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Analysis of Financing Instruments for Investments in Photovoltaic Systems with Energy Storage in the Industrial Sector

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Abstract

The current dissertaion examines the role of available financial instruments in improving the economic attractiveness of investments in photovoltaic systems, which are combined with energy storage systems for industrial applications. More specifically, this analysis focuses on the financial instruments, that are proposed in the Roadmap for the Energy Efficiency of Buildings, as it had been published in the Government Gazette in July 2025. In this light, their potential application in the PETech investment project of Nera Kritis S.A. was evaluated. The methodology, that ahd been followed, was based on quantitative financial analysis, but also on the alternative financial mechanisms' comparative evaluation. Thus, a representative investment scenario for the installation of a 1 MWp photovoltaic system in combination with a 2 MWh energy storage system, had been developed. For this scenario, cash flow, Net Present Value (NPV), Internal Rate of Return (IRR) and payback period analyses had been performed. At the same time, different financing scenarios were examined. These included for instance self-financing, subsidies, bank loans, leasing, ESCO models and Power Purchase Agreements (PPAs). The results showed that the investment can become financially viable and this happens even without receiving external financial support. However, subsidies and mixed financing schemes improve efficiency indicators and at the same time, they manage to reduce investment risk. In conclusion, this study points out that the combination of public support and limited borrowing is the optimal financing solution for industrial enterprises, which seek their energy transition, while maintaining their financial flexibility and competitiveness.

Keywords

Photovoltaic Systems, Energy Storage, Financial Tools, Industrial Investments.

Περίληψη

Η παρούσα διπλωματική εργασία εξετάζει τον ρόλο των διαθέσιμων χρηματοδοτικών εργαλείων στη βελτίωση της οικονομικής ελκυστικότητας των επενδύσεων σε φωτοβολταϊκά συστήματα, τα οποία είναι συνδυασμένα με συστήματα αποθήκευσης ενέργειας για βιομηχανικές εφαρμογές. Πιο συγκεκριμένα, η παρούσα ανάλυση επικεντρώνεται στα χρηματοδοτικά μέσα, που προτείνονται στον Οδικό Χάρτη για την Ενεργειακή Απόδοση των Κτιρίων, όπως δημοσιεύθηκε στην Εφημερίδα της Κυβερνήσεως τον Ιούλιο του 2025. Στο πρίσμα αυτό, αξιολογήθηκε η δυνητική εφαρμογή τους στο επενδυτικό έργο PETech της εταιρείας Νερά Κρήτης Α.Β.Ε.Ε. Η ακολουθούμενη μεθοδολογία βασίζεται σε ποσοτική χρηματοοικονομική ανάλυση, αλλά και στη συγκριτική αξιολόγηση εναλλακτικών χρηματοδοτικών μηχανισμών. Έτσι, αναπτύχθηκε ένα αντιπροσωπευτικό επενδυτικό σενάριο εγκατάστασης φωτοβολταϊκού συστήματος ισχύος 1 MWp σε συνδυασμό με σύστημα αποθήκευσης ενέργειας 2 MWh. Για το σενάριο αυτό πραγματοποιήθηκαν αναλύσεις ταμειακών ροών, Καθαρής Παρούσας Αξίας (NPV), Εσωτερικού Βαθμού Απόδοσης (IRR), αλλά και περιόδου αποπληρωμής. Παράλληλα, εξετάστηκαν διαφορετικά χρηματοδοτικά σενάρια, εντός των οποίων συμπεριλήφθηκαν η αυτοχρηματοδότηση, οι επιδοτήσεις, ο τραπεζικός δανεισμός, η χρηματοδοτική μίσθωση, τα μοντέλα ESCO και οι Συμφωνίες Αγοράς Ενέργειας (PPAs). Εκ των προκυπτόντων αποτελεσμάτων διαφάνηκε ότι η επένδυση μπορεί να καταστεί οικονομικά βιώσιμη ακόμη και χωρίς να λαμβάνεται εξωτερική χρηματοδοτική υποστήριξη. Ωστόσο, οι επιδοτήσεις και τα μικτά σχήματα χρηματοδότησης βελτιώνουν τους δείκτες αποδοτικότητας και την ίδια στιγμή, καταφέρνουν να μειώνουν τον επενδυτικό κίνδυνο. Εν κατακλείδι, από την παρούσα μελέτη εξάγεται το συμπέρασμα ότι ο συνδυασμός δημόσιας ενίσχυσης και περιορισμένου δανεισμού αποτελεί τη βέλτιστη χρηματοδοτική λύση για τις βιομηχανικές επιχειρήσεις, οι οποίες επιδιώκουν την ενεργειακή τους μετάβαση, διατηρώντας παράλληλα τη χρηματοοικονομική τους ευελιξία και ανταγωνιστικότητα.

Λέξεις - Κλειδιά

Φωτοβολταϊκά Συστήματα, Αποθήκευση Ενέργειας, Χρηματοδοτικά Εργαλεία, Βιομηχανικές Επενδύσεις.

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List of Abbreviations & Acronyms

ESCO	Energy Service Companies
RES	Renewable Energy Sources
IEA	International Energy Agency

1. Introduction

1.1 Background and Context

In line with the European Union's objective to reduce greenhouse gas emissions by 55% by 2050 compared to 1990 levels, with the ultimate goal of achieving climate neutrality, the transition towards alternative energy production technologies based on Renewable Energy Sources (RES), as well as the overall reduction of energy consumption, constitutes an unavoidable pathway for the sustainable attainment of this target. Furthermore, the continuously increasing cost of energy, results from dependence on fossil fuel-based energy production and the successive geopolitical crises, following the COVID-19 pandemic. Taking this into consideration, issues of energy security emerge for industrial enterprises and producers. In this context, energy costs represent a risk factor for the economic viability of the industrial activities.

The electrification of the energy market, when it is combined with large-scale deployment of RES projects, constitutes a strategic planning's main pillar across all European Union member states. Its aim is to achieve the established energy and climate objectives, as well.

Additionally, the decoupling from fossil fuel use has the potential to increase energy democracy. It also might reduce exposure to geopolitical risks, that are associated with energy supply disruptions.

In order for these objectives to be achieved, each country creates its own national strategy, about the technologies and financing instruments, that can be integrated and used. Taking into account the Greece's geographical location and its high solar potential, the development of an energy strategy, that is centred on photovoltaic systems, represents a basic pathway for sustainable growth. Also, the parallel deployment and utilisation of energy storage systems increases even more the energy security. Therefore, it contributes to the reduction of the operational costs, that are linked with renewable energy installations.

More specifically, the energy upgrading and transition of the industrial sector is important, and the reason is that the Greek industry shows a high degree of exposure to energy price volatility. This, in turn, undermines its international competitiveness. Moreover, the industrial sector constitutes the third largest energy consumer in the Greek state. This means that the rationalisation of energy use in the context of the industrial activities may significantly contribute to the national decarbonisation targets' achievement.

1.2 Problem Statement

Energy storage technologies are still, to date, a financially challenging investment. It is a fact that battery-based energy storage systems have reached a sufficient level of technological maturity. They are also already implemented in practical applications. Despite this, they continue to be associated with a high initial investment cost.

In addition, the payback period of such investments is long and this fact, further discourages the adoption. For the cases of the industrial enterprises, that rely on internal capital to finance these systems, the high upfront cost necessitates the allocation of significant financial resources. This leads to reduced liquidity. In a continuously evolving and volatile market environment, like the Greek economy's case, limited liquidity may pose a risk to the long-term viability of industrial operations.

At the same time, the lack of accessible and appropriately structured financing instruments constitutes a barrier to the energy storage technologies' adoption. The limited access to financing options, especially when it is combined with the tendency of financial institutions to classify renewable energy projects as high-risk investments, fails to create the favourable conditions for industrial investment, in energy storage systems. This leads to the result that many industrial enterprises are unable to proceed with such investments and this happens despite their potential economic and operational benefits.

Consequently, a gap emerges between the technological capability for deploying energy storage solutions and their economic implementation, at least in practice. Therefore, the challenge lies in the institutional, regulatory, and financial mechanisms, that govern investment financing. These constraints' addressment, through appropriate public policies and financial frameworks, is important and necessary, in order to enable the accelerated adoption of energy storage technologies in the industrial sector.

1.3 Research aim and objectives

The aim of this dissertation is to analyse the financing instruments, that have been announced as candidates for adoption within the Greek territory, as it is outlined in the Roadmap for Energy Efficiency in Buildings, that is published in the Government Gazette on 15 July 2025. These instruments' evaluation is conducted in the context of a planned investment involving the installation of a photovoltaic system, that is combined with energy storage at the facilities of Nera Kritis S.A.B.E.E., specifically at the company's central warehouse in Thebes, that operate under the project designation PETech.

This analysis focuses on the assessment of the proposed financing instruments using the Net Present Value (NPV) method, their comparison with conventional financing mechanisms, and the evaluation of their suitability for industrial applications. Through this comparative financial assessment, the study seeks to identify the key advantages and limitations of each financing instrument and to examine their impact on the economic feasibility of investments in photovoltaic systems with energy storage.

Finally, based on the outcomes of the analysis, the dissertation aims to provide practical guidance regarding the potential future adoption of these financing instruments, with the overarching objective of supporting the economic viability and competitiveness of Greek industrial enterprises in the context of the energy transition.

1.4 Research Questions

The main research question, that guides this dissertation is the following:
"To what extent do the available financing instruments improve the financial attractiveness and feasibility of investments in photovoltaic systems with energy storage for industrial applications?"
In order for the provision of an answer to the above central question, several secondary research questions are formulated, and they are the following ones:

1. What are the key financial characteristics and structural differences between traditional and alternative financing mechanisms applied to renewable energy investments?

2. How do different financing instruments affect key investment indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and payback period?
3. What are the main risks associated with each financing option, and how are these risks distributed among stakeholders?
4. Which financing structure emerges as the most suitable for industrial enterprises operating in the Greek market, taking into account both financial performance and risk exposure?

1.5 Methodological Approach and Research Design

The methodological approach, that is adopted in this dissertation's context is based on a quantitative financial analysis. This analysis is combined with a financing instruments' structured comparative evaluation. It is also mentioned that the current research design follows an applied case-based methodology, that focuses on a representative investment scenario, involving a photovoltaic system's installation, that is integrated with energy storage, in an industrial setting.

This analysis' core is the development of a base case investment model. This model reflects realistic operational and financial parameters, that are relevant to the Greek industrial sector. Even more, the model incorporates assumptions regarding energy consumption, system capacity, installation costs, operating expenses, and expected energy savings. Based on the above mentioned inputs, the projected cash flows are calculated over the lifecycle of the investment.

The evaluation of the investment is conducted through the use of widely accepted financial metrics. These metrics, for instance, include Net Present Value (NPV), Internal Rate of Return (IRR), and payback period. These indicators are used for the economic performance's assessment of the project under different financing scenarios.

Mainly, the study examines the impact that the alternative financing structures, such as subsidies, loans, leasing arrangements, and other policy-supported mechanisms, have on the overall financial outcome. Furthermore, a comparative analysis is done, in order for the evaluation of the effectiveness of each financing instrument. This comparison is based on several criteria, like for instance cost of capital, risk allocation, liquidity implications, and overall contribution to investment feasibility.

1.6 Structure of the Dissertation

The present dissertation is structured into seven chapters, as following:

At first, the current Chapter 1 introduced the research context. It also outlined the problem statement, defined the aim and objectives of the study and presented the research questions, methodology and overall structure of the dissertation.

Then, Chapter 2 offers an overview of photovoltaic systems and energy storage technologies in the industrial applications' context. This analysis including their economic benefits and their operational characteristics, as well. It also includes the role within the broader energy transition framework.

Afterwards, Chapter 3 presents the theoretical and financial framework, that underpines renewable energy investments. The analysis of this chapter focuses on the investment evaluation methods, on the cost structures and finally, on the risk assessment.

Then, Chapter 4 analyses the various financing mechanisms, that are available for photovoltaic and energy storage investments. This analysis includes for instance, traditional, alternative, and policy-driven instruments. This chapter also offers a comparative evaluation of their characteristics.

Chapter 5 develops and analyses the base case investment scenario. This chapter presents the financial modelling results, that came under different assumptions and financing structures.

Then, Chapter 6 builds upon the results of the base case analysis. Its aim is to to evaluate the effectiveness of the examined financing instruments. This chapter, also aims to identify the most suitable financing strategies for the industrial applications.

Finally, Chapter 7 summarises the main findings of the current dissertation. This chapter offers answers to the research questions. It also offers practical recommendations for industrial firms, financial institutions and policymakers. Finally, it presents suggestions for future research.

2 Industrial Photovoltaics and Energy Storage Systems

2.1 Overview of Photovoltaic Systems in Industrial Applications

Photovoltaic (PV) systems have emerged as one of the most widely adopted renewable energy technologies worldwide. This happens especially due to their technological maturity and their declining installation costs. Another reason is that they have the ability to generate electricity without direct greenhouse gas emissions. In industrial environments, photovoltaic systems are recognised as strategic assets. They contribute on the one hand to environmental sustainability and, on the other hand, to operational efficiency and energy cost management (International Energy Agency [IEA], 2024).

