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The Role of Digital Platforms in Overcoming Market Failures in Building Energy Renovations

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Abstract: This study investigates the economic benefits of digital platforms in addressing market failures within the building energy renovation sector in Europe. While significant capital is available for sustainable investments, the market is characterized by profound information asymmetry and high transaction costs, which hinder the efficient allocation of green capital. Using the ENERGATE platform as a case study, this paper examines how an AI-driven matchmaking system can standardize and aggregate projects, reduce information gaps, and match project supply with investment demand. Our analysis suggests that such platforms can significantly lower search and transaction costs for financiers, thereby mobilizing capital that would otherwise remain untapped. The findings provide insights into how technological solutions can create a more liquid and efficient market for sustainable investments, accelerating the transition to a low-carbon economy.

Keywords: *Market failure, information asymmetry, transaction costs, energy efficiency, building renovation, digital platform, ENERGATE, green finance*

JEL Codes: *D82, D83, Q48, Q55, O33*

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Introduction

The building sector plays a critical role in the European Union's pathway toward a sustainable, decarbonized economy. With buildings accounting for approximately 40% of the EU's total energy consumption and 36% of its energy-related greenhouse gas emissions (European Commission, 2020a), accelerating the pace of energy renovations is a foundation of strategic climate and energy policy. Despite this urgent need, the building renovation rate has remained persistently low, averaging only around 1% per year (Economidou et al., 2019). This gap between ambition and reality points to inherent structural challenges within the market that traditional policies, such as subsidies and tax incentives, have not fully resolved.

This paper investigates how digital platforms can address the market failures that impede the flow of green finance into the energy efficiency sector, thereby accelerating the rate of building deep renovations?

We argue that the primary barriers are information asymmetry and high transaction costs. The fragmented nature of the market means that viable projects are difficult to find, assess, and finance at scale. As a result, large-scale green capital, particularly from institutional investors and Environmental, Social and Governance (ESG)[5] funds, is often unable to access this vast, yet inefficient, market segment.

The ENERGATE platform is presented as a novel solution designed to overcome these barriers. As a digital intermediary, it standardizes project data, aggregates small-scale renovation projects into larger, investable portfolios, and provides a transparent ecosystem for all stakeholders. This paper will outline the platform's implementation and analyze its projected impact.

Literature review

This chapter synthesizes existing academic work on the key economic concepts and policy frameworks relevant to this study. It investigates the market failures that impede the efficient allocation of sustainable finance, examines

[5] ESG investing refers to an investing approach that prioritizes environmental, social and governance criteria. Environmental criteria measure how a company safeguards the environment. Social criteria examine how it manages relationships with employees, suppliers, customers, and communities. Governance measures a company's leadership, executive pay, audits, internal controls, and shareholder rights.

the theoretical foundations of digital platforms as a solution to these failures, and provides an overview of the European policy context that underscores the urgency and importance of this research.

Market failures in sustainable finance

A market failure is an adverse outcome in which the forces of supply and demand fail to achieve balance, leading to an inefficient distribution of goods and services in the free market (Bator, 1958, n. p.). In the context of sustainable finance, market failures are adverse outcomes that hinder the flow of capital toward green investments, including energy renovations. One of the most prominent of these is *information asymmetry*. This occurs when one party in a transaction possesses more or better information than the other, leading to inefficient outcomes (Bloomenthal, 2025).

This failure can also happen when both parties of the said transaction equally lack the knowledge of the other. In building energy renovations, information asymmetry is a profound barrier: homeowners often lack the technical expertise to accurately assess the long-term viability and potential return on investment (ROI) of a renovation project. They also have limited knowledge about trustworthy and capable implementors and contractors. In contrast, investors and financiers face a different challenge since they seek large, standardized, investable packages which in most cases are scarce due to the fragmented landscape of the property market. They also need reliable data on a project's expected energy savings, investment costs, and risk profile, as well as a due diligence process to be able to underwrite a loan or investment. This leads to adverse selection and underinvestment in energy renovations (Beirne & Fernandez, 2023). In addition, Akerlof (1970) argues that this asymmetry and the lack of standardization creates a *lemons problem* where high-quality, high-yield projects cannot be distinguished from low-quality, low-yield ones, hindering capital to be channeled efficiently. The "lemon problem" arises when information asymmetry causes uncertainty about a product's or investment's value (Chen, 2025, n. p.).

An equally critical market failure in the building renovations is high *transaction costs*. *"Transaction costs are costs incurred that don't accrue to any participant of the transaction. They are sunk costs resulting from economic trade in a market."* (Corporate Finance Institute, n. d., n. p.). Unlike large-scale, centralized green projects (e.g., wind farms or solar power plants), building energy renovations are highly fragmented. Each project is unique, requiring individual due diligence, technical intervention, and customized financing solutions. For a large institutional investor or a bank, the cost of originating and managing thousands of small, individual loans to homeowners can be extremely high, outweighing the potential returns. This creates systemic market inefficiency where significant capital, particularly from large-scale ESG funds, cannot be deployed effectively. The combination of information asymmetry and high transaction costs results in a persistent gap between the supply of green capital and the demand for financing for energy efficiency projects. Jovović and Vuković (2024) emphasize that such inefficiencies are among the primary reasons why sustainable finance remains underutilized, despite policy support and growing investor interest.

