energies

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Appraisal Modeling for FSRU Greenfield Energy Projects

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Abstract: Floating storage and regasification units (FSRU) provide a flexible and competitive energy distribution option when it comes to the regasification of liquefied natural gas (LNG). FSRU projects have become more and more popular, attracting the interest of investors, energy authorities, and governments; therefore, the project feasibility in terms of risks and profitability are a major concern. This paper deals with the appraisal of a greenfield LNG infrastructure project, where usually, decision complexity deals with the high number and different expectation of stakeholders, the capital-intensive financing nature, and the business risks in the project life cycle. Conventional wisdom is to provide a coherent, compact, and well-structured appraisal modelling framework, adjusted to FSRU technical, structural, and operational features on one hand; and business risks, long-term life cycle, and investment attractiveness on the other. Appraisal modelling structure and outputs are considered to provide key messages to the decisions involved and interested parties toward the project feasibility and the associated investment risks for the implementation of the FSRU project. The proposed modelling framework was applied to the Alexandroupolis FSRU project, where the first discussion was many years ago, but the existing conditions in the energy market are raising the interest for developing energy distribution facilities globally.

Keywords: FSRU; LNG; appraisal modeling; modeling energy project appraisal; economic assessment; project incentives; energy project accounting; greenfield project planning; project due-diligence

Citation: Dimitriou, D.; Zeimpekis, P. Appraisal Modeling for FSRU Greenfield Energy Projects. *Energies* **2022**, *15*, 3188. https://doi.org/10.3390/en15093188

Academic Editors: Bernard Ziębicki and Edyta Bielińska-Dusza

Received: 6 March 2022
Accepted: 21 April 2022
Published: 27 April 2022

1. Introduction

As the need for a more sustainable and decarbonized future is continuously growing [1], natural gas (NG) has become one of the main primary energy sources in the world, due to its environmentally friendly nature and its multiple uses across a number of sectors. In the European Union (EU), NG is mainly used to produce electricity and for heating purposes, but it can be expanded to new fields such as agriculture [2] and aviation [3], and it is the second most commonly used energy source, combining for 23.1% of total energy consumption for the year 2018 [4].

One of the biggest challenges in energy consumption that places such as Europe have faced is the extremely high dependency in NG imports. Since the only EU members which have facilities for the production of NG are Norway and the Netherlands, the import dependency of NG has reached almost 90% for 2019, with Russia being the main supplier, providing 41.3% of the NG used in European Union countries for 2019 [4], although the NG flow from Russia to the European Union is projected to significantly decrease in the coming years [5,6]. This relationship strongly affects the European gas market [7,8]. The EU, in need of securing its energy stability and primary sources availability, set the diversification of energy sources to supply one of the main aims of its energy policy [9].

For NG, this can be succeeded by Liquefied Natural Gas (LNG), which allows NG to be transported in large quantities all over the world [10], without the location-specific limitations that underground pipelines create. The traditional supply chain of LNG includes gas production, liquefaction, shipping, storage, and regasification [11]. LNG is a liquid state of natural gas which is cooled to below 113.1 K, and its volume is 600 times smaller than that of NG [12]. Upon reaching its destination, LNG is reverted to natural gas at import terminals and distributed via pipelines to the final consumers [13,14]. The conversion from the liquid phase of LNG to gas can be implemented using onshore facilities or regasification ships moored at specially designed docks for this purpose, allocating significantly fewer capital expenses than the onshore terminals [15,16]. In the last case, the terminal is based on a Floating Storage and Regasification Unit (FSRU) permanently moored at the jetty and periodically supplied by an LNG carrier. FSRU, for small- and mid-sized markets, typically offer a more cost-effective, faster, and flexible means to bring natural gas to consumers compared to shore-based terminals [17–19]. In 2020, there were 34 FSRU operating, and 12 more are under construction [20]. Most of these stations are located in Eastern Asia and America. Europe are currently operating only five FSRU: in Toscana, Italy; in Klaipeda, Lithuania; in Aliaga and Dortyol, Turkey; whereas the most recently constructed FSRU is the one in Krk, Croatia, which started operation in 2021 [21,22]. Moreover, the only FSRU that is currently constructing in Europe is in Cyprus [21].