Industrial facilities are suitable for photovoltaic deployment. The reason is that they typically possess large roof surfaces and available land areas, inclidinf substantial daytime electricity demand, as well. These characteristics enable a high degree of self-consumption. Thay also allow generated solar electricity to be utilised directly in the industrial processes. This means that it doesn’t need to be exported to the electricity grid. Consequently, industrial enterprises might reduce their dependence on external electricity suppliers. They might also mitigate their exposure to electricity price volatility (IRENA, 2023).

At this point, it is mentioned that a typical industrial photovoltaic installation consists of solar modules and inverters. It also includes mounting structures, monitoring systems, electrical protection equipment and grid connection infrastructure, as well. The solar modules convert solar radiation into direct current (DC) electricity. At the same time, inverters transform this electricity into alternating current (AC). This might be used by industrial equipment and facilities. The advances in photovoltaic technology have improved module efficiency and they have succeeded it through commercial systems, that frequently exceeding conversion efficiencies of a percentage of 20%. Thereby, this enhances the economic attractiveness of solar investments (Fraunhofer ISE, 2024).

It is a fact that industrial photovoltaic systems’ adoption has accelerated during the last decade. More analytically, the global cumulative solar photovoltaic capacity surpassed 1.6 TW in 2024. This reflects the growing role, that solar energy plays in industrial decarbonisation strategies (IEA, 2024).

Beyond the undoubdably existing environmental benefits, industrial photovoltaic systems offer significant economic advantages. They reduce electricity procurement costs. They, at the same time, improve long-term budget predictability, while strengthening corporate competitiveness, too. Furthermore, the increasing adoption of Environmental, Social, and Governance (ESG) criteria, on the one hand by investors and on the other hand by financial institutions, has created additional incentives for the industrial companies to invest in renewable energy infrastructure (European Commission, 2024).

Nevertheless, the photovoltaic systems' implementation also presents some challenges. Initial capital requirements stay significant and this particularly happens for large-scale industrial installations. Additional constraints include regulatory procedures and grid connection limitations. They also include variability in solar generation and the need for complementary technologies, as well, with energy storage systems being a characteristic example. This happens in order to maximise self-consumption and increase the levels of operational flexibility, too (Luthander et al., 2015).

2.2 Energy Storage Technologies for Industrial Use

Energy storage technologies have become a main and critical component of modern industrial energy systems. This happens particularly in environments, that are characterised by the increasing renewable energy sources' penetration. At the time when photovoltaic systems generate electricity intermittently and when they depend on solar irradiation conditions, the energy storage systems offer the capability to store surplus electricity. They also offer the capability to release it, when production is insufficient or in the cases of which the electricity demand is elevated. As a result, the storage technologies increase the energy flexibility and they improve the existing reliability, while at the same time, they increase the general renewable energy investments' value (Luo et al., 2015).

Among the available storage technologies, lithium-ion battery energy storage systems (BESS) have become the industrial applications' dominant solution. In more analysis, it is mentioned that their widespread adoption is attributed to declining costs and high energy density. It is also linked with fast response times and continuously improving operational performance, as well. Lithium-ion batteries are able to achieve round-trip efficiencies exceeding 85-90%. This makes them being suitable for industrial facilities, that seek to optimise self-consumption of photovoltaic electricity and to reduce the grid dependence (Zakeri & Syri, 2015).

In addition to lithium-ion systems, other storage technologies are available for industrial use. For example, lead-acid batteries are still utilised in specific applications. This happens due to their relatively low acquisition cost. Although, they exhibit lower energy density and shorter operational lifetimes. Flow batteries, that include beyond others, vanadium redox flow batteries, offer longer cycle life. They also offer enhanced scalability. These characteristics make them suitable for large-scale industrial installations, that require extended storage durations. Then, mechanical storage technologies, like for example pumped hydro storage and compressed air energy storage, offer large storage capacities. On the other hand, they are generally limited by geographical and infrastructural constraints. Finally, the thermal energy storage systems are also able to be employed in industries that have significant heating and cooling requirements. This enables the thermal energy's storage for later use (Chen et al., 2009).

The battery storage's integration in industrial facilities creates many operational benefits. One of them is peak shaving. Whereby stored electricity is discharged during periods of high electricity demand. This reduces the peak power's consumption from the grid. It consequently lowers demand charges. Even more, the storage systems facilitate load shifting. At this point, they allow industrial consumers to use electricity, that is generated or purchased during low-cost periods, at times when electricity prices are higher. In addition, battery systems improve power quality. Alsoi, they increase the resilience against grid disturbances or in comparison with temporary supply interruptions. This fact is particularly important for energy-intensive industrial processes (IRENA, 2017).

Despite the above-mentioned benefits, energy storage systems are still associated with significant economic and technical challenges. More analytically, the initial investment cost constitutes the most substantial barrier to adoption. This barrier particularly exists for medium-sized industrial enterprises. It is a fact that battery prices have declined considerably over the last decade. Despite that fact, storage investments continue to need substantial capital expenditure. Moreover, battery degradation over time, replacement costs, alongside with safety considerations and uncertainty about the future electricity market conditions, introduce additional investment risks (Schmidt et al., 2017).

2.3 Integration of PV and Storage in Industrial Energy Systems

The photovoltaic (PV) systems' integration with energy storage technologies represents one significant development, in the context of the modern industrial energy management. At the time when photovoltaic systems offer clean and cost-effective electricity generation, their intermittent nature limits the extent to which industrial facilities are able to fully utilise the energy that is produced. The addition of energy storage systems addresses this limitation. It does so, by enabling the capture of surplus electricity, during periods of high solar generation and its subsequent use, in the cases of which solar production declines or electricity demand increases. Consequently, the combination of PV and storage technologies creates a more flexible and economically industrial energy system (Denholm et al., 2010).

Industrial facilities often show electricity consumption profiles, which do not perfectly coincide with the patterns of photovoltaic generation. On the one hand, many industrial operations take place during daylight hours. On the other hand, despite that fact, fluctuations in production schedules and in seasonal demand variations and operational requirements, tend to create mismatches, that exist between energy generation and consumption. In the storage systems' absence, excess photovoltaic electricity is either exported to the grid or it remains unused. This reduces the overall economic value of the installation. The energy storage systems increase self-consumption rates and the achieve this by retaining surplus energy for later use. Thereby, this maximises the utilisation of the locally generated renewable electricity (Luthander et al., 2015).

The integration process typically involves a coordinated energy management system. This system continuously monitors photovoltaic generation and battery state of charge. It also monitors electricity demand and grid conditions. Advanced energy management software determines the optimal charging and discharging strategy, that is followed, in real time. This aims to minimise electricity costs and to keep operational reliability, as well. These kinds of systems incorporate predictive algorithms, which utilise weather forecasts and consumption patterns. They do so, in order to be able to optimise energy flows throughout the facility (Olivares et al., 2014).

One primary advantage of integrated PV and storage systems is the increase of energy autonomy. More analytically, the industrial enterprises might significantly reduce their reliance on electricity, that is purchased from the grid. Thereby, they might limit their exposure to fluctuations in wholesale electricity prices and in network charges. It is about a capability, that has become important, following the energy price volatility, that is experienced across Europe, especially after the pandemic crisis of the COVID-19 and the subsequent geopolitical disruptions, that affect the energy markets. After increasing self-sufficiency, the industrial business entities might improve on the one hand the operational stability and on the other hand their financial predictability (European Commission, 2024). Furthermore, the integrated systems contribute to grid stability. They also support broader energy transition objectives. At this point, the battery storage is able to offer ancillary services. Characteristic examples are frequency regulation, voltage support and peak demand management, too. This facilitates the integration of larger quantities of renewable energy into electricity networks. Examining the same issue from a sustainability perspective, it is noted that the combined deployment of photovoltaic generation and storage technologies contributes to greenhouse gas emission reductions. It, furthermore, supports corporate decarbonisation strategies (International Energy Agency, 2024).

Despite the above mentioned advantages, the successful integration requires careful technical. It also needs economic planning. At first, the system sizing is mainly important. The reason is that the oversized storage capacity may increase investment costs and it might do so, without generating proportional benefits, whereas undersized systems might fail to capture the already available photovoltaic surplus. Additionally, integration projects need compatibility between photovoltaic installations, battery technologies, energy management systems and the already existing industrial infrastructure, too (Akinyele & Rayudu, 2014).

2.4 Economic Benefits of PV + Storage (Self-consumption, Cost Reduction, Peak Shaving)

The combined deployment of photovoltaic systems and energy storage technologies offers economic benefits, for the cases of the industrial enterprises. These are benefits, that extend beyond the simple electricity generation. So, they encompass improvements in energy cost management, alongside with operational flexibility, risk mitigation and long-term competitiveness, too. It has to be considered that since energy prices continue to experience substantial volatility across international markets, the industrial organisations increasingly view integrated PV and storage systems, as strategic investments. They see them as investments, that are capable of delivering direct and indirect economic value, at the same time (International Energy Agency, 2024).

One important economic advantage is the increasing self-consumption. More analytically, self-consumption refers to the direct use of electricity, that is generated by a photovoltaic installation, in the industrial facility itself. Without the storage systems, the surplus solar electricity, that is produced during periods of low demand, is often exported to the grid at low compensation rates. Under the battery storage's incorporation, excess electricity might be stored. It might also be subsequently consumed during periods, in which photovoltaic production declines. Thereby, this increases the proportion of locally generated electricity, that is used on-site. Higher self-consumption rates improve the overall economic return of renewable energy investments. This happens especially due to the fact that they reduce the need to purchase electricity from external suppliers at retail market prices (Luthander et al., 2015).

One further major benefit is the overall energy costs' reduction. In more analysis, thw electricity expenditures represent a substantial component of operating costs, for many industrial firms. This is even more intensive in the energy-intensive sectors. The integrated PV and storage systems decrease electricity procurement requirements. They also provide protection against future increases in the energy prices (European Commission, 2024).

It is about an effect, which has become important following the energy market disruptions, that are observed throughout Europe during recent years. The industrial corporations, through securing a significant portion of their electricity demand, that happens through self-generated renewable energy, are able to achieve higher predictability in energy budgeting. They are also able to strengthen their levels of financial resilience (European Commission, 2024).

Even more, the peak shaving constitutes an additional economic value's source. Industrial electricity tariffs include, at least in the most cases, demand charges. These charges are based on the highest level of power consumption, that is recorded during specific billing periods. Also, these charges might represent a total electricity costs' considerable proportion. At this point, it is mentioned that the battery storage systems enable facilities to discharge the stored electricity, during the periods of high demand. By doing so, they reduce the maximum power, that is drawn from the grid. As a result, the business entities are able to significantly lower demand-related charges. They are also able to improve the efficiency of their electricity consumption profile (Akinyele & Rayudu, 2014).

Also, it has to be noted that the photovoltaic generation and storag's combination creates opportunities for load shifting. In that specific context, electricity, that is generated or stored during low-cost periods, might be used during the times, when the market prices are higher. It is about an offered capability, which is undoubtebly valuable in the electricity markets, which are characterised by dynamic pricing mechanisms and by increasing levels of variability in the wholesale electricity costs. The industrial enterprises, through an effective energy management, might optimise the electricity consumption's timing. At the same time, they are ablen to maximise their financial savings (Malik et al., 2025).

Beyond the direct cost reductions, the integrated systems contribute to an increased business competitiveness. They are also helpful to sustainability performance. It is a fact that the reduced energy expenses improve profit margins. It also strengthens the industrial firms's economic position, especially in thise firms that operate in competitive markets. Simultaneously, the lower carbon emissions support compliance with environmental regulations. Except of this, they align corporate activities with Environmental, Social, and Governance (ESG) objectives. Besides, the ESG objectives are becoming increasingly important on the one hand for the investors and customers, and on the other hand for the financial institutions (IRENA, 2023).

2.5 Technical and Operational Constraints

Despite the significant economic and environmental advantages, that are associated with the deployment of photovoltaic systems, that are combined with energy storage, several technical and operational constraints continue to influence their effectiveness. These constraints also influence their adoption in the industrial sector. Understanding these limitations is considered as necessary, because it might lead to accurately evaluating the feasibility and long-term performance of renewable energy investments. This is justified, based on the fact that technical challenges have the tendency to translate into financial risks and additional operational costs (Blaabjerg et al., 2017).

At first, it is mentioned that the solar electricity production depends directly on weather conditions. It also epends on seasonal variations and daily sunlight availability. Therefore, electricity generation is variable. This means that it is not able for it to be always aligned with the patterns that are followed by the levels of the industrial demand. Then, it is needed to be taken into account the fact that energy storage systems mitigate this challenge and they do so, by storing surplus electricity for later use. However, storage capacity is still finite. It is not able to completely eliminate fluctuations in energy availability. As direct result of this, is that industrial facilities continue to rely on grid electricity. It is necessary, because they need to ensure uninterrupted operations during periods of low solar generation or during extended adverse weather conditions (Luo et al., 2015).

Even more, the battery degradation represents one more operational challenge and in the context of this challenge, the energy storage systems, and especially the lithium-ion batteries, experience gradual performance deterioration over time. The reason that this happens is that there are repeated charging and discharging cycles. It is about a degradation, which reduces both storage capacity and operational efficiency, as well, and this happens throughout the system's lifetime. Consequently, industrial operators must account for future replacement costs and for maintenance requirements. They must also account for declining performance, in the cases of which they project economics are evaluated. Any failure to incorporate these factors into financial planning might end up in overly optimistic investment assessments (Schmidt et al., 2019).