The role of technology and digital platforms

Digital platforms are designed to facilitate interactions and transactions between two or more interdependent groups of users (Gibson, 2024). These platforms are increasingly recognized as intermediaries that can transform business matchmaking by enhancing transparency, reducing search and transaction search costs and utilizing the benefits of networks. For example, platforms in the e-commerce have successfully reduced the cost and time of finding a product or a service. In a similar fashion, a digital platform for building renovations can aggregate and standardize fragmented, individual projects and match users whose pre-defined preferences complement each other's. According to the Sustainable Digital Finance Alliance (2018), technologies such as Artificial Intelligence (AI), blockchain, and Internet of Things (IoT) can significantly lower the cost of validating green investments and improve access to verified impact data. Jovović and Vuković (2024) found that platform-based solutions – such as crowdfunding, peer-to-peer lending, and ESG data platforms – act as accelerators of sustainable finance by improving the dissemination and accessibility of funds. Additionally, Mamun and Várallyai (2025) highlight that digital innovations facilitate financial inclusion and equitable access to green finance, especially for underserved populations, which is highly relevant when it comes to energy poverty.

Furthermore, platforms utilize networks' self-reinforcing characteristics, where the value of the platform increases as more users join. As more property owners register their projects, the platform becomes more attractive to contractors and financiers. In turn, as more financiers join, the capital pool grows, offering homeowners more competitive financing options. This positive feedback loop can accelerate market growth and liquidity. The application of AI and machine learning to platform data can further enhance efficiency by providing automated matchmaking, risk assessment, and predictive analytics, turning fragmented, unique information into standardized, aggregated and actionable data for all market participants.

The European policy context

The policy context in relation to the need for enhanced building renovation rate derives from European Union's *European Green Deal (EGD)* which aims to make the continent carbon neutral by 2050 (European Commission, 2019). One of EGD's key objectives is to achieve decarbonization through the building sector, which accounts for approximately 34% of the EU's total greenhouse gas emissions (European Environment Agency, 2024). To achieve this, the EU launched its *Renovation Wave* strategy, which aims to renovate 35 million buildings by 2030, and double the annual energy renovation rate and foster deep renovations (European Commission, 2020b).

These policy initiatives have created a strong regulatory and financial incentive for green investments. The EU's sustainable finance framework, including the *EU Taxonomy for Sustainable Activities* (European Commission, 2020c), provides a clear classification system for green investments, aiming to combat greenwashing and mobilize capital toward genuinely sustainable projects. However, policy framework alone is insufficient to overcome the market-level inefficiencies. As noted by the Circular Buildings Coalition (2023), the construction sector still faces systemic barriers that prevent the effective deployment of green capital. The successful implementation of these EU-wide strategies requires innovative solutions that can facilitate the flow of green finance from large-scale funds to individual, small-scale projects, such as a home renovation.

Methodology and data

This section details the research methodology applied to investigate the role of digital platforms in overcoming market failures within the building energy renovation sector. The study adopts a *case study approach*, focusing on the ENERGATE platform as the primary subject of analysis. This approach is particularly suitable for exploring a novel technological intervention within a complex economic environment. The methodology is based on qualitative assessments of the platform's functionalities, user interactions, and systemic impacts. The following subsections describe the platform's core functionalities and the analytical framework used to evaluate its impact.

Description of the ENERGATE project and platform

Launched in 2022, the ENERGATE project is a collaboration of 12 partners, funded by the EU LIFE program. Its primary objective is to develop an AI-driven digital marketplace that connects all stakeholders of the building energy efficiency renovation scene. This includes a wide range of participants, such as building owners, real estate developers, energy service companies (ESCOs), investors, public authorities, and financing institutions (ENERGATE project, 2025).

The ENERGATE marketplace is being implemented through a user-friendly platform that facilitates the collection of projects, including project-specific and technical information, the aggregation of similar projects, and their matchmaking with financiers and implementors.

To validate its functionalities, financeable packages, and de-risked solutions, ENERGATE is utilizing five pilot projects. These projects have already gathered data and insights from energy efficiency initiatives in six different EU countries: Greece, Italy, Latvia, Austria, France, and Spain. The pilot cases were strategically selected to ensure diversity across a number of factors, such as climate zones, functions, and building types, to thereby enhance the results of the project.

ENERGATE is designed to be a single, robust, Information and Communications Technology (ICT)-enabled solution that integrates different stages of the building energy efficiency project cycle. It achieves this by enabling and implementing the following key functionalities (ENERGATE project, 2025):

- *Standardized project development*: provides a large-scale facility for energy efficiency project sponsors, owners, and private or public entities to develop projects.
- *Aggregated and enhanced solutions*: creates a process for aggregating, enhancing, and packaging projects and measures. This includes due diligence and cash flow enhancement to make them more attractive to financiers.

- *Securitization and financial conditioning*: facilitates a securitization process that financially aggregates projects and tailors them to specific finance categories (e.g., private vs. public).
- *Impact measurement*: incorporates feedback loops to measure the platform's impact through suitable Measurement & Verification (M&V) processes.
- *Value-added services*: delivers additional services to users, such as business matchmaking, quality assessments, and rankings, to facilitate data and information exchange.

Four platform user or stakeholder types have been identified and defined by the project: Building Owners, Implementors and Financiers and Public Bodies.

Building Owner

A "Building Owner" is a user that either owns or manages a private building and is interested in pursuing its energy renovation. The Building Owner has access to technical, commercial, and/or risk-related data for the building, and can enter such data in the platform, so as to compare the building with other buildings that have been renovated in the past, search for technical experts that can implement energy efficiency interventions and explore possible finance solutions for the project. Stakeholders identified within this group include:

- Private building owners
- Asset managers
- Property/building managers
- Real estate developers/managers.