Greece is one of the EU members that is most dependent in NG imports, since it imports the 100% of its needs. The energy transportation to renewable sources has turned NG to one of the main energy sources used in Greece, increasing the usage from 3.500 mil NM3 in 2009 to almost 5000 mil NM3 in 2019 [23]. The need for the diversification of sources has also changed the ways that Greece imports its NG quantities, and increased the needs for LNG. The LNG supplied to Greece for 2019 was 47.6% of the whole NG imported, whereas it was only 19.7% in 2018 [23]. According to Greece's yearly National Natural Gas System (NNGS) allocation data, the LNG was supplied mainly from USA (48.26%) and Qatar (22.36%) [24].

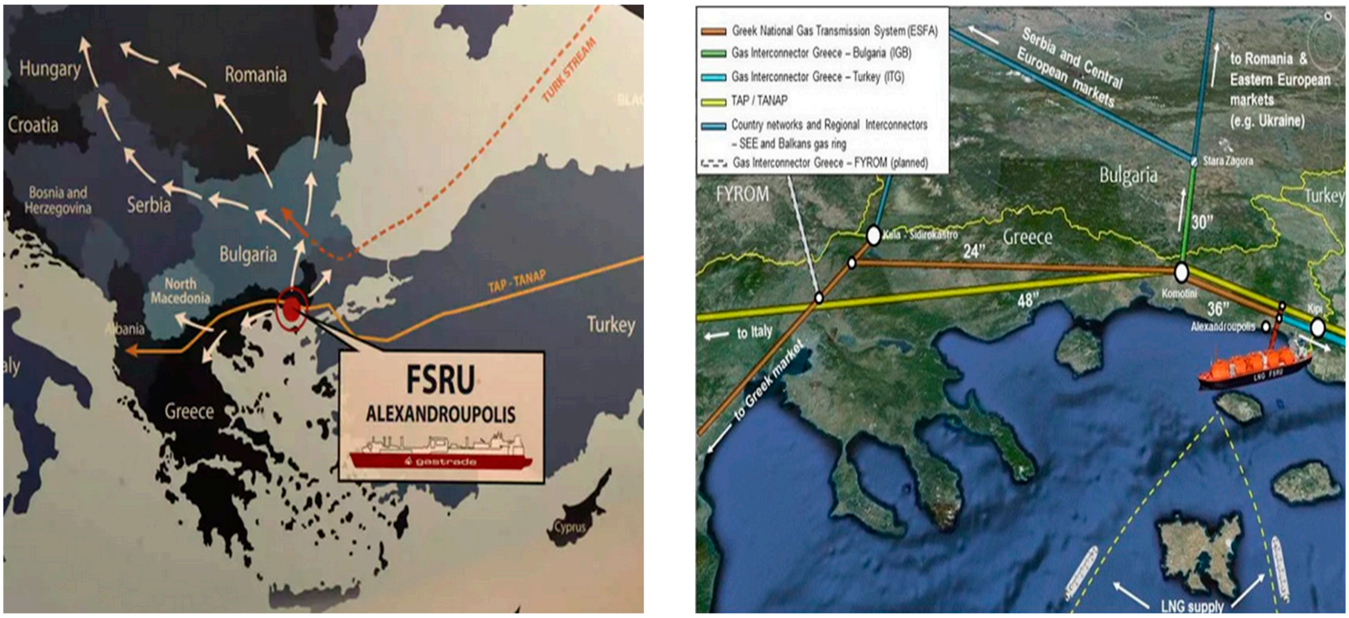
While the demand is growing so fast, the necessity for more expanded and well-developed natural gas distribution infrastructure is rising as well. Greece currently disposes an onshore terminal facility for the regasification process in Agia Triada, next to Athens. Besides this, a new energy projects initiative with the approval of the government decided on the construction of a new FSRU station at the Alexandroupolis sea area, located in the northern part of Greece.

This paper sets a comprehensive dynamic framework to evaluate the feasibility and economic footprint for the development of a new FSRU Station, considering the energy market characteristics, the project development phases, and the financing volatility. By a systemic approach, the appraisal modelling is presented, and it is applied to the Alexandroupolis city FSRU project in Greece. The output sensitivity, reviewed based on the FSRU station usage rate, linked the project viability with the energy demand risks. Additionally, the analysis provides key messages to planners and decision-makers regarding the incentives towards FSRU project implementation, promoting risk-sharing measures towards investment attractiveness.