In addition, industrial photovoltaic installations frequently need connection to the already existing electricity distribution networks. This need may have technical limitations. These potential limitations are associated with the distributed renewable generation's absorption. In some cases, grid congestion, alongside with connection restrictions or regulatory requirements, might delay project implementation. It might increase development costs, too. Furthermore, the growing distributed renewable energy sources' penetration places further demands on electricity networks. This, in fact, creates challenges and these challenges are mostly related to voltage regulation and to frequency stability. They might be also related to power quality management (IEA, 2023).

As for the operational complexity, it increases substantially and it does so, when photovoltaic systems and battery storage are integrated into the already existing industrial processes. The operation, in order for it to be considered as effective, needs sophisticated energy management systems. More specifically, it needs systems, which might be capable of coordinating electricity generation and storage utilisation, with consumption patterns. It is usual, that industrial facilities often possess highly variable production schedules. This creates a necessity to continuously optimise charging and discharging strategies. These systems' successful management needs specialised technical expertise. It also needs ongoing monitoring, so as to be ensured that there is optimal performance and in order for the economic benefits to be maximized (Olivares et al., 2014).

Even more, it has to be noted that safety considerations should not be underestimated, especially in the energy storage deployment. In further analysis, the battery systems store substantial amounts of energy. This means that a strict compliance with safety standards, which are related to thermal management, fire protection, electrical isolation and emergency response procedures, is required. Despite the fact that the modern battery technologies have achieved high levels of safety, there are incidents involving thermal runaway and battery fires and these incidents have made the importance of proper system design and maintenance, even higher (Chen, 2025).

Finally, uncertainty about the future technological developments presents an additional operational challenge, since papid advancements in the battery technologies' field and in the energy management systems and renewable energy equipment may lead to concerns, that are about technological obsolescence. Therefore, the industrial investors may hesitate to commit substantial financial resources. This happens especially if the investing audience anticipates that significantly more efficient or less expensive technologies are going to become available, at least during the the near future. This means that there is an uncertainty, which in fact is able to influence, on the one hand the investment timing and on the other hand, the financing decisions (Zakeri & Syri, 2015).

2.6 Market Trends and Adoption in the Industrial Sector

The adoption of photovoltaic systems and of the energy storage technologies in the industrial sector has accelerated during the past decade and at the same time, it is driven by technological advancements and by declining equipment costs, alongside with increasing energy prices, including the the growing emphasis that is placed on decarbonisation. Industrial enterprises, worldwide, are even more recognising renewable energy investments as environmental initiatives, but also as strategic tools, that help the enhancing of their competitiveness, the reduction of their operational costs and finally, this might lead to improving energy security (International Energy Agency [IEA], 2024).

Over the last fifteen years, the levelised cost of electricity (LCOE), which is generated by solar photovoltaic systems, has declined. This happened due to economies of scale, while another reason is the technological innovation. The improvements in manufacturing processes have also contributed to this consequence. As a result, photovoltaic electricity is a cost-effective form of electricity generation, in many regions, including Southern Europe and Greece. We mostly refer to regions, where solar irradiation levels are favourable (International Renewable Energy Agency [IRENA], 2023).

At the same time, energy storage technologies have known technological progress, including the cost reductions. The prices of the lithium-ion battery have decreased considerably. This happend due to large-scale production, that is associated with the electric vehicle industry. This makes battery storage increasingly attractive for industrial applications. It is about a development, which has enabled industrial facilities to move beyond simple renewable electricity generation and towards integrated energy management strategies. It is about strategis, that are able to maximise self-consumption and at the same time, to enhance operational flexibility, as well (Schmidt et al., 2017).

The recent volatility, which is observed in European energy markets, has further accelerated industrial investment, in the renewable energy systems' context. After the recent pandemic crisis of coronavirus, and after the geopolitical tensions that are affecting global energy supply chains, the electricity prices presented unprecedented increases and this happened across Europe. Therefore, the industrial companies have become even more interested in their dependence reduction on external energy suppliers. This happens die to the fact that they need to protect themselves from future price fluctuations. In that context, the photovoltaic systems, when they are combined with energy storage, are even more viewed as effective solutions for the greater energy autonomy's achievement. There are also seen as solutions towars improving business resilience, as well (European Commission, 2024).

In addirion, it has to be reminded that Environmental, Social, and Governance criteria are important considerations for investors and for other interested parties. The industrial companies are under increasing pressure to reduce their carbon footprint. They are also obliged to demonstrate commitment to sustainable business practices. Renewable energy investments contribute directly to these objectives. They do so, especially, by lowering greenhouse gas emissions and through supporting compliance with national and international climate policies (IEA, 2024).

In the Greece's case, the industrial adoption of photovoltaic systems has been supported by favourable solar resources and by regulatory reforms. It is also supported by the broader energy transition strategy, that is promoted through the National Energy and Climate Plan (NECP). It is a fact that the increasing deployment of self-generation schemes, when it is combined with emerging financing mechanisms and with energy storage incentives, at the same time, is expected to further stimulate investment activity in the industrial sector, over the coming years. These are developments, that suggest that photovoltaic and storage technologies are going to play a central role in industrial energy management and competitiveness, during the future.

2.7 Policy Framework and Energy Transition Roadmap

At the European level, the energy transition is mainly guided by the European Green Deal. More specifically, the European Green Deal aims to achieve climate neutrality by 2050, while increasing at the same time the energy security and economic competitiveness (European Commission, 2019).

Supporting this objective, the European Climate Law creates a legally binding emission reduction targets. At the same time, the Fit for 55 package introduces a broad set of legislative measures. These measures are designed, in order to be able to to reduce greenhouse gas emissions by at least a percentage of 55% by the year of 2030, compared with levels that had been observed during the year 1990 (European Commission, 2021). These initiatives are complemented by the Renewable Energy Directive (RED III) and, at the same time, by the Energy Efficiency Directive (EU) 2023/1791. Both of them strengthen the role that is played by the renewable energy and energy efficiency, in the decarbonisation objectives' achievement and coverage.

In the case of Greece, the national policy framework is defined by the revised National Energy and Climate Plan (NECP). This, in fact, outlines the country's strategic priorities for the period up to the year 2030 and beyond. Even more, the revised NECP emphasises the accelerated deployment of renewable energy sources. It also points out the expansion of electricity storage infrastructure and the electrification of energy consumption. Finally, it mentiones the improvement of energy efficiency across all sectors of the economy. Also, emphasis is placed on reducing energy dependence and on strengthening energy security, while improving the competitiveness of Greek enterprises through investments in clean energy technologies, is equally emphasized, as well (Ministry of Environment and Energy, 2024).

A recent development is the publication of the Energy Efficiency Roadmap for Buildings in July 2025, by the Greek Ministry of Environment and Energy. At first, it is noted that the roadmap focuses on energy efficiency investments. Despite that fact, it offers an extensive analysis of innovative financing mechanisms, which may also be applied to broader energy transition projects. These projects include, for example, renewable energy and storage investments. Among the mechanisms, that are examined are Pay-As-You-Save (PAYS) models, On-Bill Financing (OBF), Property Assessed Clean Energy (PACE) schemes, Energy Service Companies (ESCOs), Energy Performance Contracts (EPCs), Green Bonds, White Certificates, Revolving Loan Funds, Energy Efficiency Funds, and crowdfunding platforms.

Even more, theroadmap identifies these instruments as potential tools for overcoming financial barriers. It also sees them as tools that are helpful in mobilising private capital towards sustainable energy investments. The importance of these financing instruments is evident in the case of photovoltaic systems, that are combined with battery storage. More analytically, the technological viability of such projects has improved considerably and despite that fact, high upfront investment costs continue to limit widespread adoption, and especially among industrial enterprises (Mungai et al., 2022).

As Mungai et al. (2022) mentioned, the policy framework recognises that the national energy transition objectives' covering needs on the one hand technological innovation. Onb the other hand, it needs the development of financing structures, that are going to be able to reduce the investment risk's levels and to further improve project bankability. For this reason, recent policy initiatives have shifted their focus. More specifically, they used to focus on direct subsidies alone and now, they focus on more sophisticated financing mechanisms, that leverage private-sector participation and at the same time, they might facilitate any long-term investments.

3 Financial and Investment Framework for Renewable Energy Projects

3.1 Characteristics of Energy Investments in the Industrial Sector

Energy investments, in the context of the industrial sector, show some characteristics, which distinguish them from conventional capital investments. More analytically, the energy-related projects primarily create value through cost reduction, efficiency improvements, risk mitigation, and enhanced operational resilience, something that is not happening in the case of investments, which directly expand production capacity or create immediate revenue streams. This means that the financial evaluation of such projects needs a wider perspective, which incorporates on the one hand direct and on the other hand the indirect economic benefits (Trianni et al., 2016).

At first, the projects, that involve photovoltaic systems, battery energy storage systems, energy efficiency technologies or the integrated energy management solutions need substantial upfront expenditure, before any financial benefits can be realised. It needs to be considered that the operating costs are generally low, once the systems become operational. However, the initial capital requirement constitutes a significant barrier. This happens especially for small and medium-sized industrial firms (Polzin et al., 2019).

One further characteristic is the long investment horizon associated with energy projects. Gor instance, the industrial photovoltaic installations' economic life typically exceeds the twenty years. At the same time, the battery storage systems might operate for ten to years and the duration of their operation depends on technology and on utilisation rates and on maintenance practices, as well. As a direct result of this, the project profitability depends on long-term assumptions, that concern electricity prices, technological performance, maintenance costs and regulatory conditions. After small changes in these variables, projected returns and investment feasibility might be affected (Branker et al., 2011).

Energy investments are also characterised by their high levels of dependence on external policy and regulatory frameworks, too. Project economics are influenced by Government incentives, subsidies, tax benefits, renewable energy regulations, grid access conditions and carbon reduction policies, too. The supportive policy measures' existence might significantly improve the project viability. Whereas regulatory uncertainty might possibly increase investment risk. It might also discourage capital allocation (Bürer & Wüstenhagen, 2009).

Additionally, it has tro be taken into account that industrial energy projects are subject to multiple categories of risk. This includes market risk, technological risk, operational risk, financing risk and regulatory risk. Electricity price fluctuations directly affect the economic value of self-generated energy. At the same time, technological uncertainties related to equipment performance, degradation and maintenance, might possibly influence long-term financial results. Furthermore, changes in financing conditions, with characteristic example the interest rate increases, might alter project profitability. The reason that this might happen is the capital-intensive nature of these investments (Steffen, 2020).

Industrial energy investments, even more, tend to generate strategic benefits. These benefits are not always fully captured through conventional financial metrics. The photovoltaic systems and energy storage technologies' installation is able to improve energy security. It might also reduce dependence on external suppliers and strengthen corporate sustainability performance. Furthermore, it may support the compliance with increasingly demanding environmental regulations. In recent years, these strategic benefits have gained importance and this has happened as industrial companies face growing pressure from their stakeholders, to reduce their carbon emissions and to show commitment to sustainable development (International Energy Agency, 2024).

Finally, energy investments involve complex financing structures. Rather than relying on corporate capital, the industrial enterprises have the tendency to use bank loans, or alternatively, leasing arrangements, public support schemes, energy performance contracts, green bonds and other innovative financing instruments. The selection of an appropriate financing structure influences project cash flows and it might also affect risk allocation and the overall investment attractiveness. This makes the financing decisions an integral component of project evaluation (Polzin et al., 2019).

3.2 Cost Structure of PV and Storage Systems (CAPEX & OPEX Analysis)

The economic evaluation of photovoltaic and energy storage investments needs a better and deeper understanding of their cost structure. More analytically, the investment costs are generally divided into capital expenditures (CAPEX) and operating expenditures (OPEX). Both of them influence project profitability and financial feasibility (Branker et al., 2011).

In further detail, CAPEX represents the initial investment, that is required for project development and installation. In the photovoltaic systems, capital costs include, for instance, solar modules, inverters, mounting structures, electrical equipment, engineering services, permitting procedures, grid connection costs,and installation labour. For battery energy storage systems, CAPEX includes battery modules, battery management systems, power conversion systems and thermal management equipment. It also includes safety infrastructure and integration costs, as well. Generally, the battery storage accounts for a substantial proportion of total project expenditure. It usually represents the largest cost component in the integrated PV-storage projects (Schmidt et al., 2019).

As for OPEX, it includes the recurring expenses, that are associated with system operation throughout its lifetime. These costs especially consist of preventive and corrective maintenance, system monitoring and insurance. They also consist of equipment replacement, administrative expenses,and electricity consumption and all of these are associated with auxiliary equipment. Photovoltaic systems show relatively low operating costs and the reason that this happens is the absence of moving parts. Whereas battery systems may require additional maintenance and eventual replacement, because of the performance degradation (IRENA, 2023).

At this point, it needs to be understool that the relative contribution of CAPEX and OPEX differs significantly between technologies. In more analysis, the photovoltaic investments are characterised by high upfront costs. They are also characterized by low operating expenses. Parallely, battery systems involve both substantial initial expenditure and ongoing lifecycle management requirements, as well. Therefore, project profitability is influenced by financing conditions and it is also affected by the cost of capital. This happens because most project costs occur at the beginning of the investment period.

Finally, it is afact that accurate estimation of CAPEX and OPEX is essential for developing reliable financial models. It is also necessary for calculating investment performance indicators such as Net Present Value (NPV), Internal Rate of Return (IRR) and payback period.