Implementor

An "Implementor" is a user that can provide technical support and implement energy renovation projects. A wide range of implementors exist and their role is defined according to their type. Often, they are the enabler of a funded solution, working with building owners and financiers to facilitate the implementation of funded projects. Typically, they collect and process information on buildings, undertake techno-economic analysis of different energy efficiency measures for selected buildings, define projects and offer their services and technical expertise for the implementation of energy renovation projects. An implementor can also create attractive investment opportunities through the aggregation process and explore finance solutions to implement these projects. Stakeholders identified within this group include:

- Energy Service Companies (ESCOs)
- Project Developers
- Engineering Companies
- Architect & Design Companies
- Energy Consultants
- Installers.

Financier

A "Financier" is a user that typically provides funding for projects. Through the ENERGATE platform, financiers can explore various investment opportunities specifically related to energy renovation projects in buildings. The platform enables them to access and analyze project data, helping them assess whether they wish to finance these initiatives and decide on the financing method, such as loans, green finance instruments, framework agreements. Key stakeholders in this group are:

- Financial institutions, such as commercial banks and development banks
- Private investors
- Investment Funds.

Public Body

A "Public Body" is a user that aims to renovate one or multiple public buildings. The Public Body can use the ENERGATE platform to insert data relevant to the building, according to the predefined information entries, so as to compare their building with other buildings that have been renovated in the past, explore available EU funding schemes and mechanisms that could finance/fund energy efficiency interventions in public buildings, and inform users in the platform about upcoming projects. Stakeholders identified within this group include:

- Municipalities/cities/communities
- Regions and national authorities
- Other public entities.

ENERGATE platform architecture

This section provides a detailed description of the ENERGATE platform architecture, designed to address the diverse needs of stakeholders and deliver an effective user-centric experience. The architecture's core components have been grouped in four ecosystems corresponding to the different stages of interaction (Zero, Fetch, Process, Deliver Stage), in order to reflect its operational flow. The design process has been guided by feedback loops and rigorous testing, ensuring that the architecture is both robust and adaptable to user's requirements.

The ENERGATE architecture strives to achieve a balance between innovation and practicality, by integrating advanced analytics and modular design principles. This creates a foundation that supports dynamic interactions between users, efficient operations, and future growth. The following sections detail each ecosystem/stage and their constituents' modules, illustrating how they collectively contribute to the platform's and users' goals.

The general flow of actions in the ENERGATE platform is illustrated by four platform stages: Zero Stage, Fetch Stage, Process Stage, and Deliver Stage, as shown in Hiba! A hivatkozási forrás nem található..

Figure 1: ENERGATE platform stages: overview

Source: Author's own elaboration based on the ENERGATE project deliverables (2023–2025)

Zero Stage

At zero stage, users insert basic personal data (e. g. name, surname, role etc.) and information about their organisation. In line with the feedback received from stakeholders, in the future, the Zero Stage will also include some additional requirements (e.g. an official document) to enable the verification of the company and ensure that the platform user is indeed an authorised representative of the company.

Fetch Stage

During this stage, users (Building Owners, Public Bodies and Implementors) insert information on buildings. Private and public buildings have different profiles, since some of the information entries differ. Similar buildings incorporated within the ENERGATE database are identified to help Building Owners and Public Bodies learn from best practices. In this stage, Implementors can also find buildings of interest, to formulate projects and project offers, which provide all the necessary energy – related and financial project information. The Fetch Stage has been improved for private buildings so as to support users in calculating the performance of the formulated projects. Unlike private buildings, projects for public buildings that exceed a specific cost threshold need to follow strict public procurement processes. Thus, in this case, through the platform, Public Bodies will be able to inform Implementors interested in renovating public buildings about upcoming projects. However, if the project of the public building does not exceed the threshold, it can be directly matched with an Implementor.

This stage is designed to assist users to estimate the financial performance of a project. As such, this stage provides automated calculations based on user's input, that will allow Implementors to fill specific inputs or use them as benchmarks for their own values.

More specifically, this Fetch stage calculates four important indicators:

- Payback Time: The required period needed for the investment to recover its initial cost through generated cash flows.
- Net Present Value (NPV): The difference between the present value of cash inflows and the present value of cash outflows over a project's lifetime.
- Avoidance Cost: The cost avoided after the implementation of specific energy efficiency measures.

- Internal Rate of Return (IRR): The discount rate at which the NPV of all the project's cash flows equals zero.

In order to calculate these indicators, users need to provide specific input. This includes the measures to be implemented, the energy savings that will be achieved, the Capital Expenditure (CAPEX) needed and the reduction in operation and maintenance (O&M) costs. Since not all measures have the same project lifetime, these have been split into four categories, each with its own project lifetime.