This paper's novelty is to provide a coherent FSRU appraisal modelling structure adjusted for a new energy infrastructure project with a long-term payback period and high volatile business environment, which may support planners, economists, and decision-makers to illustrate conclusions on project feasibility, compare it with other projects, and apply it to similar cases. The analysis output sensitivity, reviewed based on the energy FSRU station usage rate, linked the project viability with the energy demand risks. Additionally, the analysis provides key messages to planners and decision-makers regarding the incentives towards FSRU project implementation, promoting risk-sharing measures towards investment attractiveness. This paper's novelty is to provide a coherent FSRU appraisal modelling structure adjusted for a new energy infrastructure project with a long-term payback period and high volatile business environment, which may support planners, economists, and decision-makers to illustrate conclusions on project feasibility, compare it with other projects, and apply it to similar cases.

2. Alexandroupolis FSRU Station Features

The Alexandroupolis, Greece, FSRU Station is planned to be constructed in the sea area southwest of the town of Alexandroupolis at a distance of 17.6 km from Alexandroupolis Port (Figure 1). The floating unit is planned to have four LNG storage tanks with a total capacity of up to 170,000 cubic meters. The dimensions of the floating unit will be approximately 300 m in length (LOA), 32.5 m in breadth, and 26.5 m in height (depth to upper deck) [25].



(**a**) (**b**)

Figure 1. (**a**) Alexandroupolis FSRU interconnections [25]; (**b**) Alexandroupolis FSRU location [25].

The NG after the regasification process will be transferred to the Greek National NG System (NNGS) via a 24 km subsea pipeline, which will be laid on a sea depth over 15 m, and a 4 km, 30″, and 100 bar operating pressure onshore underground pipeline [25]. A new Metering Station is constructed to act as the connection point with the (NNGS).

The key activities for the new FSRU Station are:

- Feed directly into the Greek NG Transmission System (NNGS) to supply the Greek market.
- Provide direct access to the Bulgarian market via the under-construction Greek–Bulgarian Interconnector Pipeline (IGB) and through the Bulgarian pipelines to the Balkan region, Hungary and Eastern Europe markets.
- Supply the Turkish market via reverse flow functionality of the existing Turkey–Greece Interconnection Pipeline.
- Connect with the European South Corridor gas projects such as TAP.

The exact location of the station and the interconnections with the neighboring countries are presented in Figure 1.

3. FSRU Appraisal Modelling Framework

The appraisal modelling framework was developed by a breakdown of the key unit cost in the project lifecycle. The FSRU project characteristics taken into consideration for the definition the project unit cost distinguished the lifecycle in two time periods: the construction and the operation. In the operation period, the energy market volatility has taken into consideration the promotion of a dynamic formulation of the equations. In the following part, the modelling structure and the associated explanations are expressed.

3.1. Initial Capital Cost

The total capital cost required during the construction period includes the construction cost and the project implementation cost. The construction cost includes the FSRU Vessel purchase, which is usually the larger unit cost; the mooring of the Vessel; the construction of subsea and inland pipelines to transfer the NG to the larger transmission pipeline; and the cost of other equipment needed for the FSRU Station operation. Project implementation cost is considered the cost of the project team, management support services, the specialists, and consultants prior to the final investment decision; and the administrative costs, such as the contract preparation, the procurement, the permits, and the licenses from authorities.

Therefore, the project capital cost calculated by the following equation:

$$\mathrm{ICC} = \mathrm{Con} + \mathrm{Own} + \mathrm{Cont} \tag{1}$$

where,

ICC is the total Initial Capital Cost during the construction period;
Con is the Construction Cost;
Own is the project implementation costs undertaken by the FSRU project shareholders; and
Cont is the cost of any contingency that may happen.

3.2. Financing

In such a large investment, usually, the funding for the capital costs is undertaken either by the shareholders equity or by a project financing tool, such as bank loan, bond issue, or by a combination of shareholders and bank or market funds. Therefore, the total capital cost is:

$$\mathrm{ICC} = \mathrm{E} + \mathrm{B} \tag{2}$$

where,

ICC is the total Initial Capital Costs during the construction period (see Equation (1));
E is the Shareholders Equity; and
B is the funds retrieved by a bank loan.