3.2.1 Net Present Value (NPV)

Net Present Value (NPV) is a widely used method for the evaluation of the investment projects. This method calculates the difference that exists between the present value of future cash inflows and the present value of cash outflows, over an investment's lifetime. By discounting future cash flows, through the use of an appropriate discount rate, NPV incorporates the time value of money. Therefore, it offers an estimate of the value created by a project (Brealey et al., 2022).

Especially, for renewable energy investments, NPV is useful, because photovoltaic and storage projects involve significant upfront costs, that are followed by long-term economic benefits. A positive NPV shows that the project is expected to generate value above the required rate of return. Whereas a negative NPV means that the investment fails to meet the investors' expectations. Due to the fact that the current dissertation evaluates alternative financing structures, NPV is the primary financial indicator, that is used to compare project attractiveness under different financing scenarios.

3.2.2 Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) represents the discount rate, in the context of which, the Net Present Value of an investment becomes equal to zero. In practical terms, IRR shows the annualised rate of return, that is generated by a project over its lifetime. Investors frequently use this metric, due to the fact that it offers an intuitive measure of project profitability, which might easily be compared with alternative investment opportunities (Ross et al., 2022).

For photovoltaic and energy storage projects, the IRR reflects the combined effect of installation costs and of the operating expenses, electricity cost savings and financing conditions. Investments are overall taken into account as financially attractive, especially in the cases of which the IRR exceeds the required rate of return or the cost of capital. IRR is widely applied in renewable energy project evaluation, but despite that fact, it is commonly used together with NPV and this happens in order to obtain a more comprehensive financial performance's assessment.

3.2.3 Payback Period

The payback period measures the amount of time, that is required for an investment to recover its initial cost through cumulative cash inflows. It is about an indicator, that is frequently used in industrial decision-making and this happens because of its simplicity and because it focuses on liquidity considerations. Generally, a shorter payback period implies lower investment risk. It is also accomopanies by faster recovery of invested capital (Atrill & McLaney, 2022).

In the context of photovoltaic and storage systems, the payback period depends on installation costs, electricity savings and on financing arrangements, too. This method does not consider the time value of money or cash flows occurring after the recovery period. Despite this, it remains an important supplementary indicator, because many industrial companies place emphasis on capital recovery, when they evaluate their energy investments.

3.3 Financing Theory and Capital Structure in Energy Projects

Financing decisions play a protagonist role in the renewable energy investments' economic performance. More analytically, the capital structure theory examines the way through whoch the organisations combine debt and equity financing, in order to maximise the firm's value, while minimising its financing costs. For capital-intensive projects, like for example photovoltaic and energy storage installations, financing arrangements have a significant impact on investment feasibility, while they also impact profitability (Brealey et al., 2022).

As for the debt financing, it allows business entities to undertake investments without committing substantial internal resources. For example, the bank loans and other debt instruments reduce immediate capital requirements. At the same time, they create repayment obligations and expose investors to interest rate risk. Conversely, equity financing does not generate fixed repayment commitments. On the other hand, it may involve higher opportunity costs, because shareholders need compensation for the risk that is undertaken (Modigliani & Miller, 1958).

Renewable energy projects tend to rely on mixed financing structures, that combine debt, equity, public incentives and alternative financing mechanisms. The rationale that exists behind this approach, is to achieve an optimal balance between financial flexibility, risk exposure and cost of capital. Therefore, lower financing costs increase project profitability. The reason is that they reduce the discount rate, that is applied to future cash flows. Parallely, they improve indicators, like for instance NPV and IRR (Steffen, 2020).

The importance of sustainable finance has also contributed to the emergence of specialised financing instruments, for the energy projects. More specifically, the green bonds, the sustainability-linked loans, the blended finance mechanisms and the energy performance contracts are additional sources of capital. These resources are able to improve investment accessibility. They are also capable of reducing the financing barriers. These instruments are relevant for industrial enterprises, that seek to implement large-scale renewable energy projects, while at the same time preserving their liquidity and operational flexibility levels (Polzin et al., 2019).

3.4 Risk Assessment in Renewable Energy Investments

3.4.1 Market Risk (Electricity Prices)

Market risk arises from uncertainty, regarding future electricity prices. Since the economic benefits, which are generated by photovoltaic and storage systems, depend even more on avoided electricity purchases and on the energy cost savings, the fluctuations in electricity prices might affect a project's profitability. Therefore, higher electricity prices tend to improve investment returns. At the same time, declining prices reduce expected economic benefits. Fonally, the volatility in wholesale electricity markets, changing tariff structures and evolving market regulations constitute important sources of uncertainty, for the industrial investing audience (Sinsel et al., 2019).

3.4.2 Regulatory Risk

Regulatory risk is the possibility that changes in legislation, market rules, incentive schemes or taxation policies might alter the project economics. Renewable energy investments are used to be influenced by public support mechanisms. This makes them sensitive to policy changes. For example, any delays in permitting procedures, modifications to subsidy schemes or changes in grid access regulations might negatively affect the expected financial outcomes. It might also increase investment uncertainty (Bürer & Wüstenhagen, 2009).

3.4.3 Technological Risk

Technological risk is linked with uncertainties, regarding equipment performance, reliability, degradation and technological obsolescence, as well. It is a fact, that battery storage systems are exposed to degradation risk. The reason is that their performance declines over time. In addition, rapid technological developments might possibly end up in newer and more efficient technologies, that are becoming available shortly after a project implementation. These kinds of uncertainties are able to affect lifecycle costs and the maintenance requirements. They are also able to affect long-term project profitability, too (Schmidt et al., 2019).

3.5 Investment Decision-Making in Industrial Firms

Investment decisions in the context of the industrial organisations are influenced by a combination of financial, strategic, operational, and environmental considerations. At the time when traditional capital budgeting techniques are still central to decision-making, the renewable energy investments increasingly need a broader evaluation framework. They need a framework, that incorporates risk management, alongside with sustainability objectives and long-term competitiveness (Trianni et al., 2016).

The financial criteria are still highly influential and considering this, it is notes that the industrial firms typically evaluate the investments, based on expected cash flows, profitability indicators, capital requirements and financing conditions. In these contexts, the projects that show positive NPVs or satisfactory IRRs and acceptable payback periods are overall taken into account as more attractive. However, energy investments tend to compete with other strategic projects for limited financial resources. This increases the accurate economic assessment's importance (Brealey et al., 2022).

According to Sembiyeva et al. (2023) and Xiong et al. (2026), strategic considerations have become equally important, in recent years. More analytically, rising energy prices, climate policies and stakeholder expectations have encouraged the business entities to view renewable energy investments as instruments for strengthening energy security and their corporate sustainability performance. Investments in photovoltaic systems and energy storage may create a strategic value. It is about a value, whose creation extends beyond immediate financial returns.

Finally, the risk perception influences decision-making. In that context, the industrial managers frequently consider uncertainties, that are related to electricity prices, technological performance, financing conditions and regulatory developments. The financing mechanisms' availability, which reduce upfront costs or transfer part of the investment risk, might improve project attractiveness. It is also able to increase the likelihood of implementation (Polzin et al., 2019).

4 Financing Mechanisms for PV and Storage Investments

4.1 Overview of Financing Structures for Energy Projects

Renewable energy investments are characterised by high upfront capital requirements. They are also accomopanied by relatively low operating costs. Both of these characteristics, make the financing arrangements a base determinant of project feasibility and profitability, at the samer time. Unlike conventional industrial investments, which may generate immediate revenue streams, photovoltaic and energy storage projects recover their costs through electricity savings. They also recover their costs through improved energy efficiency and reduced exposure to energy market volatility. Therefore, the selection of an appropriate financing structure directly influences project cash flows and risk allocation, leading to an overall investment attractiveness (Donastorg et al., 2017).

Financing structures for energy projects might generally be classified into three broad categories. These are traditional financing mechanisms, alternative market-based financing models and public or policy-supported financing instruments. In more analysis, the traditional approaches include bank lending and corporate financing, where project costs are covered through debt or internal company resources. These mechanisms are widely used, but they may be constrained by capital availability and by borrowing capacity or liquidity considerations (Steffen, 2020).

Alternative financing models have gained increasing importance, due to the fact that governments and financial institutions seek to accelerate investment in sustainable energy technologies. These mechanisms include for instance leasing arrangements, Energy Service Company (ESCO) schemes, Energy Performance Contracts (EPCs), and Power Purchase Agreements (PPAs). These structures tend to reduce the initial capital burden on investors and facilitate risk sharing among stakeholders.

At the same time, public policy has become an increasingly important driver of renewable energy financing. For example, subsidies, grants, European funding programmes, guarantee mechanisms, revolving funds, and innovative financing tools have been developed to address market failures and improve access to capital. The Energy Efficiency Roadmap, that had been published by the Greek Ministry of Environment and Energy in 2025, mentionds highlights several innovative financing mechanisms. For example, Pay-As-You-Save

(PAYS), On-Bill Financing (OBF), Property Assessed Clean Energy (PACE), ESCO schemes, Green Bonds and Energy Efficiency Funds, are included and they are presented as as promising instruments for mobilising investment capital towards sustainable energy projects.

4.2 Traditional Financing Approaches

4.2.1 Bank Loans

Bank financing is the main external financing mechanism for businesses, especially in bank-centric financial systems, such as the Greek one. The institutional framework, that governs the operation of credit institutions, is determined by the legislative provisions of Law 4261/2014, which incorporated Directive 2013/36/EU, as well as by Regulation (EU) 575/2013, which sets out capital adequacy and risk management requirements.

In this context, bank financing is based on the assessment of the creditworthiness of the business. More analytically, it includes the analysis of financial statements. It also concerns the viability of the business plan and the ability to service the loan. Basel III regulatory requirements, as reflected in Regulation (EU) 575/2013, need the banking organizations to hold capital in proportion to credit risk. This ends upo leading to to stricter credit standards.

Bank financing takes various forms. Characteristic examples are working capital loans, investment loans, credit lines, as well as specialized tools such as factoring and leasing. These forms allow business entities to meet different needs. These needs range from liquidity management to investment financing. However, access to them could not be considered as uniform (Demirgüç-Kunt et al., 2020).

The existence of collateral is of particular importance for the granting of bank financing. In Greek law, the provision of collateral is regulated through general provisions of property law, but also through specific legislation, a typical example of which is Law 3156/2003 on bond loans and the securitization of receivables, as well as Law 2844/2000 on the publicity of collateral. Although collateral reduces credit risk for credit institutions, it often acts as a barrier for small or newly established enterprises that do not have sufficient assets.

Also, information asymmetry is one of the main factors, that end up affecting access to bank financing. In order to reduce selection risk and moral hazard, banks apply evaluation mechanisms. These mechanisms are based on both "*hard*" and "*soft*" data (Bellucci et al., 2020).

Also, the banking system is influenced by the general macroeconomic and regulatory environment. It is a fact, that especially, during the times of economic uncertainty, banks have the tendency to limit lending. This ends up exacerbating the financial constraints of business entities (Hyz & Gikas, 2016).

Finally, it needs to be further mentioned that recent developments, that concern the field of financial technology (FinTech) affect the way, that bank financing is provided, without however substituting the role of the banking organizations. Therefore, the banks are incorporating new risk assessment tools and digital processes, enhancing financing efficiency. At the same time, they remain the main provider of credit to businesses (Thakor, 2020).

4.2.2 Corporate Financing

The issuance of shares is a basic form of financing through the capital market. It is the main mechanism for raising equity capital for businesses, especially for Societes Anonymes. In contrast to borrowing, financing through shares does not create an obligation to repay capital. It implies the transfer of part of the ownership and the participation of investors in future profits and decision-making (Wieczorek-Kosmala et al., 2020).

In the Greek law, the institutional framework for the issuance of shares is mainly regulated by Law 4548/2018, as well as by EU law concerning capital markets and investor protection. At the European level, the issuance of shares is also governed by Regulation (EU) 2017/1129 on the prospectus (Cicchiello & Leone, 2020).

From a financial perspective, equity financing strengthens the business entities' capital base. It also leads to an improvement of the compoanies' leverage ratios. In this regard, for instance, the study that had been conducted by Kenourgios et al. (2020) and the additional study of Demirgüç-Kunt et al. (2020), noted that strengthening equity reduces financial risk. They also mentioned that it increases the business entity's resilience, in times of crisis. At the same time, access to the capital market is linked with higher levels of transparency and corporate governance. This empowers even more the investors' confidence.

However, the issuance of shares involves a loss of some control over the company, because of the fact that new shareholders gain decision-making rights. Even more, the process of issuing and listing on the market is complex and expensive and this is happening because it needs requires compliance with strict regulatory requirements and control procedures. Finally, companies are exposed to market fluctuations. This affects the value of shares and the ability to raise capital (Goodhart & Lastra, 2020; Nassr & Wehinger, 2016).

4.3 Alternative Financing Models

4.3.1 Leasing and Asset Financing

Leasing and asset financing constitute practical mechanisms for the acquisition of photovoltaic and energy storage equipment. These mechanisms doesn't need full upfront payment by the industrial enterprise. In this model, the company gains access to the use of the equipment, through periodic payments. At the same time, ownership may either remain with the leasing provider or be transferred to the user at the end of the contractual period. It is about a structure, which is relevant for capital-intensive energy investments. The reason is that it reduces the immediate liquidity burden and allows the investment cost to be distributed over time (Simões et al., 2025).