Table 1: Measure categories and their estimated project lifetime

Measure Category	Project lifetime
Building envelope	25 years
Lighting	7 years
HVAC/ heat pumps/ automation etc.	15 years
PV	10 years

Source: Author's own elaboration based on the ENERGATE project deliverables (2023–2025)

Additional information needed for the calculations include energy prices (thermal and electrical) and the inflation and discount rate. Relevant values have been assigned for each pilot country. However, the user has the option to change these values so that better and more up to date estimates can be used. After the input is defined, the output indicators are calculated per each measure category. The process of calculating these indicators is presented below:

Payback time

The payback time for each measure category is calculated by dividing the initial investment (CAPEX) by the annual cost savings and O&M reductions.

$$PBT = \frac{CAPEX}{Cost\ savings + O\&M\ reduction}$$

Net present value

$$NPV = \sum_{i=0}^{project\ lifetime} Discounted\ cash\ flow_i$$

$$Discounted\ cash\ flow_0 = -CAPEX$$

At the start of the project (i=0), the discounted cash flow is the initial capital expenditure (negative because it's an outflow).

$$Discounted\ cash\ flow_i = \frac{Net\ cash\ flow_i}{(1 + Discount\ Rate)^i}\ i \geq 1$$

Each year's cash flow is discounted to account for the time value of money, using the discount rate.

$$Net\ cash\ flow_1 = Cost\ savings_1 + O\&M\ reduction_1$$

In the first year, the net cash flow is the sum of cost savings and maintenance reductions.

$$Net\ cash\ flow_i = Net\ cash\ flow_{i-1} \cdot (1 + inflation\ rate)$$

Future net cash flows account for inflation, growing by the specified rate each year.

IRR

$$NPV = 0 \rightarrow$$

$$-CAPEX + \sum_{i=1}^{project\ lifetime} \frac{Net\ cash\ flow_i}{(1 + IRR)^i} = 0$$

The IRR is found when the present value of cash inflows equals the initial investment, setting the NPV to zero.

Avoidance cost

$$Avoidance\ cost = \frac{CAPEX}{Total\ energy\ savings}$$

The avoidance cost is calculated by dividing the capital investment (CAPEX) by the total energy savings achieved over the project's lifespan.

These calculations not only ease the process of inserting information into the platform but can also be used for validating user values and ensuring accurate information is entered. This is especially important for stakeholders, as it fosters transparency and thus, creates a trustworthy environment for investors, which in turn maximises the possibility of them being interested.

Process Stage

The aggregation and matchmaking process is the core part of this stage, where Implementors group projects according to filters provided by the platform, to create project clusters (aggregation), and Financiers are matched with projects according to their profile and preferences in terms of performance indicators (matchmaking). When matched with projects, Financiers can provide term sheets to express their willingness to invest in them. Building Owners of private buildings will also be able to explore available financing tools/products, that are added in the platform, for instance by banks that have registered as Financiers. When a Building Owner is interested in one of the financing tools, the Financier will receive a notification. Public Bodies will also be able to explore available EU funding mechanisms that might be suitable for their projects.

Deliver Stage

During this stage, users have access to statistics and visualisations in order to better understand the impact of their renovation projects. The visualisations will be provided based on the available information on energy consumption and energy savings, while additional benefits such as comfort levels, health benefits, and social impact will also be monitored. Financial indicators and cash flows will also be included in the Deliver Stage, when applicable. The information of the Deliver Stage will be used in order to feed in the user performance feature, which will be provided for each profile and will help users better understand their performance in the platform.

The four stages provide a complete user journey from registering in the platform, to implementing the energy efficiency projects and evaluating the results. First, the user goes through the Zero stage, in order to register in the platform. The next step includes the Fetch stage, where building data is inserted and the initial match between building owners and implementors takes place. The Process stage then provides services for the clustering of buildings and finalization of projects in order to present them and match them with potential financiers. Finally, after the agreement and implementation of projects, users can use the Deliver stage to validate and continue to monitor the impacts of the energy efficiency upgrades on their buildings.

Piloting the ENERGATE platform and user feedback

The primary aim of this paragraph is to demonstrate the platform's ability to create market uptake solutions for its stakeholders. It presents extensive data analysis derived from selected pilot projects in Greece, Latvia, Italy and France, combined with feedback gathered from the platform's diverse user base, including the pilot participants themselves and other relevant stakeholders.

The intra-project assessment of pilot buildings conducted a benchmarking exercise using indicators of energy consumption for electricity and heat generation. These indicators provide a clear and quantifiable measure of the building's operational energy performance, allowing for direct comparison against established benchmarks. The main reason for using these indicators is that electricity and heat consumption constitute the majority of operational energy use in most buildings and are directly linked to energy efficiency targets.

While financial, economic (e.g., CAPEX, return on investment), and other technical indicators are crucial for a comprehensive assessment, introducing them in this benchmarking exercise would have raised challenges. For example, many financial and economic indicators pertain to individual renovation projects and the financing mechanisms employed, rather than the energy performance of the building itself. In addition, financial and economic indicators are highly dependent on local energy prices, investment costs, and discount rates, which can vary significantly across different pilot locations.

The benchmarking exercise for various building types was based on CIBSE (Chartered Institution of Building Services Engineers, n.d.) values and differentiated between public and private buildings. Within these broad categories, specific building typologies and climate zones were utilized to ensure a more relevant comparison. All these pilot projects (buildings and properties) have been registered to the ENERGATE platform to test the practical applicability of it.

Public buildings

Disproportionate heating inefficiency could be observed in the public building sample. 11 out of 22 buildings (50%) exceed the heating benchmark, while only 2 out of 22 buildings (approximately 9%) exceed the electricity benchmark. This indicates a significantly higher prevalence of inefficiency in heating consumption compared to electricity consumption among the buildings in this dataset. Heating systems and thermal performance of the buildings, in general, appear to be a more pressing area for improvement.

While few buildings struggle with electricity consumption, a larger proportion of buildings are performing at or below the electricity benchmark. This suggests that, relatively speaking, the buildings are in a better position regarding electricity efficiency. However, there are still opportunities for improvement in the 2 buildings that exceed the benchmark. The benchmarking analysis of public buildings registered in the ENERGATE platform reveals a critical disparity between heating and electricity efficiency.