In case of a bank loan, the annual installment is determined by the following equation:

$$\mathrm{L_i} = \frac{\mathrm{B} * \ \mathrm{i_{RL}} * (1 + \mathrm{i_{RL}})^{\mathrm{n}}}{(1 + \mathrm{i_{RL}})^{\mathrm{n}} - 1} \tag{3}$$

where, $\mathrm{i} \in \mathrm{N}$ and $1 \leq \mathrm{i} \leq \mathrm{n}$;

$\mathrm{L_i}$ is the annual loan installment in the year i;
B is the total funds retrieved by the bank loan;
$\mathrm{i_{RL}}$ is the loan interest rate; and
n is the years that the loan must be paid.

For the project financing lifecycle, the total loan cost is:

$$\mathrm{TL} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{L_i} \tag{4}$$

where, $\mathrm{i} \in \mathrm{N}$ and $1 \leq \mathrm{i} \leq \mathrm{n}$;

TL is the total loan cost during the whole period of the loan payment;
$\mathrm{L_i}$ is the annual loan installment in the year I (see Equation (3)); and
n is the years that the loan must be paid.

The annual loan installment includes both an interest and a principal amount. The interest amount is used in order to calculate the net income before taxes, so it must be estimated. The mathematic formula is given below:

$$\mathrm{L_{Ii}} = \mathrm{L_i} + (1 + \mathrm{i_{RL}})^{\mathrm{i}-1} * (\mathrm{B} * \mathrm{i_{RL}} - \mathrm{L_i}) \tag{5}$$

where, $i \in N$ and $1 \leq i \leq n$;

L_{Ii} is the interest paid amount of the loan that is given during the year i;
L_i is the annual loan installment in the year I (see Equation (3));
B is the total funds retrieved by the bank loan (see Equation (2)); and
i_{RL} is the loan interest rate.

The principal paid amount in each annual installment is given by the following formula:

$$L_{pi} = L_i - L_{Ii} \tag{6}$$

where, $i \in N$ and $1 \leq i \leq n$;

L_{Pi} is the principal paid amount of the loan that is given during the year i;
L_{Ii} is the interest paid amount of the loan that is given during the year i (see Equation (5));
L_i is the annual loan installment in the year i (see Equation (3)).

3.3. Sales Income

The FSRU revenue streams deal with the regasification services that it provides. The extent of the sales income depends on the capacity of the FSRU's Vessel, due to the fact that the larger the storages are, the more LNG quantity can be degasified. Moreover, it depends on the quantity of the LNG carriers that use the facilities, which, in this analysis, is called "usage rate" of the Station, and is expressed as a percentage of the Station's yearly usage. Finally, it depends on the tariff that the Station charges its customers for the regasification services, and is usually expressed on price per normalized cubic meter (Nm^3). The Station will operate for (T) years, and given the above, the annual Sales income is given by:

$$RV_i = C_V * uf_i * TR_i \tag{7}$$

where, $i \in N$ and $1 \leq i \leq T$;

T is the years of operation of the FSRU Station;
RV_i is the annual revenue for the operation year i;
C_V is the total annual capacity of the Vessel in Nm^3;
uf_i is the usage rate of the FSRU Station for the operation year i;
TR_i is the tariff price charged per normalized cubic meter or LNG for the operation year i.

The total sales income for the whole operation period of the Station is:

$$R = \sum_{i=1}^{T} RV_i \tag{8}$$

where, $i \in N$ and $1 \leq i \leq T$;

RV_i is the annual revenue for the operation year i.

3.4. Operating and Capital Costs

The main operational cost covers the personnel working in the Station, usually around 120 persons, who work on the onshore facilities, in the marine section for the transportation of the personnel, in the operating department, and the maintenance department of the FSRU. Furthermore, the operational costs include the power and steam generation needed for the FSRU's equipment; the maintenance and inspection costs; the underwater inspections; the materials, chemicals, and spare part supply; the insurance; the harbor fees; the service boat maintenance; the dredging inspection; and finally, the head office support to the operations.