In the case of photovoltaic systems and battery storage, leasing might be able to cover core assets. Characteristic examples of these assets are PV panels, inverters, battery modules, power conversion systems and monitoring infrastructure. For the industrial businesses, this might be advantageous, especially when internal capital must be preserved for production activities, working capital or other strategic investments. Also, leasing facilitates technology adoption when the business entities are reluctant to commit large amounts of equity to assets, which might possibly become technologically outdated over time (Melo et al., 2026).

However, leasing does not eliminate an investment's economic cost. The periodic payments include the financier's required return and risk premium. These may increase the total lifetime cost, in comparison with the direct purchase. Moreover, contractual terms that concern for example maintenance, insurance, equipment replacement and early termination are important and worthy to pay attention to. More aanalytically, in the PV and storage projects, the financial attractiveness of leasing depends on whether the annual energy savings exceed lease payments and associated operating expenses. Therefore, leasing should be assessed, on the one hand as a financing convenience, and on the other hand as a complete cash-flow structure, that affects NPV, IRR and payback period (Xie & Lin, 2025).

4.3.2 Energy Service Companies (ESCO Models)

Energy Service Companies (ESCOs) offer a financing and implementation model. In this model's context, an external specialised entity designs, finances, installs, operates or keeps the energy efficiency or renewable energy project on behalf of the client. The main characteristic of the ESCO model is that project repayment use to be linked to the savings, which are generated by the intervention. This reduces the need for the industrial enterprise to assume the full technical and financial burden of the investment, from the outset (Bergman & Foxon, 2020).

In the contexts of the PV and storage projects, an ESCO may undertake the installation of the photovoltaic system, the sizing and integration of the battery storage unit, the energy management system's operation and the actual performance's monitoring. For industrial users, it is about a model, that is attractive. This happens because it transfers part of the technical and operational risk to a specialised provider. It is also useful in the cases of which the company lacks internal expertise in renewable energy project development or in battery operation or energy performance monitoring (Hofer et al., 2016).

The Greek Energy Efficiency Roadmap identifies ESCOs and Energy Performance Contracting as important mechanisms for mobilising investment, in the contexts of the energy efficiency projects. It is a fact that the Roadmap focuses mainly on buildings. Despite this, the same logic is able to be extended to industrial PV and storage investments. This might happen especially when the project is structured around measurable cost savings and performance guarantees. The ESCO models' relevance becomes even stronger, when the industrial companies seek to avoid high upfront CAPEX, while still benefiting from the energy costs that are successfully reduced (Suhonen et6 al., 2013).

Nevertheless, ESCO schemes need careful contractual design. More analytically, the baseline energy consumption must be clearly defined. Also, the savings must be measurable and, at the same time, the responsibilities for underperformance must be allocated in advance. If the contract is poorly structured, disputes may arise. These disputes may concern whether savings are attributable to the installed system, changes in production activity, electricity prices or operational behaviour. Therefore, on the one hand ESCO models can improve project bankability, but on the other hand, they require transparent measurement and verification procedures (Shyu et al., 2012).

4.3.3 Power Purchase Agreements (PPAs)

Power Purchase Agreements (PPAs) are contractual arrangements. Under these arrangements an electricity producer sells electricity to a consumer at an agreed price over a long-term period. In the context of industrial photovoltaic investments, a PPA may allow an industrial business entity to consume renewable electricity and this might be done without directly financing, owning or operating the photovoltaic system. Instead, a third-party investor develops and owns the installation. At the same time, the industrial consumer purchases the generated electricity under predefined contractual terms (Gatzert & Kosub, 2016).

For industrial users, PPAs are able to reduce exposure to electricity market volatility. They might also improve energy cost predictability. This is relevant in periods of high or unstable electricity prices, during which long-term price certainty is valuable for business planning. Even more, an PPA can also support decarbonisation objectives. The reason is tha fact that the firm gains access to renewable electricity, without having the immediate direct investment's capital burden (Stanitsas & Kirytopoulos, 2023).

In the PV and storage applications' contexts, a PPA might be combined with battery storage and it might do so in order to increase supply reliability and in order to shift solar generation, during the periods of time that the demand levels are higher. Even more, PPA might be combined with battery storage in order to improve the alignment thet exists between production and consumption. However, the inclusion of storage increases project complexity. It additionaly affects the electricity price that is agreed in the contract, since the investor must recover both PV and battery costs (Fischer & Schreiber-Orosz, 2026).

The main limitation of PPAs concerns contractual rigidity, too. More analytically, long-term agreements may become less attractive in the caes of which the market prices decline significantly or if the company's energy needs further changes. Moreover, creditworthiness is important. The reason of its importance is that the project developers and financiers evaluate the industrial consumer's ability to honour long-term payment obligations. For this reason, additionally, PPAs are suitable for industrial business entities that have stable energy demand and for those with credible financial standing and long-term operational planning, as well (Wallace, 2019).

4.4 Public Support and Policy-Based Financing Instruments

4.4.1 Subsidies and Grants + National Energy Transition Programs

Public grants and state programs are a basic form of non-repayable or indirectly subsidized financing of businesses (Hall, 2009). In the Greek legal order, the main body of this system is based on the development law, initially with Law 4399/2016 and then with Law 4887/2022.

More analytically, Law 4887/2022 already defines from article 1 the developmental and productive purpose of the framework. As the article 3 of the same law, it integrates the operation of the law into EU state aid law. We consider this point to be crucial, due to the fact that subsidies must be granted in the limits of Articles 107 and 108 TFEU and in the context of the General Aid Regulation 651/2014.

In terms of forms of aid, Law 4399/2016 in Article 10 had already established basic categories. Indicative examples of the categories are tax exemption, grant, leasing subsidy and subsidy of the cost of employment created. On the other hand, Article 11 linked the intensity and amount of aid to the the Regional Aid Charter and the size of the enterprise, as well.

The same logic is folliwed in the newer framework of Law 4887/2022. More specifically, it organizes specific aid schemes by sector or investment objective and provides, per scheme, eligible costs, beneficiaries, types of aid and intensity limits. This implies that public subsidies are differentiated according to the investment object, the geographical area and the size of each enterprise.

On this point, the fact that the Greek state aid scheme is inextricably linked to the EU compatibility framework is of particular importance. Regulation (EU) 651/2014 exempts certain categories of aid from the obligation of prior notification, provided that specific conditions are met regarding eligibility, intensities and the incentive nature of the aid.

More specifically, Article 1 of this Regulation mentions aid to small and medium-sized enterprises, regional aid and aid for research, innovation and environmental protection. For Greek practice, this is of particular value, if we take into account that a large part of national programmes and schemes are designed in such a way as to fall under the exemptions of the Regulation and to be implemented more quickly and with greater legal certainty.

Moreover, the practical operation of grants is also associated to specific administrative procedures for inclusion, control and sanctions. More analytically, in the context of the Law 4399/2016, Articles 13 to 16 regulate the submission and evaluation of investment projects. Even more, Decision 48505/2025 on the imposition of sanctions on investment projects subject to Law 4399/2016, shows that state subsidies are accompanied by strict obligations to comply with the terms of the decision to include and keep the investment result.

Looking at the issue from a financial perspective, public subsidies are also important for the reason that they reduce the financing gap. For instance, recent OECD reports record that public programs remain a central means of supporting the financing, while for Greece it is noted that subsidies and direct aid maintain a significant importance in supporting productive and innovative investments (OECD, 2023).

At the same time, the EIB notes that Greek companies continue to face constraints in financing investments. This is an element that makes public grants a crucial complementary mechanism to bank lending. Therefore, as it was also confirmed by Xiang et al. (2021), public grants and state programs are, on the one hand, a traditional form of state financial intervention, but also a complex institutional tool of development policy. Additionally, Barbieri et al. (2020) mentioned that their operation depends on compatibility with EU state aid law, on the structure of national development laws, but also on the ability of businesses to submit mature and eligible investment plans. Finally, Xiang et al. (2021) pointed out that that in the modern business environment, grants remain crucial, especially for high-upfront investments, for regional development projects and for activities related to innovation, digital transformation and sustainability.

4.4.2 European Union Funding Mechanisms

The European Union has developed a framework of financial instruments, whose aim is to accelerate the transition towards a low-carbon economy. It also aims to support investments in renewable energy technologies. These mechanisms play an important role in facilitating investments in photovoltaic systems and in the context of the energy storage projects. Besides, they address market failures, while at the same time they reduce financing barriers and improve project bankability (European Commission, 2023).

Worth-mentioning is the Recovery and Resilience Facility (RRF). The Recovery and Resilience Facility had been established under the NextGenerationEU programme following the COVID-19 crisis. Through national Recovery and Resilience Plans, significant financial resources have been allocated to renewable energy deployment and to energy efficiency improvements, as well, including also the energy storage infrastructure. In Greece, the Recovery and Resilience Plan includes dedicated measures, which support the installation of renewable energy systems and the battery storage facilities and industrial decarbonisation projects. Thereby, they contribute to the achievement of the objectives that had been set in the context of the national energy transition (European Commission, 2024).

One further worth-mentioning mechanism is the Modernisation Fund. In more analysis, Modernisation Fund supports lower-income Member States in the modernization of their energy systems and in the energy efficiency's improvement. The fund is financed through revenues, which are generated by the European Union Emissions Trading System (EU ETS). Also, the fund offers grants for investments in renewable energy generation and electricity storage, as well (European Investment Bank, 2024).

Critically evaluating the above-mentioned ones, taking into consideration the increasing importance that energy storage has for the integration of renewable energy sources, the Modernisation Fund is expected to be an increasingly relevant financing source for industrial energy projects in Greece, during the future

The Innovation Fund also is a significant source of financial support for energy-related investments. Funded through the EU ETS, has as main purpose to support innovative low-carbon technologies. It also aims to support the large-scale demonstration projects. This fund primarily targets highly innovative projects, energy storage technologies, smart energy management systems and industrial decarbonisation initiatives. On the other hand, it frequently falls within its scope (European Commission, 2023).

In addition, the InvestEU Programme offers guarantees and risk-sharing mechanisms, that are designed to mobilise private investment, in the sustainable infrastructure and in the projects that belong in the context of the renewable energy. Through the participation of financial intermediaries, like for instance the European Investment Bank (EIB), InvestEU eases the access to capital for projects, which might otherwise face difficulties in holding the commercial financing, because of the perceived risk or dut to the long payback periods (EIB, 2023).

Finally, the European Structural and Investment Funds contribute to renewable energy financing and the programmes, which are implemented under the European Regional Development Fund (ERDF) and the Cohesion Fund, have historically supported energy infrastructure and energy efficiency interventions, across the Member States. These are instruments, that remain important for regions, that undergo energy transition and industrial restructuring (European Commission, 2023).

4.5 Innovative and Sustainable Financing Instruments

4.5.1 Green Bonds

Green bonds are debt instruments, whose proceeds are allocated only to projects that have environmental benefits. Characteristic examples of these projects are renewable energy, energy efficiency, clean transportation and the climate adaptation ones. In the context of PV and storage investments, the green bonds have the ability to offer access to capital for companies or financial institutions, that aim to finance large-scale clean energy projects and at the same time to be aligned with the sustainable finance principles (Flammer, 2021).

If we compare them with conventional corporate bonds, we conclude that the green bonds require additional transparency about the use of proceeds, project eligibility, reporting and, in many cases, an external review. The financing logic is still the same and it is characterized as debt-based. The reason is that the issuer undertakes the obligation to repay investors. On the contrary, the bond's environmental designation allows the issuer to attract investors with mandates that are characterized as ESG-oriented. This is relevant in the European context, in which sustainable finance regulation and investor demand have increased how important the credible green investment products are.

For industrial PV and storage projects, the green bonds might be suitable, when the investment is large enough so as to be able to justify bond issuance or in the cases of which multiple projects are aggregated into a wider and broader green financing portfolio. A single medium-sized industrial installation might not be sufficient to support a standalone bond issue. On the other hand, it might be financed through a corporate green bond programme, or alternatively, through a banking green loan portfolio or a project aggregation vehicle, as well.

Also, it is mentnioed that the Energy Efficiency Roadmap faces green bonds as an innovative financing instrument. It links them with the mobilisation of capital for sustainable energy interventions. In practice, their relevance for the current dissertation is mainly the ability that they have to reduce dependence on traditional bank lending and to broaden the investor base for clean energy infrastructure. However, green bonds need strong reporting capacity and sufficient issuer size. This means that they are more accessible to large companies or public investment vehicles and not so easily accessable to industrial firms that are considered as smaller.

4.5.2 Blended Finance

Blended finance refers to financing structures, which combine public, concessional or policy-driven capital with private investment. Their main purpose is to to improve the risk-return profile of projects, which might otherwise remain underfinanced. The purpose of blended finance is not to replace private capital. On the contrary, theor purpose is to mobilise it, by reducing specific barriers. Indicative examples of these barriers are high upfront costs, perceived technology risk, long payback periods or insufficient collateral (OECD, 2018).

In PV and storage investments, blended finance is able to take many different forms. A public grant might reduce initial CAPEX. At the same time, a while a bank loan finances the remaining cost. A guarantee fund may reduce the lender's credit risk. It might also allow more favourable interest rates. A revolving loan fund might offer lower-cost capital. Parallely, private investors contribute additional funds. Similarly, crowdfunding or citizen investment platforms might complement institutional funding and this happens especially when the projects have a strong local or sustainability dimension.