Commercial buildings

The study included 17 registered commercial buildings, largely from Italy and to a lesser degree from France and compared their performance against CIBSE benchmarks. A key conclusion is that the climate zone influences heating needs, with the Mediterranean zone generally showing lower heating consumption relative to benchmarks compared to the semi-continental zone. Many of the commercial buildings in this category, particularly restaurants and shopping centres in the Mediterranean climate, demonstrate good heating efficiency compared to their benchmarks.

Building type seems to be a significant factor. Restaurants (specifically fast food) show a different pattern than retail, potentially due to their specific operational needs and internal heat generation. Shopping centres, despite their larger size, appear to be relatively efficient in heating but have mixed electricity performance.

Industrial buildings

The study examined 9 registered industrial buildings from Italy and compared their performance against CIBSE benchmarks. A consistent trend across most of the listed industrial buildings (factories and general industrial) is significantly higher electricity consumption compared to their respective benchmarks, regardless of the climate zone. This suggests a potential area for major energy efficiency improvements in the electrical systems and processes within these industrial facilities. Heating efficiency shows a more mixed picture. While most industrial buildings show lower heating consumption than the benchmark, one building stands out with extremely high heating consumption.

Office buildings

The study includes 2 registered office spaces from Italy and France and compared their performance against CIBSE benchmarks. The buildings show significant deviations from their respective benchmarks, highlighting opportunities for targeted energy efficiency measures. The office spaces show contrasting performance between electricity and heating.

Healthcare facilities

The study includes 21 registered healthcare facilities France and Italy, and compared their performance against CIBSE benchmarks

For retirement homes in France, the climate zone does not appear to have a drastically different impact on energy consumption relative to their benchmarks. The trends are relatively consistent across Semi-continental, Mediterranean, and Oceanic climates, with both electricity and heating slightly exceeding their respective benchmarks.

The type and scale of the healthcare facility (e.g., large hospital complex vs. smaller retirement home or office within a hospital) seem to be a more significant driver of energy consumption, especially in the Intermediate climate zone. Larger hospitals tend to have much higher heating consumption.

Two out of the three healthcare facilities in Italy demonstrate notably higher electricity consumption than the benchmark. This suggests potential inefficiencies in their electrical systems, equipment usage, or operational practices.

User feedback

The ENERGATE platform's development was based on extensive stakeholder consultations across Europe, particularly within the pilot countries (Greece, Italy, Spain, France, Austria, Latvia) and extending to Ireland, Belgium, Hungary, and Croatia. The primary aim of this engagement was to ensure the platform's plurality, usefulness, and user-friendliness, especially concerning the project entry front-end. General feedback highlighted strong initial interest in the platform, coupled with concerns regarding data management (ownership, access, validation, and long-term operation). Users emphasized the need for trust in the platform's data and the identity of its participants.

The building aggregation function for financing created significant interest, with implementors taking the lead in creating aggregates with platform support. It was suggested to analyze user profiles to understand the rationale behind potential matches which resulted in the development of a User Performance System. This system analyses user activity to enhance engagement and performance, providing indicators (badges, etc.) to showcase platform activity and suitability as potential partners. Liability and reputation management are crucial aspects for this feature. Users expressed the need for a database of successfully implemented past projects to learn from best practices. The provision of predictions, statistics, and visualized results was also requested to support in understanding project impacts and validating results. In addition, the validation phase was extended beyond energy and financial gains to include non-energy benefits such as social inclusion, indoor air quality, and occupant health.

In summary, the ENERGATE platform is designed to streamline the building energy renovation process by acting as a central intermediary. Its core functionality is to facilitate a transparent and efficient connection between four key user groups: building owners, qualified implementors, financiers and public bodies. The platform's central feature is its AI algorithm. Once user profiles are established, the algorithm processes this data to identify optimal matches between the four user groups. For example, a homeowner's renovation project is automatically linked to financiers offering suitable loan products and to implementors with the required expertise and availability. This process effectively standardizes and aggregates heterogeneous projects into comparable, data-rich profiles. The standardized data format and the digital interactions ensure a higher degree of data reliability. For financiers, this means they no longer have to conduct extensive, project-specific due diligence to assess economic viability. The platform provides them with a structured overview of a project's key metrics, allowing for more efficient, portfolio-based lending decisions.

Analytical framework

The research analyzes the ENERGATE platform's features, specifically focusing on how its functionalities address the market failures identified in the literature review. This framework goes beyond a conceptual analysis by integrating insights from the platform's architecture, user-specific functionalities, and empirical data from the pilot projects.

Addressing information asymmetry

The platform's ability to standardize projects is the primary mechanism for reducing information asymmetry, particularly the "lemons problem" where the lack of reliable data discourages investment. ENERGATE directly addresses this by creating a structured and transparent information base for all four user types: Building Owners, Implementors, Financiers, and Public Bodies.

During the Fetch Stage, the platform requires users to input building and project data into a uniform format. This standardization is critical, as it transforms diverse, heterogenous projects into quantifiable data points. For financiers, this is a significant de-risking factor, as they can accurately and rapidly assess a project's risk and returns without costly, individual due diligence. The platform further enhances this by providing automated calculations for key financial indicators such as Payback Time, Net Present Value (NPV), and Internal Rate of Return (IRR). The transparency of contractor portfolios and the development of a User Performance System with badges and rankings also fosters a foundation of trust and accountability, directly addressing user feedback regarding the need for reliable partner verification.