The operational cost for the power and steam generation during the regasification process is estimated according to the below formula:

$$PowCost_i = PowCost_Y * uf_i \tag{9}$$

where, $i \in N$ and $1 \leq i \leq T$;

$PowCost_i$ is the power and steam generation cost for the operation year i;
$PowCost_Y$ is the power and steam generation cost if the usage rate was 100%; and
uf_i is the usage rate of the FSRU Station for the operation year i.

In addition, the operational costs depending on the usage rate of the Station are essential to take into consideration. To quantify the variable cost that is related to the usage rate of the FSRU, it is estimated by correlating it with the operational expenses when the usage rate is 100%, and the usage rate through a variable named b_i. Respectively, the fixed costs to the operational costs of 100% usage rate use a variable named a_i. Therefore, the fixed and variable costs, as well as the operational costs given from the below group of equations:

$$FC_i = a_i * OPEX_{100\%} \tag{10}$$

$$VC_i = b_i * OPEX_{100\%} * uf_i \tag{11}$$

$$OPEX_i = FC_i + VC_i \tag{12}$$

where, $i \in N$ and $1 \leq i \leq T$;

$OPEX_{100\%}$ is the annual operating cost for 100% usage rate of the FSRU Station;
$OPEX_i$ is the annual operational cost except from the LNG consumption cost for the operation year i;
FC_i is the fixed cost for the operation year i;
VC_i is the variable cost, for the operation year i;
a_i and b_i are numbers that correlate the fixed and variable costs with the operational costs, $a_i, b_i \in R$, $0 < a_i < 1$, $0 < b_i < 1$, and $a_i + b_i = 1$.

The annual capital expenditures include all the costs related to the upgrade of the existing facilities and equipment that are necessary for the operation of the FSRU. Furthermore, they include the costs of acquiring new assets, and research and development (R&D) costs. The annual capital costs are usually correlated to the initial investment cost, and can de expressed as:

$$CAPEX_i = c_i * ICC \tag{13}$$

where, $i \in N$ and $1 \leq i \leq T$;

$CAPEX_i$ is the capital expenditures for the operation year i;
c_i is a number that correlates the annual capital expenditures with the capital costs of the construction period, $c_i \in R$, $0 < c_i < 1$.

3.5. Depreciation and Amortization

It is important to analyze and distinguish the capital expenditures from the operating cost, because the first is depreciated and reduces the final payable tax. Moreover, the depreciation depicts the value of the project assets over time, providing the market value of the project. To calculate the depreciation, we have to add the depreciation of the initial capital cost to the depreciation of the annual capital expenditures produced every operating year. This means that to estimate the depreciation cost for the 10th year of operation, the following are added: the depreciation of initial capital cost during the 10th year, the depreciation of capital expenditure of 1st year of operation during the 10th year, the depreciation of capital expenditure of 2nd year of operation during the 10th year, etc. In real-life applications, it uses methods to account for depreciation, such as straight line depreciation, declining balance, double declining balance, sum of the year's digits, and units of production. In this analysis, the straight line method approach is selected, because the project production ability is not stabile over time, and it provides more accuracy for a long lifecycle project with a long payback period.

Using the straight line method, the salvage value of the asset after the depreciation period and the depreciation rate must be set according to accounting norms and the used materials and equipment in the project. In this analysis, the depreciation ratio received was stable over time, and it covered the overall project lifecycle. This means that the depreciation amount for each infrastructure and equipment unit cost will be stable for all of the operating period, except from the last year that it can get a lower price, until it matches its salvage value.

Therefore, the depreciation for the construction cost is estimated by:

$$\text{If } i = 1, \text{ then } D_{(i)Con} = d_{Con} * (Con - SAL_{Con}) \tag{14a}$$

$$\begin{gathered}\text{If } i > 1 \text{ and } REMV_{(i-1)Con} - D_{(i-1)Con} > SAL_{Con}, \text{ then} \\ D_{(i)Con} = d_{Con} * (Con - SAL_{Con})\end{gathered} \tag{14b}$$

$$\begin{gathered}\text{If } i > 1 \text{ and } REMV_{(i-1)Con} - D_{(i-1)Con} \leq SAL_{Con}, \text{ then} \\ D_{(i)Con} = REMV_{(i-1)Con} - SAL_{Con}\end{gathered} \tag{14c}$$

where, $i \in N$ and $1 \leq i \leq T$;