For industrial enterprises, the blended finance is important, due to the fact that PV and battery storage projects usually combine technological maturity with financial barriers. The project might be technically feasible and environmentally beneficial. At the same time, the same project might be still unattractive. More analytically, it might be unattractive if the payback period is long or if the firm is unwilling to allocate substantial internal funds. The combination of grants, guarantees, concessional loans and private capital, blended finance might be a practice that is able to improve NPV. This practice is also able to reduce payback time and lower risk exposure, too.

However, blended finance involves administrative complexity. In more analysis, it needs compliance with eligibility rules and it is accompanied by further reporting obligations, state aid limitations and coordination among many different stakeholders. Therefore, its effectiveness depends on whether the financial benefit outweighs the additional procedural burden or not. For the base case investment, that is examined in this dissertation, blended finance is relevant and the reason is that it is able to be modelled as a scenario, in which part of the initial investment cost is covered by public support and at the same time, the remaining amount is financed through debt or corporate funds.

At this point, crowdfunding is also worth-noting and analysing. It is about a a dynamically developing form of alternative financing. It is also mentioned that it is based on the collective collection of funds from a large number of investors or supporters, usually through online platforms. The basic principle of crowdfunding is the exploitation of the "*wisdom of the crowd*" (Belleflamme et al., 2014).

It is about a form of financing, which has gained importance for start-ups and innovation projects (Camilleri & Bresciani, 2024). The two main categories of crowdfunding, that are related to business financing,g are equity-based crowdfunding and reward-based crowdfunding (Zhao & Ryu, 2020). In more analysis, in equity-based crowdfunding, investors acquire a stake in the business tntity's equity. At the same time, they also assume the business risk and expect future financial benefits (Aggarwal et al., 2021). This is not happening in tha case of reward-based crowdfunding. In that case, participants do not acquire equity, but they are rewarded with services or other non-financial benefits, which are associated with the funded project (Mollick, 2014).

It is a fact that crowdfunding reduces transaction costs and bridges geographical barriers. Thus, it allows easier access of business units to the international investment community (Agrawal et al., 2015). One adittional advantage is the facilitation of access to financing, which it is offered especially for business units that do not have sufficient guarantees or operating history (Belleflamme et al., 2014). Furthermore, crowdfunding functions as a market validation tool and in the fact, the reason is that the success of a campaign is an indication of demand for the product or service (Sheldon & Kupp, 2017; Hornuf & Schwienbacher, 2017).

However, this form of financing entails an information asymmetry. This fact increases investment risk. It is also likely to lead to incorrect investment decisions (Ahlers et al., 2015). In addition, the lack of experience of investors, alongside with the limited supervision on some online platforms increase uncertainty even more (Oladejo et al., 2023). Also, the existence of a large number of minority shareholders is possible to make decision-making difficult and this might lead to corporate governance problems (Cumming & Johan, 2017).

4.6 Comparative Assessment of Financing Options

4.6.1 Cost of Capital

The cost of capital is one of the most important criteria for the financing instruments' comparison. The reason of its importance is that it directly affects the discount rate. It also affects the present value of future cash flows. Financing structures, that present lower interest rates and that have lower required returns or concessional characteristics, generally improve the NPV of PV and storage investments, too. Corporate financing might avoid explicit interest payments. On the other hand, it involves an opportunity cost. This happens because internal capital could have been used for alternative investments. Bank loans create explicit financing costs and at the same time, leasing, PPAs and ESCO schemes embed the financier's return within contractual payments (Steffen, 2020).
Usually, public grants and subsidies tend to reduce the effective cost of capital. They achieve this by lowering the amount, that must be financed by the business entity. Similarly, guarantee funds and blended finance are able to reduce lender risk. They also have tha ability to improve borrowing terms. Green bonds might also lower financing costs, when investors accept lower yields for credible sustainable investments. Although this effect depends on market conditions and issuer quality. Therefore, the financing option with the lowest nominal cost is not always the most suitable. The relevant criterion is the total effect on project cash flows and financial performance.

4.6.2 Risk Allocation

Risk allocation differs importantly across financing instruments. Under corporate financing, the industrial company bears almost all the project risks. This includes for example construction risk, performance risk, electricity price risk and technological risk. Bank loans transfer little operational risk to the lender and this happens since repayment obligations are still fixed, regardless of the performance that the project might have. This might increase pressure on the company itself, if actual energy savings are lower than expected.

By contrast, ESCO models, EPCs and PPAs allow a risk sharing's higher degree. In ESCO and performance-based contracts, a part of the technical and performance risk may be transferred to the service provider. In the PPAs, the third-party developer is possible to assume construction, ownership and operational risks. On the contrary, the industrial consumer assumes long-term purchase obligations. Subsidies reduce financial risk, after lowering the capital exposed to uncertainty. Then, guarantees reduce lender risk and not so much the project risk itself. Therefore, the optimal structure depends on which stakeholder is best able to manage each risk's category.

4.6.3 Flexibility and Scalability

Flexibility refers to the ability that a financing structure has to adapt to changing operational, technological or market conditions. Corporate financing offers high managerial flexibility. The reason is that the company owns the asset and therefoe, it has the abilitu to adjust its operation, according to existing internal needs. Also, the bank loans allow ownership flexibility. Although, loan covenants may impose restrictions. Leasing and PPAs may be less flexible, because they involve long-term contractual commitments and predefined payment or also predefined pricing structures.

Scalability is important for industrial PV and storage projects. The reason is that companies may initially install a smaller system and later expand capacity. Financing mechanisms, like for instance the bank loans, leasing and green bonds, are able to support scaling, if the business entity is still creditworthy. They might also do so, if additional assets can be financed under similar terms. ESCO models might also be scalable, in the case of which the service provider manages multiple energy interventions across the same facility. Hoewever, public grants, may be less flexible. This is happening because they depend on programme availability and on eligibility windows and that they have specific investment criteria.

4.6.4 Suitability for Industrial Applications

The suitability of each financing option for industrial PV and storage investments depends on the size of the company. It also depends on its liquidity position, on the creditworthiness and the energy consumption profile or the risk tolerance that the company has. Bank loans are suitable for business entities, that have stable cash flows and sufficient collateral. On the contrary, they may be less attractive when the interest rates are high. Corporate financing is appropriate for companies that have strong liquidity. At the same time, it can reduce financial flexibility. Leasing is useful when a firm wants to preserve cash and when it needs to avoid asset ownership complexity.

ESCO models and PPAs are suitable for industrial enterprises, whose priority is the operational simplicity and risk transfer, as well. They allow businesses to benefit from renewable energy, without needing to internalising technical and financing responsibilities. Public grants and blended finance are relevant, in the cases of which the investment has strong environmental benefits, but faces a financing gap, that exists due to high upfront CAPEX. Green bonds are more suitable for large companies or aggregated investment portfolios and not so suitable for isolated and small-scale projects.

Finally, it is now mentioned that for the base case, tha is examined in the current dissertation, the most relevant financing options are, thereforem bank financing, corporate financing, subsidy-supported investment, leasing, ESCO/EPC-type arrangements and blended finance. These instruments directly affect the investment’s NPV, IRR, payback period and risk profile.

5 Base Case Investment Analysis (PV and Energy Storage)

5.1 Description of the Base Case Investment Scenario

The economic evaluation, that is presented in this chapter, is based on the planned PETech investment project of Nera Kritis S.A.B.E.E., which concerns the installation of a photovoltaic system combined with battery energy storage, at the company's central warehouse facilities, that are located in Thebes. Due to the fact that detailed technical specifications and financial information regarding the project are not publicly available, the current analysis adopts representative industrial assumptions, which are based on the current market conditions that exist in Greece. This approach allows the evaluation of financing instruments in the context of the PETech project. At the same time, the approach that we followed maintains methodological consistency and analytical comparability, too.

The base case assumes that the industrial facility seeks to maximize self-consumption of renewable electricity, while reducing dependence on grid purchases, during peak-price periods. The storage component enables load shifting. It also enables on the one hand improved utilization of solar generation and on the other hand enhanced flexibility in the electricity management.

The investment horizon is assumed to be twenty years, corresponding to the typical economic lifetime of a commercial photovoltaic installation. Financial performance is assessed through discounted cash flow analysis, Net Present Value (NPV), Internal Rate of Return (IRR) and through Payback Period calculations. The resulting financial indicators are the foundation for the comparative evaluation of the financing alternatives, that are presented in the following chapters.

At this point, it should be emphasized that the objective of the analysis is to evaluate how different financing instruments may influence the financial feasibility, profitability and risk profile of a representative PV-storage investment, that is associated with the company's planned energy transition strategy. Therefore our purpose is not to estimate the exact future performance of the PETech project.

The following table presents the basic technical and economic assumptions of the PETech investment scenario:

Table 1. Basic technical and economic assumptions of the PETech investment scenario

Parameter	Value
Annual Electricity Consumption	2,500 MWh
PV Capacity	1 MWp
Battery Storage Capacity	2 MWh
Annual PV Generation	1,500 MWh
Self-Consumption Rate	85%
Electricity Price	€0.15/kWh
PV CAPEX	€850,000
Battery CAPEX	€700,000
Total Investment Cost	€1,550,000
Annual Gross Savings	€191,250
Annual O&M Costs	€23,250
Annual Net Cash Flow	€168,000
Project Lifetime	20 years
Discount Rate	7%

5.1.1 Industrial Energy Profile

The energy profile, that had been adopted in the analysis, is intended to represent the operational characteristics of the central warehouse facilities of Nera Kritis S.A.B.E.E. and similar industrial logistics installations. The annual electricity consumption is estimated at approximately 2,500 MWh. It represents a typical consumption level for a medium-sized manufacturing company.

Electricity demand is distributed across production processes, machinery operation, lighting systems, HVAC equipment and auxiliary services, as well. Peak demand occurs during daytime operating hours, coinciding with the production schedule. This consumption profile was considered as suitable for photovoltaic self-consumption strategies and the reason is that a substantial portion of electricity demand occurs simultaneously with solar generation. These consumption characteristics are consistent with warehouse and logistics operations, in which electricity demand is concentrated during daytime working hours. Therefore, it coincides with photovoltaic electricity production.

It is also assumed that the company currently purchases all electricity from the grid at an average electricity price of €0.15 per kWh. Consequently, annual electricity expenditure reaches approximately the amount of €375,000. Also, both rising electricity prices and increasing uncertainty in energy markets create strong incentives for investments, that reduce exposure to external energy costs.

Furthermore, the company has adopted sustainability objectives, that are aligned with broader environmental, social, and governance strategies. Therefore, the installation of renewable energy technologies is expected to generate on the one hand the economic and on the other hand the environmental benefits. In the context of PETech, these benefits are expected to support at the same time operational cost reduction and the company's overall sustainability objectives, too.

5.1.2 System Configuration (PV Capacity & Storage Size)

The proposed investment consists of a 1 MWp photovoltaic installation, that is combined with a battery energy storage system (BESS) of 2 MWh capacity. These technical specifications do not represent officially disclosed project data from Nera Kritis S.A.B.E.E. They are a representative configuration adopted for financial modelling purposes. The selected system size reflects a typical industrial-scale PV and storage investments, that are currently implemented in the Greek market.

Even more, the photovoltaic system is assumed to be installed either on available rooftop space or adjacent industrial land. Under Greek solar irradiation conditions, annual electricity generation is estimated at about 1,500 MWh.

The battery storage system is designed mainly to increase self-consumption rates and in order to reduce electricity purchases, during the peak-price periods of time. Energy produced during the periods of excess solar generation might be stored and used later, when electricity demand exceeds PV production.

The combined PV-storage configuration is expected to achieve a self-consumption rate of approximately a percentage of 85%. This significantly improves the economic value of generated electricity, at least compared with a standalone PV installation.

The selected system size represents a balanced configuration, that addresses the facility's energy requirements. At the same time it is able to hold reasonable investment costs and operational flexibility, as well.

5.2 Cost and Technical Assumptions

All technical and financial assumptions, that have been used in the analysis were derived from recent market data, industry reports and representative cost benchmarks for industrial photovoltaic and battery storage systems. At this point, it is mentioned that a detailed project-specific information regarding the PETech investment is not publicly available. Taking this into account, the assumptions had been selected to offer a realistic approximation of the existing current investment conditions in Greece.

5.2.1 Installation Costs

Capital expenditure (CAPEX) represents the largest component of the investment. It includes all the costs, which are associated with equipment procurement, engineering, installation, grid connection and commissioning.

For the base case scenario, the photovoltaic system cost is estimated at €850,000. It corresponds to approximately €850 per kWp installed. This value reflects current market conditions for utility-scale and industrial photovoltaic systems in Southern Europe.

The investment cost includes PV modules and inverters. It also includes mounting structures, electrical infrastructure, engineering services, installation labour, permitting expenses and commissioning activities.

The assumed CAPEX level is consistent with the recent market trends, that show significant reductions in photovoltaic technology costs. The reason is the economies of scale and technological improvements, too.

5.2.2 Operating and Maintenance Costs

Although photovoltaic systems have relatively low operating expenses, periodic maintenance is still necessary. It necessity lies on the need to ensure optimal performance throughout the project's lifetime.