Lowering transaction costs

The platform directly addresses high transaction costs through its core functions of aggregation and automation, primarily executed during the Process Stage. Instead of engaging in costly and time-consuming individual searches, financiers can access a large, pre-qualified pool of projects through a single digital interface. The AI-driven matchmaking process automates the initial search and filtering, drastically reducing the time and resources required to find viable investment opportunities.

Similarly, the platform's ability to aggregate fragmented profiles of multiple building owners creates a more predictable and efficient pipeline of projects for Financiers and Implementors. This aggregation of both project supply creates significant network effects, leading to greater market liquidity and efficiency. The platform further lowers transaction costs by offering business matchmaking, quality assessments, and data exchange, which streamline interactions and reduce the need for external services.

Validating the framework with pilot data and user feedback

The analytical framework is validated by the insights and data gathered from five pilot projects across six EU countries. These pilots provide empirical evidence that the platform's functionalities effectively address market failures in practice. The benchmarking exercise, for instance, revealed specific and disproportionate heating inefficiencies in public buildings, highlighting a clear area for targeted improvements that the platform can facilitate.

User feedback from the pilot participants confirms that the platform's functions directly respond to market needs. The strong interest in the aggregation function for financing and the request for a User Performance System demonstrate that users see the platform as a tangible solution to issues of trust and project viability. The inclusion of non-energy benefits in the Deliver Stage – such as social inclusion and indoor air quality – further validates the platform's comprehensive approach to de-risking projects beyond purely financial metrics, which is crucial for attracting a broader range of investors and stakeholders.

The subsequent chapters will present findings from the case study analysis, supported by platform data and stakeholder interviews.

Results and findings

Since the platform is still in its post-development, initial phase this chapter presents the hypothetical results and observations from the platform's implementation, demonstrating how the ENERGATE project is expected to address key market failures. The findings are based on a synthesis of the platform's design principles, a projected analysis of market trends and technical data, as well as insights gathered from stakeholder feedback, which together validate the potential efficacy of the platform's features.

Impact on transaction costs

The core objective of the ENERGATE platform is to reduce transaction costs, which have historically hindered the energy efficiency market. A hypothetical analysis would show that the platform's centralized database and standardized project data would significantly reduce the time and resources required for due diligence. The theoretical model suggests that, by providing pre-screened, validated project information, the platform would cut the time needed for financiers to source and evaluate a portfolio of projects by an estimated *70%.* This conceptual projection is based on tested user workflows and the breakdown of the typical steps and associated time a financier would face *without* a platform like ENERGATE.

a) Project origination and sourcing: this involves manually searching for viable projects. A financier might spend a significant amount of time (estimated 30% of total time) networking, reviewing ad-hoc project proposals, or scouring public databases (European Federation of Engineering Consultancy Associations, 2001).
b) Preliminary due diligence: once a potential project is found, the financier must spend time gathering basic information, such as building plans, energy audit reports, and ownership details. This step is often slow and inefficient due to a lack of standardized data (25% of total time) (Phase 1. Guide, n.d.).
c) Legal and administrative costs: This includes drafting contracts, securing legal counsel, and handling paperwork (10% of total time) (Tonello & Singer, 2015).
d) The remaining time and costs associated with in-depth technical analysis and legal work would still exist but would also be streamlined by the platform's tools and standardized data, leading to a further hypothetical efficiency gain of about 15% (Bindeeba et al., 2025). This brings the total projected time savings to approximately 70%.

This efficiency gain would not only lower direct costs (e.g., staff hours, travel for initial inspections) but also dramatically shorten the project-to-funding timeline, making it a more attractive investment class.

Sensitivity Analysis

The initial 70% time saving estimate is calculated by assuming near-total elimination of manual steps (project origination, preliminary due diligence, legal/administrative) plus an additional streamlining of the remaining technical work. The projection is highly sensitive to the platform's ability to fully automate the largest components: Sourcing (30%) and Preliminary Due Diligence (25%).

Scenario 1: sensitivity to project sourcing and origination (30% Component)

The largest time component is the 30% spent on manual project origination and sourcing (networking, reviewing ad-hoc proposals). The 70% estimate assumes ENERGATE effectively eliminates this manual effort by providing a pre-filtered, centralized pipeline of viable projects.

- Assumption failure: if the platform only achieves 50% effectiveness in replacing manual sourcing (meaning financiers must still spend 15% of their time on external sourcing), the total projected time saving drops immediately from 70% to approximately 55%.
- Implication**:** if the platform's marketing, data quality, or reach is insufficient to fill the pipeline, the 70% target becomes unattainable.

Scenario 2: sensitivity to data standardization (25% Component)

The second largest component is the 25% dedicated to preliminary due diligence: gathering basic, non-standardized information like building plans and energy audit reports. The 70% estimate relies on the platform providing this data in a standardized, pre-screened format.

- Assumption failure: if the data provided by ENERGATE is incomplete or requires substantial manual validation by the financier, reducing the effectiveness of this component by half (meaning 12.5% of time is still spent on preliminary due diligence), the total projected time saving falls from 70% to approximately 57.5%.

- Implication: time saving is deeply dependent on the quality and trustworthiness of the platform's validated data. If financiers do not trust the "pre-screened" data, they will continue to perform manual checks, negating the primary value proposition.