$D_{(i)Con}$ is the depreciation amount of the initial construction capital cost for the operating year i;

d_{Con} is the depreciation rate, expressed as percentage (%) of the initial construction capital cost;

Con is the initial construction capital cost (see Equation (1));

SAL_{Con} is the salvage value of the initial construction capital cost; and

$REMV_{(i)Con}$ is the remaining value of the initial construction capital cost after depreciation in the operating year i, and is given by the below equation:

$$\begin{gathered}\text{If } Con - i * d_{Con} * (Con - SAL_{Con}) > SAL_{Con}, \text{ then} \\ REMV_{(i)Con} = Con - i * d_{Con} * (Con - SAL_{Con})\end{gathered} \tag{15a}$$

$$\begin{gathered}\text{If } Con - i * d_{Con} * (Con - SAL_{Con}) \leq SAL_{Con}, \text{ then} \\ REMV_{(i)Con} = SAL_{Con}\end{gathered} \tag{15b}$$

The depreciation amount for the capital expenditure costs produced during the (i) year of operation is calculated using the same logic as above, and given according to the following equations:

$$\text{If } i = j, \text{ then } D_{(i)CAPEX_j} = d_{CAPEX_j} * \left(CAPEX_j - SAL_{CAPEX_j}\right) \tag{16a}$$

$$\begin{gathered}\text{If } i > j \text{ and } REMV_{(i-1)CAPEX_j} - D_{(i-1)CAPEX_j} > SAL_{CAPEX_j}, \text{ then} \\ D_{(i)CAPEX_j} = d_{CAPEX_j} * \left(CAPEX_j - SAL_{CAPEX_j}\right)\end{gathered} \tag{16b}$$

$$\begin{gathered}\text{If } i > j \text{ and } REMV_{(i-1)CAPEX_j} - D_{(i-1)CAPEX_j} \leq SAL_{CAPEX_j}, \text{ then} \\ D_{(i)CAPEX_j} = REMV_{(i-1)CAPEX_j} - SAL_{CAPEX_j}\end{gathered} \tag{16c}$$

where, $i \in N$, $1 \leq i \leq T$, $j \in N$, $1 \leq j \leq T$, and $i \geq j$;

$D_{(i)CAPEX_j}$ is the depreciation amount for operating year i of the capital cost that was produced during operating period j, $i \geq j$, $i \in N$, $j \in N$;

d_{CAPEX_j} is the depreciation rate of the capital cost that was produced during operating period j, $j \in N$;

SAL_{CAPEX_j} is the salvage value of the capital cost that was produced during operating period j, $j \in N$;

$REMV_{(i)CAPEX_j}$ is the remaining value of the capital cost that was produced during operating year j, after depreciating in the operating year i, and is given by the below equations:

$$\begin{gathered}\text{If } CAPEX_j - (i-j) * d_{CAPEX_j} * \left(CAPEX_j - SAL_{CAPEX_j}\right) > SAL_{CAPEX_j}, \text{ then} \\ REMV_{(i)Con} = CAPEX_j - (i-j) * d_{CAPEX_j} * \left(CAPEX_j - SAL_{CAPEX_j}\right)\end{gathered} \tag{17a}$$

$$\text{If } \mathrm{CAPEX_j} - (\mathrm{i}-\mathrm{j}) * \mathrm{d_{CAPEX_j}} * \left(\mathrm{CAPEX_j} - \mathrm{SAL_{CAPEX_j}}\right) \leq \mathrm{SAL_{CAPEX_j}},\ \text{then} \\ \mathrm{REMV_{(i)Con}} = \mathrm{SAL_{CAPEX_j}} \tag{17b}$$

Given the Equations (14) and (16), the depreciation amount for all capital costs, including initial capital costs and annual capital costs, for each operating year is expressed as:

$$\mathrm{D_i} = \mathrm{D_{(i)Con}} + \sum\nolimits_{j=1}^{i} \mathrm{D_{(i)CAPEX_j}} \tag{18}$$

where, $i \geq j$, $i \in N$, $1 \leq i \leq T$ $j \in N$, and $1 \leq j \leq T$.