Annual operation and maintenance (O&M) costs are assumed to equal 1.5% of total project CAPEX. More analytically, these are expenses, that include preventive maintenance, equipment inspections, cleaning activities, monitoring services, inverter replacement reserves, insurance costs and administrative expenditures.

For the base case scenario, annual O&M costs are estimated at approximately an amount of €23,250.

The maintenance requirements of the battery system are incorporated in the overall O&M estimate. At the time when the battery systems need more sophisticated monitoring and control procedures than the photovoltaic installations do, advancements in battery management technologies have reduced operational complexity. They have also reduced the maintenance needs.

5.2.3 Storage System Costs

Battery energy storage constitutes a significant proportion of total investment expenditure.

The 2 MWh battery system is assumed to require an investment of €700,000. This includes also battery modules, power conversion systems, battery management systems, installation costs, safety systems and integration with the photovoltaic installation.

It is a fact that the battery costs remain relatively high, at leas in comparison with photovoltaic technologies. Despite that fact, declining battery prices have significantly improved the energy storage projects’ economic attractiveness.

The storage system is assumed to keep adequate performance throughout the project horizon. For instance, moderate degradation rates are assumed, that do not materially affect the overall investment evaluation.

5.3 Financial Modelling of the Investment

5.3.1 Cash Flow Analysis

The financial evaluation is based on a discounted cash flow methodology. This methodology compares initial investment costs with future energy savings generated by the project.

The total project investment amounts to €1.55 million. It consists of €850,000 for the photovoltaic installation and €700,000 for battery storage.

Annual electricity savings are estimated, based on the reduction of grid electricity purchases, that result from PV generation and storage utilization. We assume annual effective savings of approximately 1,275 MWh and an electricity price of €0.15 per kWh. According to these assumpition annual gross savings are estimated at a level of €191,250.

After the deduction of annual operating expenses of €23,250, the project generates net annual cash flows of approximately €168,000.

These annual cash flows form the basis for the profitability indicators' calculations.

5.3.2 NPV and IRR Calculation

Net Present Value (NPV) measures the difference that exists between the present value of future cash inflows and the initial investment cost.

After the use of a discount rate of 7% and a project lifetime of twenty years, the estimated NPV of the investment is positive. This means that the project creates economic value for the industrial firm.

Similarly, the Internal Rate of Return (IRR) exceeds the assumed discount rate. This shows that the investment generates returns above the firm's required rate of return.

The positive NPV and satisfactory IRR, also mean that the combined PV-storage project is financially feasible, under the assumptions that had been adopted in the base case scenario.

5.3.3 Payback Period Estimation

The payback period shows the time, that is required for cumulative cash flows to recover the initial investment.

Based on the annual net savings of approximately €168,000 and total investment costs of €1.55 million, the simple payback period is estimated at approximately 9.2 years.

This recovery period may appear relatively long, compared with conventional investments. However, it is still acceptable, if we take into account the long operational lifetime of photovoltaic assets and the increasing strategic importance of energy independence, too.

Furthermore, potential subsidies, favourable financing conditions and future increases in electricity prices, are factors that could shorten the payback period.

The following table presents the financial performance indicators of the base case scenario:

Table 2. Financial Performance Indicators of the Base Case Scenario

Indicator	Value
Total Investment Cost	€1,550,000

Annual Net Cash Flow	€168,000
Payback Period	9.2 years
NPV	Positive
IRR	Higher than 7% discount rate

5.4 Scenario Analysis

Scenario analysis had been conducted to evaluate how different financing arrangements influence the economic performance of the proposed PV and energy storage investment, that is associated with the PETech project of Nera Kritis S.A.B.E.E.. Three scenarios were examined. These are a base case without financial support, a subsidized investment scenario, and alternative financing structures involving debt-based financing mechanisms. The objective of the analysis is to identify how financing conditions affect project profitability and how they also affect capital requirements and investment attractiveness.

5.4.1 Base Case (No Financial Support)

The base case assumes that the overall investment is financed through the company's own resources without any subsidy, grant, or external financing mechanism. Under this scenario, the industrial enterprise bears the full capital expenditure of €1.55 million, at the beginning of the project.

The resulting financial performance shows the intrinsic economic value that the investment has. The positive NPV and satisfactory IRR, that had been calculated in the previous section, show that the project is still financially viable and this happens even without external support. However, the requirement to allocate substantial internal funds might create liquidity constraints. It is also possible to increase the opportunity cost of capital.

From a corporate finance perspective, self-financing offers maximum operational control and eliminates financing costs. Nevertheless, it concentrates all project risks on the investing company. It also reduces financial flexibility for future investments. This issue is relevant for industrial firms, that operate in uncertain economic environments, in which maintaining liquidity reserves is strategically important.

Consequently, while the base case shows that the project is economically feasible, the large upfront investment might discourage implementation. This happens particularly among small and medium-sized industrial enterprises.

5.4.2 Subsidized Scenario

The second scenario assumes the availability of public financial support through national or European funding programmes. Consistent with the financing mechanisms, that ahd been discussed in Chapter 4 and the Greek Energy Efficiency Roadmap, a grant covering 40% of the total investment cost is assumed.

Under this scenario, the company's initial investment decreases from €1.55 million to approximately €930,000. Since annual energy savings are still unchanged, the reduction in capital expenditure significantly improves all financial performance indicators.

The NPV increases substantially. This happens because the project generates identical future cash flows. At the same time requires a lower initial investment. Similarly, the IRR improves considerably. The reason is the lower capital commitment. The payback period decreases significantly. This makes the investment more attractive from a managerial perspective.

Furthermore, public subsidies reduce financing barriers. They also improve access to renewable energy technologies. This effect is important for energy storage investments, which use to face higher capital costs.

The results show that grants and public support mechanisms might play a decisive role in accelerating the adoption of industrial renewable energy projects. They might do so, by reducing investment risk and enhancing profitability, at the same time.

5.4.3 Alternative Financing Structures

The third scenario examines alternative financing mechanisms. These include bank loans, leasing arrangements, Energy Service Company (ESCO) contracts and Power Purchase Agreements (PPAs).

Under bank financing, the company avoids a large initial capital outlay, by spreading investment costs over a predetermined repayment period. On the one hand, it is a fact that interest expenses reduce net project profitability, compared with self-financing. Despite that fact, the preservation of liquidity may create additional strategic benefits.

Leasing arrangements offer similar advantages. It does so, by distributing investment costs over time, while allowing the company to use the equipment immediately. The main benefit of leasing is the reduction of initial capital requirements. Although total financing costs may exceed those of direct ownership.

ESCO models represent a different financing philosophy. In that context, the energy service provider assumes part or all of the investment cost and recovers its investment through a share of achieved energy savings. This arrangement reduces financial risk for the industrial company. It also limits the share of economic benefits retained by the investor.

Finally, the Power Purchase Agreements offer another alternative. It allos companies to procure renewable electricity without directly owning the generation assets. PPAs eliminate capital expenditure requirements. On the contrary, they generally offer lower long-term economic benefits, in comparison with the direct asset ownership.

The following table summarizes the results of the comparative assessment of financing scenarios:

Table 3. Comparative Assessment of Financing Scenarios

Financing Scenario	Initial Capital Requirement	Profitability	Risk Exposure	Liquidity Impact
Own Funds (Base Case)	Very High	High	High	High Capital Commitment
Subsidized Scenario	Moderate	Very High	Low	Favourable
Bank Loan	Low Initial Outlay	Moderate-High	Moderate	Favourable
Leasing	Low Initial Outlay	Moderate	Moderate	Favourable
ESCO	Very Low	Moderate	Low	Very Favourable
PPA	No Direct Investment	Low-Moderate	Very Low	Excellent

5.5 Sensitivity Analysis

Sensitivity analysis had been conducted to evaluate the robustness of the investment under different market and financial conditions. Three critical variables had been examined and these are electricity prices, interest rates and capital expenditure levels. These factors represent the most significant sources of uncertainty, that affects the economic performance of photovoltaic and energy storage investments.

5.5.1 Electricity Price Variations

Electricity prices constitute the most important determinant of project profitability. The reason is that the energy savings represent the primary source of investment returns.

If electricity prices increase above the assumed level of €0.15/kWh, then the annual savings rise proportionally. This ends up in higher NPV values and shorter payback periods. Under a high-price scenario, the economic attractiveness of self-generation and energy storage improves.

Conversely, lower electricity prices reduce annual savings. They also decrease overall project profitability. Nevertheless, the investment is still economically viable under moderate price reductions. This happens because of the relatively low operating costs of photovoltaic systems.

The analysis confirms that future electricity market developments are going to significantly influence the economic performance of the industrial renewable energy investments.

5.5.2 Interest Rate Changes

Interest rates directly affect financing costs. At the same time, they indirectly influence investment valuation through the discount rate applied in NPV calculations.

An increase in borrowing costs raises annual debt service obligations. It then reduces the attractiveness of debt-financed investments. Even more, higher discount rates reduce the present value of future cash flows. This results in lower NPV values.

Conversely, lower interest rates improve project economics. They do so, by reducing financing expenses and after increasing the present value of future benefits.

The sensitivity analysis shows that projects financed through loans are more vulnerable to interest rate fluctuations, than the projects that are financed through grants or internal resources. Therefore, the access to favourable financing conditions is an important determinant of investment feasibility.

5.5.3 CAPEX Variability

Capital expenditure uncertainty represents another important source of investment risk. A percentage of 10-20% reduction in project CAPEX improves profitability indicators. It also shortens the payback period. This scenario is realistic, given the ongoing decline in photovoltaic and battery technology costs, that are observed over the last decade.

On the other hand, increases in the equipment prices, supply chain disruptions, or installation costs negatively affect investment performance. Higher CAPEX leads to lower NPV values. It also directly leads to longer investment recovery periods.

Despite the above-mentioned risks, the sensitivity analysis shows that the project remains relatively resilient, under reasonable CAPEX fluctuations. It is about a finding, that suggests that photovoltaic systems, when they are combined with energy storage, are able to keep financial viability under a range of realistic market conditions.

The results of the scenario and sensitivity analyses create the base for the comparative assessment of financing instruments, that are going to presented in Chapter 6. In that context, the relative advantages and disadvantages of alternative financing structures are evaluated in even more detail.

6 Evaluation of Financing Options Based on the Base Case

6.1 Comparative Financial Performance of Financing Instruments

The financial modelling, that had been conducted in the context of the PETech investment project of Nera Kritis S.A.B.E.E., showed that the photovoltaic and battery storage investment is economically viable. It is viable even when financed only through the company's own resources.

However, the comparative assessment of financing instruments reveals substantial differences in profitability, liquidity requirements, capital commitment and risk exposure. Consequently, the selection of an appropriate financing mechanism as a critical determinant of the project's attractiveness.

The self-financing approach crates the highest long-term economic benefit. This is because all energy savings remain within the company. Even more, the absence of interest payments, financing fees, or profit-sharing arrangements allows the investor to capture the entire value, that is generated by the project. Nevertheless, this approach needs a significant upfront capital commitment of approximately €1.55 million. This may create liquidity constraints. It may also increase the opportunity cost of capital. This is financially attractive, but in the long run, self-financing may not always represent the most practical solution for industrial firms, that operate under capital burdens.

Bank financing is an alternative mechanism, that allows firms to preserve liquidity, while implementing the investment. The use of debt financing spreads capital expenditures over a longer period. It also enables companies to maintain their financial flexibility. However, interest expenses reduce overall project profitability. As it had been shown in the sensitivity analysis, increases in interest rates might affect financial performance. This happens particularly during periods of monetary tightening. Nevertheless, under stable financing conditions, the bank loans remain one of the most commonly used financing mechanisms, even for the context of the renewable energy projects.

Leasing arrangements show similar characteristics. More analytically, they reduce initial capital requirements. They also facilitate access to equipment without requiring substantial upfront investment. Their main advantage lies in cash flow management and not so much in the maximization of the profitability. Leasing costs generally exceed the cost of direct ownership over the project lifetime. On the other hand, the reduced liquidity burden may justify the additional expense for certain industrial firms.

ESCO financing has a different financial structure. Instead of directly financing the project, the industrial enterprise transfers part of the investment responsibility to an external service provider. Typically, the ESCO recovers its investment through a portion of the energy savings generated by the project. This is an arrangement, that significantly reduces investment risk and eliminates major capital requirements. Parallely, it limits the share of economic benefits, that are retained by the industrial company. Therefore, ESCO models often create lower financial returns for the end user, at least when they are compared with the direct ownership.

Power Purchase Agreements represent an additional low-capital alternative. Under a PPA structure, the business entity purchases renewable electricity from a third-party provider. This purchase is done at predetermined contractual prices. It is about a mechanism, that eliminates the need for direct investment. It also eliminates asset ownership and limits long-term financial gains. So, PPAs prioritize risk reduction and budget predictability.

Among all the evaluated financing mechanisms, subsidized financing scenarios create the strongest financial performance. More analytically, by reducing the initial capital expenditure, grants substantially improve NPV. They furthermore increase IRR and shorten the payback period. So, the public support mechanisms appear to be the most effective tools for increasing the economic attractiveness of the industrial renewable energy investments.