Mobilization of green capital

The aggregation feature is designed to directly address the needs of large-scale investors, such as ESG funds and institutional banks, that typically avoid small, individual projects. The platform's ability to bundle multiple, smaller energy efficiency projects into a single, cohesive investment opportunity would be a key factor in mobilizing green capital. This aggregation would provide investors with a diversified portfolio of projects that meets their minimum deal size requirements while simultaneously mitigating risk. This demonstration of a robust and de-risked project pipeline would be critical for attracting substantial investment flows, effectively connecting the supply of green capital with the demand for project funding.

The ENERGATE platform targets a significant and growing market. According to Gangadia and Guo's (2024) calculation as of mid-2024, approximately 51.6% of the European Union's total fund assets are allocated to sustainability-related, including ESG investments. This means that sustainability-focused funds represent €7.23 trillion out of EU's total fund market size of €14 trillion.

Out of the total EU ESG investments, approximately 15–25% is directed toward building energy efficiency projects. This includes renovation and retrofitting of public and private buildings, insulation, heating system upgrades, and renewable energy integration and smart building technologies and automation systems. Beyond private capital, significant public funds are also being mobilized. Under the 2021–2027 Cohesion Policy, the EU allocated €25 billion for energy efficiency measures, of which €17 billion specifically targets building energy performance improvements. Additionally, the Recovery and Resilience Facility (RRF) and other EU funds are expected to bring the total investment in building renovation to over €66 billion by 2029 (Renovate Europe, 2023).

In summary, ENERGATE is positioned to address this huge and growing appetite for investment by providing a streamlined, efficient mechanism to channel both private and public green capital towards energy efficiency projects.

Market efficiency and project completion rate

The current deep renovation rate in the EU is only ~0.2% annually, far below what is needed to meet climate targets. According to the International Energy Agency (IEA) (2022), to meet the EU's 2030 goals, the annual deep renovation rate must exceed 2%. Platforms like ENERGATE are expected to contribute to a 2–3% increase in annual deep renovation rates, especially in targeted markets (public and residential buildings) (author's own estimation based on the ENERGATE project deliverables [2023–2025]). The platform's combined effect of reducing information asymmetry and lowering transaction costs would lead to a quantifiable improvement in overall market efficiency. It is expected that digital platforms', such as ENERGATE's streamlined process could substantially contribute to the required 2-3% in the annual deep renovation rate for public and residential buildings in the targeted markets. This increase would be a direct result of a more fluid project lifecycle, from initial identification and technical assessment, aggregation and matchmaking to final financial closure and implementation, signaling the platform's success in unlocking a previously under-utilized market segment.

Projected environmental and social outcomes

Beyond its core function of enhancing financial efficiency, ENERGATE's additional impact is defined by its contribution to key European climate, energy transitions and social objectives:

Climate and energy impacts

- CO_2 emission reduction: the deep renovation projects accelerated by ENERGATE are projected to reduce CO_2 emissions by an estimated 60-90% compared to pre-renovation levels (Buildings Performance Institute Europe [BPIE], 2021). The standardized data sheets provided by the platform (which include calculated energy performance certificates and post-renovation energy demand) would ensure that the environmental impact is measurable, transparent, and verifiable by ESG investors.

- Primary energy demand reduction: deep renovations typically result in primary energy demand reductions of over 60%, a figure consistent with achieving nearly Zero-Energy Building (nZEB) standards in retrofits (D'Agostino, et al., 2017). By validating and financing these projects, the platform contributes directly to the EU's Energy Efficiency First principle and reduces dependency on imported fossil fuels, bolstering energy security.

Social impacts

- Energy poverty mitigation: a significant portion of the platform's target market is the residential sector. By enabling financing for deep renovation, ENERGATE directly helps reduce the energy consumption of vulnerable households, lowering their utility bills and mitigating energy poverty. This prioritization aligns with the principles of the EU's Renovation Wave strategy (European Commission, 2020b), which emphasizes tackling energy poverty through efficient retrofits.
- Green job creation**:** the increase in renovation activity driven by improved financing is expected to create local green jobs. For every €1million invested in building renovation, an estimated 18 jobs are created or sustained (Renovate Europe, 2020). The platform therefore serves as a catalyst for economic recovery and the development of a skilled, green workforce.
- Improved health and comfort: deep renovations result in improved indoor air quality, better thermal comfort, and reduced maintenance costs for building occupants, leading to quantifiable public health benefits that lessen the burden on national health services.

In summary, the results from both the projected pilot data and user consultations would demonstrate that the ENERGATE platform is a viable and effective solution. Its staged architecture and user-centric features are designed to successfully address the market failures of information asymmetry and high transaction costs, paving the way for a more liquid and efficient market for energy efficiency projects in the building sector.

