportunity to identify the best options of available energy efficient solutions in terms of their economic performance and prioritize needs through an optimal investment strategy.
- Enhance competition through the creation of clear and standardized Offers from the Providers, hence promoting competitive prices for Services given that Providers (ESCOs or private professionals) will be able to procure – and secure – comparatively larger volumes of products, materials and equipment, delivering them locally, in shorter timeframes without necessarily having to rent the required storage capacity, thus significantly reducing associated expenses.
- Aggregate small investments to achieve economies of scale. This can be achieved by a specific attribute/ requirement that a provider may introduce when preparing an offer, the so-called "Targeted budget". If such requirement is selected, the Provider needs to indicate for each Service included in the Bundle, the budget that is required to be covered in-advance by interested Consumers (through their matching requests) before the former is committed to initiate project implementation. This enables the aggregation feature of the Marketplace, as it requires the creation of a group of a number of Requests consisting of one ("Single Offer" type) or more identical projects ("Bundled Offer" type).
- Benchmark EE project based on common principles on the basis of standardized calculation methodologies for residential and commercial building types.
- Inform Energy Efficiency planning and strategies through an open database, offered through the Marketplace of requests and offers for specific energy efficiency investments. More specifically, it is expected that once the requests and offers start to pile up within the Marketplace, project financing needs will be more distinguishable, especially indicating the types of investments (essentially those with higher financing risks) as well as the specific needs in terms of technical solutions and financing, for each location of the country.

- Promotes de-risking of investments in energy efficiency through the provision of funding as a Service (either through grant or loan)
- Assist both sides (Consumer and Provider) to clarify all necessary specificities through a messaging tool to efficiently and effectively reach an agreement for works.

Among the most crucial challenges for the successful operation of the Marketplace is to ensure a level playing field among the Users of both request and offer sides as well as a fair play through proper monitoring of Participants practices. Another critical factor for the Administrator is to frequently update critical parameters through the back-office interface, especially in terms of their performance and costs as technological advancements gradually provide more efficient and – on average – more affordable solutions. Finally, and with regards to the Marketplace's long-term viability, the Administrator, through a consistent oversight needs to ensure proper project implementation guarantees. This may entail the inspection of the evolution of bilateral agreements following their "official" confirmation from the platform, even on a sample-based approach. For instance, such oversight could be achieved by communicating with both Parties of the agreement in specific intervals to ask for relevant information on the implementation of the project.

V. REFERENCES

Buildings Performance Institute Europe, Report on the evolution of the European regulatory framework for buildings efficiency (2022). Available: https://www.bpie.eu/publication/a-guidebook-to-european-buildings-efficiency-key-regulatory-and-policy-developments/. Accessed: 17/11/2024

Commission Recommendation (EU) 2021/1749 of 28 September 2021 on Energy Efficiency First: from principles to practice — Guidelines and examples for its implementation in decision-making in the energy sector and beyond

Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency

Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast)

Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)

Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)

Eurostat, Nomenclature of territorial units for statistics (NUTS) – Overview. Available: https://ec.europa.eu/eurostat/web/nuts

Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action.

ANNEX I – Consumer Module Initial Values

Table 6 Weekly Operation factor

Weekly Operation factor (WOF) for Commercial building [days/week]	
7 days	100%
5 days	80%

Table 7 Daily Operation factor

Daily Operation factor (DOF) for Commercial building [hours/day]	
4 hours	80%
8 hours	100%
12 hours	110%
24 hours	120%

Table 8 Elevation factor

Elevation factor (EF) [m]	
<500	0%
>500	15%

Table 9 Building Density Factor

Building Density Factor (BDF)	
High density: clustered/ dense built-up area and a protected building	-2%
Medium density: sparse built-up area and partially protected building	0%
Low density: minimum (or non) built up area around an exposed building	3%

Table 10 Building elements surface areas indicators

Surface areas						
Number of floors	**1-2**	**3-5**	**6-8**	**9-12**	**13-15**	**>16**
Roof area	100%	29%	14%	9%	7%	6%
Roof area available for PV	70%	20%	10%	6%	5%	4%
Wall area						
Residential building	44%	42%	34%	28%	24%	23%
Commercial building	65%	60%	50%	45%	40%	38%
Openings area						
Residential building	19%	23%	27%	29%	30%	32%
Commercial building	33%	40%	47%	52%	55%	58%