Similarly, according to Equations (15) and (17), the remaining value after depreciation of the whole project's capital costs for each operating year can be expressed as:

$$\mathrm{REMV_i} = \mathrm{REMV_{(i)Con}} + \sum\nolimits_{j=1}^{i} \mathrm{REMV_{(i)CAPEX_j}} \tag{19}$$

The amortization consists of the loan's amortization and the intangible asset amortization. The loan's amortization is the interest-paid amount of the loan given using Equation (5). The amortization of the intangible assets is calculated in the same way used above for the calculation of depreciation. Finally, the amortization is expressed as follows:

$$\mathrm{A_i} = \mathrm{L_{Ii}} + \mathrm{A_{(i)Con}} + \sum\nolimits_{j=1}^{i} \mathrm{A_{(i)CAPEX_j}} \tag{20}$$

where, $i \geq j$, $i \in N$, $1 \leq i \leq T$ $j \in N$, and $1 \leq j \leq T$.

3.6. Income Statement

Taking into consideration the sales revenues (Equation (7)), the operating (Equation (12)) and capital expenditures (Equation (13)), the interests (Equation (5)), the depreciation (Equation (18)), and the amortization (Equation (20)), the earnings before taxes (EBT) for the operating year i are given by:

$$\mathrm{EBT_i} = \mathrm{RV_i} - \mathrm{PowCost_i} - \mathrm{OPEX_i} - \mathrm{D_i} - \mathrm{A_i} - \mathrm{LI_i} \tag{21}$$

where, $i \in N$, $1 \leq i \leq T$.

For the EBT of each year, a certain tax applied, being set by the government and local authorities. The tax is applied only when the EBT is higher than 0, and the company has earnings in that specific tax year:

$$\mathrm{TAXES_i} = \begin{cases} \mathrm{tax_i} * \mathrm{EBT_i},\ \text{if } \mathrm{EBT_i} > 0 \\ 0,\ \text{if } \mathrm{EBT_i} \leq 0 \end{cases} \tag{22}$$

where, $i \in N$, $1 \leq i \leq T$;

$\mathrm{TAXES_i}$ is the tax expense for the operating year i;

$\mathrm{tax_i}$ is the tax percentage set by the government for operating year i.

The net earnings (NE) for each year reflect the earnings of the organization after the imposed taxes, and it is an important element to evaluate the profitability of an investment because it takes into account all revenues and expenses the company has. For the operating year i, the net earnings are calculated as follows:

$$\mathrm{NE_i} = \mathrm{EBT_i} - \mathrm{TAXES_i} \tag{23}$$

where $i \in N$, $1 \leq i \leq T$.

3.7. Cash Flow

The total cash inflows for the FSRU Station of the current study come only from the revenues we have calculated from Equation (7). As such, total cash inflows are:

$$CFI_i = RV_i \tag{24}$$

where CFI_i is the cash inflows for the operating year i, $i \in N$.

The total cash outflows come from the power generation costs during the regasification process (see Equation (9)), the operating (see Equation (12)) and capital expenses (see Equation (13)), and the interest (see Equation (4)) and the taxes expenses (see Equation (22)), and they are calculated by the following formula:

$$CFO_i = PowCost_i + OPEX_i + CAPEX_i + D_i + A_i + L_i + TAXES_i \tag{25}$$

where CFO_i is the cash outflows for the operating year i, ieN.

From the above Equations (24) and (25), the total cash flows are expressed by:

$$CF_i = CFI_i - CFO_i \tag{26}$$

where CF_i is the cash flows for the operating year i, ieN.

3.8. NPV and IRR

To be able to conduct an economic assessment of the project, there are several financial techniques. The most common methods include Break Even Point Analysis, Payback Time Period, Net Present Value (NPV), and Internal Rate of Return (IRR). In the present paper, we have conducted the NPV and IRR analysis in order to assess the results of our study. The main purpose of the financial analysis is to use the project cash flow forecasts to calculate suitable net return indicators [26–29].

To calculate the NPV, we use the cash flows for each operating year, and then discount the stream back to the present time period. The formula for deriving NPV is:

$$NPV = (-ICC) + \sum_{i=1}^{T} \frac{CF_i}{(1+DR)^i} \tag{27}$$

where $i \in N$ $1 \leq j \leq T$; and

DR is the discount rate.