Table 2: Systemic summary of ENERGATE pilot findings and strategic impacts

Area of analysis	Main finding (assessment result)	Observed or expected impact
Benchmarking: public buildings	Disproportionate heating inefficiency: 50% (11/22) of public buildings exceeded the heating benchmark, while only 9% exceeded the electricity benchmark.	Validates heating systems and thermal envelopes as the most critical and high-impact areas for targeted deep renovation financing in the public sector.
Benchmarking: industrial buildings	Consistent trend of significantly higher electricity consumption compared to benchmarks across most facilities, regardless of the climate zone.	Highlights electrical systems and industrial processes as the primary focus for major energy efficiency improvements.
Benchmarking: commercial buildings	Performance is sensitive to climate zone (Mediterranean shows lower heating consumption) and building type (restaurants vs. retail have distinct operational patterns).	Necessitates the platform's use of typology- and climate-specific filters (based on CIBSE standards) to ensure accurate analysis and tailored solution matching.
Benchmarking: office buildings	Significant deviations from benchmarks with contrasting performance observed between electricity and heating consumption in the small sample.	Highlights immediate opportunities for targeted energy efficiency measures that address the specific, asymmetrical inefficiencies (e.g., HVAC versus IT/plug loads).
Benchmarking: healthcare facilities	Facility type and scale (e.g., large hospitals) were more significant drivers of high energy consumption (especially heating) than climate zone.	Supports the platform's ability to segment and aggregate large, complex projects, matching them effectively with suitable institutional financing pools.
User feedback	Strong interest in the aggregation function and demand for a User Performance System (badges, rankings) to verify partner reliability.	Fosters trust and accountability among the four key user groups (Owners, Implementors, Financiers, Public Bodies).
Reducing transaction costs	Hypothetical analysis shows the standardized data and centralized database can cut financier due diligence time by an estimated 70%.	The platform lowers investment barriers and shortens the project-to-funding timeline, making energy efficiency a more liquid and attractive asset class.

Mobilization of green capital	Platform's function to aggregate, standardize, and transparently report (ESG metrics, financial KPIs) across diverse, fragmented projects facilitates the mobilization of green private capital.	Unlocks dedicated institutional and ESG capital pools by making energy efficiency projects suitable for large-scale, standardized investment vehicles (e.g., green bonds, funds).
Market efficiency and project completion rate	Platform is expected to contribute to a 2–3% increase in annual deep renovation rates in targeted markets (public and residential buildings).	Leads to a quantifiable improvement in overall market efficiency, enabling the EU to close the gap on its required renovation targets (currently ~0.2% annually).
Information asymmetry	Standardization (Fetch Stage) and automation of key financial indicators (Payback Time, NPV, IRR) are core functionalities.	De-risks projects for financiers by providing structured, transparent information, thereby solving the "lemons problem" and boosting investor confidence.
Climate and energy outcomes	Projects are projected to reduce CO_2 emissions by 60–90% and achieve Primary Energy Demand reductions over 60% (nZEB standard).	Ensures the environmental impact is measurable, transparent, and verifiable by ESG investors while bolstering EU energy security by reducing fossil fuel dependency.
Social outcomes	Improved renovation rate in the residential sector helps mitigate energy poverty. The increased level of deep renovation activity is expected to create green jobs (18 jobs per €1M invested).	Directly aligns with the EU's Renovation Wave strategy, improving health and thermal comfort for occupants and serving as a catalyst for economic recovery.

Source: Author's own elaboration

Conclusions, policy implications, and limitations

This final section summarizes the main findings from the platform's implementation and discusses their broader significance for both academic theory and practical application. It concludes by acknowledging the study's limitations and proposing a roadmap for future research.

Summary of findings

The analysis of the ENERGATE platform's conceptual implementation demonstrates its significant potential to address two major market failures in the building energy efficiency sector: *information asymmetry* and *high transaction costs*. The platform offers a centralized, digital database, standardizes heterogeneous project data, and conducts due diligence efficiently. The aggregation of numerous small-scale projects into larger, more attractive portfolios is a key innovation, directly addressing the size requirements of institutional investors and ESG funds. This process is projected to reduce the time and resources needed for project evaluation, thereby lowering transaction costs for all participants. Furthermore, the incorporation of stakeholder feedback and user-centric features, such as data validation and a User Performance System, is critical for building the trust required to foster a liquid and transparent marketplace. In essence, the platform acts as a digital market maker, transforming a fragmented landscape into a coherent and investable market for energy renovations.

Implications for theory and practice

The development and hypothetical outcomes of the ENERGATE platform offer notable implications for both academic theory and practical application.

- *For Theory*: The platform's model provides a practical example of a *two-sided market* in the context of sustainable finance, where network effects are driven by both the number of viable projects and the availability of green capital. It highlights how a digital intermediary can de-risk green investments and overcome the green finance gap by leveraging technology to standardize data and create economies of scale in an otherwise illiquid market. This model can serve as a theoretical foundation for understanding how to digitize and scale other fragmented sustainability-focused markets.
- *For Practice*: For policymakers, the findings suggest that targeted digital initiatives can be a powerful complement to traditional policy instruments like subsidies and tax incentives. It is recommended that policymakers support the development and application of such platforms by creating supportive regulatory frameworks, standardizing data protocols, and providing incentives for broad participation and

data sharing. For industry leaders, the platform demonstrates that collaboration and the use of technology can unlock significant investment opportunities. Adopting a data-driven approach to project management and using such platforms for project origination and financing can lead to greater efficiency and access to a broader range of capital.

Limitations and Future Research

This study's primary limitation is its reliance on hypothetical data and projected outcomes from a pre-implementation model. The ENERGATE platform is still in its early phase, and its practical application is therefore limited. While the findings are theoretically sound and grounded in stakeholder feedback, they have not yet been validated by real-world, long-term empirical evidence from a fully operational platform. Consequently, the actual reduction in transaction costs or increase in market efficiency may differ from these projections. A future revision of this analysis will be needed after a few years of testing to confirm the platform's actual benefits.

Future research should focus on a longitudinal study of the platform after its full-scale deployment. A comparative analysis could be conducted to empirically measure the platform's impact on energy consumption, property values, and the annual renovation rate against control groups that do not use the platform. Researchers could also investigate the scalability of this model to other sectors, such as renewable energy or water management projects, and explore how different business models could impact the platform's long-term sustainability and market penetration.

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