Table 11 U-Values of building elements

Building Element	Building Elements Characteristics – options	U-Value [W/(m²K]
Roof/ Ceiling	Insulated/	2.30
	Non (adequately) insulated	0.50
Wall	Insulated/	1.20
	Non (adequately) insulated	0.45
Floor/ Basementr	Insulated/	0.80
	Non (adequately) insulated	0.40
Openings (Frames and glazing)	Single glazing - window without thermal break	6.00
	Double glazing - window without thermal break	4.00
	Energy efficient window with thermal break	1.20

Table 12 External elements in contact with building elements

External Elements (in contact with Building Elements) – options	CF - North side	CF - Other side
Elements in contact with building walls & openings		
Air (free side)	0%	0%
Other, non-air-conditioned area of the building (eg storage room, staircase)	-20%	-10%
Other, air-conditioned area of the building (eg other apartment)	-30%	-15%
Ground (Basement wall)	-10%	-5%
Elements in contact with building roof		
Air		15%
Other, non-air-conditioned area of the building		-10%
Other, air-conditioned area of the building (e.g. other apartment)		-15%
Slab under roof		-5%
Roof		-2%
Elements in contact with building basement		
Ground (Basement)		-5%
Other, non-air-conditioned area of the building (eg warehouse, closed parking area)		-10%
Other, air-conditioned area of the building (eg other apartment)		-15%
Air (Open space)		10%

Table 13 Heating and cooling technologies performance factors

Technology	Energy product	PF
Heat pump	Grid Electricity	3.60
Split type air conditioning units (A/C split units) with inverter	Grid Electricity	3.20
Split type air conditioning units (A/C split units) without inverter	Grid Electricity	3.00
Electric heater (convector, fan, halogen, etc)	Grid Electricity	1.00
Condensing Natural Gas Boiler - autonomous system	Natural Gas	0.98
Condensing Natural Gas Boiler – central system	Natural Gas	0.98

Conventional oil boiler	Heating Oil	0.85
Old oil boiler	Heating Oil	0.71
Biomass boiler	Wood Pellet	0.78
Fireplace - Closed Combustion	Firewood	0.50
Fireplace - Open fire	Firewood	0.20
Other (specify)	Specify	-

Table 14 Energy products costs

Energy product	**Value / Unit Price**	**Units**
Grid Electricity	0.159	€/kWh$_e$
Natural gas	0.137	€/kWh$_{th}$
Heating oil	1.180	€/lt
Wood pellets	0.700	€/kg
Firewood	0.353	€/kg

Table 15 Energy efficiency measures specific costs

Description	**Specific cost** (including procurement/supply, transport and installation) **(€/m^2)**
Thermal insulation of walls (including corner bead placement)	50
Thermal insulation of roof	45
Thermal insulation of basement	40
PVC or aluminum with thermal break and double glazing	500
Heat pump (heating only)	70
Heat pump (heating and cooling)	95
A/C split type with inverter	50
Condensing Gas Boiler – autonomous system	30
Condensing Gas Boiler – central system	25
Smart Building Automation Systems	10
Mechanical Ventilation with Heat Recovery	40
Insulation of heating and cooling networks	3
Solar Water Heater	4
Rooftop PV system	130

ANNEX II - Regions of Greece, NUTS 3 level

NUTS 3 - Code	NUTS 3 - Label
EL301	Voreios Tomeas Athinon
EL302	Dytikos Tomeas Athinon
EL303	Kentrikos Tomeas Athinon
EL304	Notios Tomeas Athinon
EL305	Anatoliki Attiki
EL306	Dytiki Attiki
EL307	Peiraias, Nisoi
EL413	Chios
EL421	Kalymnos, Karpathos – Iroiki Nisos Kasos, Kos, Rodos
EL422	Andros, Thira, Kea, Milos, Mykonos, Naxos, Paros, Syros, Tinos
EL432	Lasithi
EL433	Rethymni
EL511	Evros
EL512	Xanthi
EL513	Rodopi
EL514	Drama
EL522	Thessaloniki
EL523	Kilkis
EL524	Pella
EL525	Pieria
EL526	Serres
EL531	Grevena, Kozani
EL532	Kastoria
EL533	Florina
EL541	Arta, Preveza
EL542	Thesprotia
EL543	Ioannina
EL611	Karditsa, Trikala
EL613	Magnisia, Sporades
EL621	Zakynthos
EL622	Kerkyra
EL624	Lefkada
EL631	Aitoloakarnania
EL632	Achaia
EL642	Evvoia
EL643	Evrytania
EL644	Fthiotida
EL651	Argolida, Arkadia
EL652	Korinthia
EL653	Lakonia, Messinia