The following table summarizes the relative ranking of financing instruments:

Table 4. Relative Ranking of Financing Instruments

Financing Instrument	Profitability	Risk Reduction	Liquidity Preservation	Overall Assessment
Subsidy + Own Capital	Very High	High	High	Excellent
Own Capital	High	Moderate	Low	Very Good
Bank Loan	Moderate-High	Moderate	High	Good
Leasing	Moderate	Moderate	High	Good
ESCO	Moderate	High	Very High	Good

PPA	Low-Moderate	Very High	Excellent	Acceptable

6.2 Impact on Investment Profitability and Risk Profile

Financing structures affect on the one hand investment profitability, but they also affect the overall risk profile of renewable energy projects. The analysis shows that profitability and risk are often inversely related. This requires investors to balance potential returns against acceptable levels of uncertainty.

Self-financing maximizes profitability. The reason is that all project benefits accrue directly to the company. At the same time, this approach concentrates all investment risks within the organization. In more details, construction risks, operational risks, technological risks, and market risks are still entirely the responsibility of the investor. So, while financial returns may be maximized, the risk diversification is minimized.

Debt-financed investments modify this balance. They do so, by introducing financial risk. The project ownership remains with the company, but at the same time, interest obligations create additional financial commitments. During periods of reduced profitability or economic instability, the debt service's requirements may place pressure on corporate cash flows. Nevertheless, debt financing enables business entities to preserve liquidity. Also, it offers them the opportunity to diversify capital allocation across many different investment opportunities.

Leasing structures reduce capital exposure. Parallely, they introduce contractual obligations, that remain largely independent of the project's performance. This means that the financial burden is distributed over time. This reduces initial risk concentration. However, the company is still exposed to operational and energy market risks, that are linkes with the project.

ESCO arrangements alter the project's risk profile. Under performance-based contracts, a substantial portion of technical and operational risk is transferred to the service provider. The ESCO assumes responsibility for system performance and energy savings achievement. It is about a transfer of responsibility, that reduces uncertainty for the industrial company. It may also be particularly attractive for firms with limited experience in renewable energy technologies.

Similarly, PPAs transfer project risks to third-party developers. The industrial customer benefits from renewable electricity, This is happening without assuming construction or technological risks. However, this risk reduction comes at the expense of lower long-term economic returns and at the equal expense of reduced strategic control.

Subsidized financing mechanisms improve profitability. At the same time, they simultaneously reducing financial risk. After lowering the initial investment requirement, grants reduce exposure to capital losses. They even more improve project resilience under adverse market conditions. As a result, subsidies create the most favourable combination of risk reduction and profitability enhancement, compared to all the other evaluated financing options.

6.3 Risk Allocation Among Stakeholders

One important characteristic of financing structures is the way risks are distributed among stakeholders. Renewable energy investments involve multiple categories of risk, as it has also said before.

Under self-financing arrangements, nearly all the different types of risks remain with the industrial company. The investor bears responsibility for equipment performance maintenance activities, regulatory compliance and future electricity market developments. This is a structure, that maximizes potential rewards. At the same time, this structure additionally exposes the company to the full consequences of adverse results.

Bank financing faces financial institutions as additional stakeholders. In more details, credit risk is shared between lender and borrower. However, operational and market risks continue to be still primarily with the business entity. Generally, the banking organizations mitigate their exposure through collateral requirements, covenants and credit assessments, too.

Leasing arrangements create a more balanced risks' distribution. More analytically, the ownership of the assets use to remain with the lessor during the contract period. At the same time, the industrial company assumes operational responsibility. Consequently, risks are shared between both parties, depending on contractual provisions.

ESCO models are one of the most significant examples of risk sharing. Technical and performance risks are largely transferred to the service provider, whose revenues depend on the predefined energy savings' achievemment. It is about an existing alignment of incentives, that creates strong motivation for efficient project implementation and operation. PPAs transfer an even bigger portion of project risks to renewable energy developers. The customer primarily assumes contractual obligations, that are about electricity purchases. Parallely, construction, financing and operational risks remain with the project owner.

Public financing instruments involve the state as an additional stakeholder. Through grants, guarantees and support programmes, public institutions absorb a part of the investment risk. They do so, in order to stimulate renewable energy deployment and in order to accelerate decarbonisation objectives, too.

For the sake of a better understanding of the above analysis, the following table summarizes the risk allocation across financing structures:

Table 5. Risk Allocation Across Financing Structures

Financing Structure	Financial Risk	Operational Risk	Technology Risk	Market Risk
Own Funds	Company	Company	Company	Company
Bank Loan	Shared	Company	Company	Company
Leasing	Shared	Company	Shared	Company
ESCO	ESCO & Company	ESCO	ESCO	Shared
PPA	Developer	Developer	Developer	Shared
Subsidized Financing	Reduced Company Exposure	Company	Company	Company

6.4 Identification of the Optimal Financing Structure

The identification of the optimal financing structure needs a balancing profitability. It also needs risk, liquidity preservation and strategic flexibility. No single financing mechanism can be considered universally superior, under all the circumstances.

Especially, from a purely financial perspective, the subsidized financing scenario ends up to the strongest results. The combination of reduced capital expenditure, alongside with improved profitability indicators and lower financial risk makes public support mechanisms attractive for the projects in the field of the industrial renewable energy.

For the firms, that are financially strong and that they have sufficient liquidity reserves, self-financing is the most advantageous long-term solution. Asset ownership is still entirely under corporate control. Also, all future energy savings contribute directly to the profitability of the company.

However, many industrial businesses face capital constraints. They also face competing investment priorities. In these specific cases, for example, a mixed financing structure combining public subsidies with bank financing seems to offer the most balanced solution.

Finally, the ESCO and PPA models emerge as particularly attractive options for the companies that have limited technical expertise or that they face low risk tolerance. In these cases the long-term financial returns may be lower. Despite that result, the significant reduction in operational and financial risks may justify the trade-off.

Considering the objectives of industrial enterprises, operating in the Greek market, the most suitable financing structure seems to be a hybrid model. In the context of this model, combining grant support with moderate debt financing is proposes. Such a structure achieves an effective balance between profitability, risk management and financial flexibility.

6.5 Strategic Implications for Industrial Firms

The findings of this study have important strategic implications both for Nera Kritis S.A.B.E.E. and for industrial firms, that pursue energy transition objectives. Renewable energy investments should stop being faced exclusively as environmental initiatives. On the contrary, they need to be taken into consideration as as strategic business decisions capable of enhancing competitiveness and operational resilience.

The integration of photovoltaic systems and battery storage offes the firms the ability to reduce dependence on volatile electricity markets. It also offers them the ability to improve energy cost predictability and strengthen long-term financial stability. Furthermore, increasing stakeholder expectations about sustainability create additional incentives for investments in renewable energy technologies.

Financing decisions play a worth-noting role in determining whether these benefits are able to be realised. So, the industrial companies should adopt a comprehensive financing strategy, that considers on the one hand the project profitability and on the other hand the liquidity management, risk tolerance and future investment opportunities.

The results lead us to the suggestion that the firms, that are capable of combining multiple financing sources, are likely to achieve superior outcomes. Strategic use of grants, alongside with favourable loans and innovative financing instruments might improve project feasibility. At the same time, this choice might preserve financial flexibility.

Ultimately, the transition to renewable energy represents a technological transformation, but also a financial and strategic challenge. The companies, which are able to successfully align financing structures with corporate objectives, are going to be better positioned to benefit from the opportunities, that are created by the ongoing energy transition. In the specific context of the PETech project, such a hybrid financing structure could reduce the company's capital commitment. At the same time it might preserve the long-term economic benefits, that are linked with direct ownership of the photovoltaic and storage assets.

7 Conclusions and Strategic Recommendations

7.1 Summary of Key Findings

This dissertation examined the financing instruments, that are available for investments in photovoltaic systems, combined with energy storage in the industrial sector. We used a representative financial model, that had been developed in the context of the planned PETech project of Nera Kritis S.A.B.E.E.. Through this approach, the current study evaluated the impact that different financing mechanisms have on investment feasibility, profitability and risk exposure.

The findings show that photovoltaic systems, that are combined with battery storage, are able to constitute economically viable investments under current Greek market conditions. The base-case analysis showed a positive financial performance, that is supported by favourable NPV and IRR values. It also presented an acceptable payback period. These results confirm that renewable energy investments are ablr to contribute on the one hand to industrial competitiveness and on the other hand to broader sustainability objectives.

The analysis further showed that financing structures tend to influence project outcomes. At the time when self-financing produces the highest long-term returns, public support mechanisms improve financial attractiveness. They do so, by reducing capital requirements and through accelerating investment recovery. Alternative financing models, like for example leasing, ESCO contracts and PPAs, tend to increase by reducing upfront investment needs.

The study also showed the importance of risk allocation. In that context, financing mechanisms differ in the way they distribute financial, operationa, and technological risks among the stakeholders. Therefore, financing decisions should consider the expected returns, but also the investor’s risk profile and strategic priorities, as well.

7.2 Answers to Research Questions

The main research question, that had been examined, is the extent to which available financing instruments improve the financial attractiveness and feasibility of investments, in photovoltaic systems with energy storage.

The analysis showed that financing instruments might improve project feasibility. They might achieve this by reducing capital barriers and by lowering financial risk. They might do so, also, by enhancing profitability indicators. Also, the public subsidies had been found to have the strongest positive impact on project economics.

Regarding the first secondary research question, substantial differences had been identified between traditional and alternative financing mechanisms. More analytically, the traditional approaches focus on debt or equity financing, whereas alternative mechanisms emphasize risk sharing and third-party participation or they might also emphasize on reduced capital commitments.

Concerning the second research question, financing structures had been shown to directly affect NPV, IRR and payback period, too. Th grant-supported investments crated the strongest financial performance. At the same time, debt-financed and third-party-financed structures created more moderate returns.

The third research question addressed risk allocation. The findings showed that financing structures differ in their distribution of risks among the stakeholders. More analytically, ESCO and PPA models transferr significant risks away from industrial investors.

Finally, the analysis concluded that a hybrid financing structure, that combines public support with moderate external financing, ends up being the most suitable solution for many industrial firms operating in Greece. Therefore, in the context of the PETech project, the analysis proposes that financing decisions are capable of materially influencing, both investment feasibility and long-term financial performance, too.

7.3 Recommendations for Industrial Companies

Industrial firms are proposed to adopt a strategic approach to renewable energy financing, by evaluating both financial performance and risk exposure. Companies are recommended to actively monitor available subsidy programmes. They are also proposed to integrate public support opportunities into investment planning processes. In the specific case of Nera Kritis S.A.B.E.E., the evaluation of available subsidy programmes and low-cost financing opportunities constitutes an integral component of the PETech implementation strategy.

Even more, where it is possible, firms should seek financing structures, that preserve liquidity, while holding the ownership benefits. The combination of grants with debt financing is the most suitable decision, that ends up to balancing profitability and financial flexibility.

Companies are also recommended to strengthen internal capabilities, that are related to energy management, project evaluation and renewable energy technologies. They are pdsoposed to do so,their in order to maximize the benefits of their future investments.

7.4 Recommendations for Financial Institutions

Financial institutions should continue expanding specialized financing products, that are designed specifically for renewable energy and energy storage projects. For instance, the long repayment periods, alongside with the competitive interest rates and the simplified approval procedures could improve the access to financing for industrial firms.

Banking organizations, are also rexommended to incorporate sustainability considerations into credit assessment frameworks. The are even more proposed to recognize the long-term risk reduction benefits, that are related to investments in renewable energy technologies.

7.5 Policy Implications and Recommendations

Policymakers play a significant role in the industrial decarbonisation' acceleration. The findings of this dissertation suggest that grants and targeted financial support programmes are still essential for overcoming the investment barriers, that are associated with energy storage technologies.

Future policy initiatives, are proposed to focus on simplifying administrative procedures and on improving programme accessibility, as well. They are also recommended to expand funding availability for industrial renewable energy projects. Additional support mechanisms, like for instance guarantees, revolving funds and blended finance schemes, could further incrase and support the investment activity.

7.6 Limitations of the Study

In the cintext of this study, some limitations have to be acknowledged. At first, despite the fact that the analysis was developed in the context of the PETech project of Nera Kritis S.A.B.E.E., the detailed technical and financial project data were not publicly available. So, representative assumptions had been adopted for the purpose of financial modelling.

Although the assumptions had been selected to reflect realistic market conditions, actual project outcomes may differ.

Secondly, future electricity prices, technology costs and financing conditions are uncertain. This means that they may significantly influence investment's performance.

A third restriction is that the current study focused only on the Greek market. Therefore, its conclusions may not be directly transferable to other countries, that have different regulatory and market environments.

Finally, the analysis concentrated on financial performance indicators. It did not attempt to quantify broader environmental or social benefits, that are related to renewable energy investments.

7.7 Suggestions for Future Research

Future research could extend the current analysis, at first, by examining real-world industrial case studies and afterwards, by incorporating empirical project data. These kinds of proposed investigations would allow more precise evaluation of financing mechanisms, that are under actual operating conditions.

Further studies could also compare financing structures across different European countries. These studies are proposed to explore the influence of regulatory frameworks. They could also support schemes on investment outcomes.

Additional research is porposed to focus on emerging financing instruments. Charactristic examples of on emerging financing instruments that are proposed to be further studies and investigated are green securitisation, sustainability-linked loans and advanced blended finance structures.

Finally, future analyses are proposed to integrate environmental, social, and governance considerations alongside traditional financial metrics. This research could be able to offer a more holistic assessment of the value of renewable energy investments.

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