Financial sustainability is ensured if NPV of cumulated cash flow is positive for all the years considered [26].

For the IRR calculation, in Equation (27), we set NPV equal to zero and DR=IRR. Then, we can solve to find the IRR:

$$NPV = (-ICC) + \sum_{i=1}^{T} \frac{CF_i}{(1+IRR)^i} = 0 \tag{28}$$

The IRR should match a certain price that is set by the shareholders in order to assess positively the investment, and, at least, should be greater than the discount rate.

3.9. Tax Incentives

In this section, the key question is if, and in what level of capitals, the state's authorities could promote the investment by offering tax benefits and making the investment more attractive to potential investors. Large infrastructure projects develop, assess, and support activities providing a positive contribution to the regional economy [26–28]. This can boost the socioeconomic development of regional and remote areas of a state, such as Alexandroupolis [29–31]. Therefore, the state would favor to promote and facilitate the construction of such a project.

The methodology used includes estimating the economic benefits that the state will indirectly gain from the operation of the Station. "Indirectly" benefits include all the other sources of income the FSRU will generate, except from the taxes that will be paid to the state at the end of every tax year. Such sources can be the taxation of works and activities related to the Station, the taxation of the employees' salaries, and others. In this analysis, firstly, these activities will be pointed out, and then, the total turnover of each activity will be estimated, and the taxation incomes will be found out. Finally, these profits that the state will gain from the FSRU's operation can be given to the FSRU as tax reliefs.

Specifically, the state will gain tax incomes during the construction period. For the construction of the Station's heavy equipment, such as the FSRU vessel or the NG pipelines, these will be supplied and imported to the country, and works and services will be performed, such as the construction of the pipeline, the dredging of the vessel, the Project's reporting, and others. All of these supplies and works will be taxed by the government. Furthermore, extra jobs will be created, and the state will be benefited by the taxation on their salaries.

During the operation period, the Station shall employ around 120 people personnel. The state gains taxes from the salaries that the FSRU pays to these employees. These taxes come not only from the direct taxation, but also from the fact that these people will spend their wages, and they will be taxed for these purchases.

Moreover, during the operating period, each year, the Station generates operating and capital expenditures, which concern the supply of goods and services which include taxes to the state. These expenses for each operating year i are the sum of $\mathrm{OPEX_i}$ and $\mathrm{CAPEX_i}$ (Equations (12) and (13)) minus the wages of the personnel mentioned above, and expressed from the following formula:

$$\mathrm{FSRUEXP_i} = \mathrm{OPEX_i} + \mathrm{CAPEX_i} - \mathrm{Sal_i} \tag{29}$$

where, $\mathrm{i} \in \mathrm{n}$, $1 \leq \mathrm{i} \leq \mathrm{T}$;

$\mathrm{FSRUEXP_i}$ is the total turnover generated by the annual operating and capital costs of the FSRU for the operating year i;
$\mathrm{OPEX_i}$ is the operating expenses during operating year i;
$\mathrm{CAPEX_i}$ is the capital costs during operating year i;
$\mathrm{Sal_i}$ is the total salaries paid to the FSRU personnel during operating year i.

Finally, the Station produces some extra activities. An FSRU needs, for its maintenance and inspection, someone with technical expertise, who will probably need to come from other areas of Greece or even from abroad. These people will generate turnover by their transport, food, and accommodation expenses. Moreover, the regasification process usually lasts almost a day. This means that the LNG carriers' personnel (around 20 people) will stay for one day in the town of Alexandroupolis, spending money on food, coffee, gifts, and others. This tax income depends on the usage rate of the FSRU.

The tax income from all the above-mentioned cases can be expressed by the following equation:

$$\begin{aligned} \mathrm{STATEINC} = \mathrm{Con} * \mathrm{TAX_{ICC}} + \textstyle\sum_{i=1}^{T} [\mathrm{Sal_i} * \mathrm{Tax_{Sali}} + \mathrm{FSRUEXP_i} * \\ \mathrm{Tax_{FSRUEXPi}} + \mathrm{Local_i} * \mathrm{Tax_{Locali}}] \end{aligned} \tag{30}$$

where, $\mathrm{i} \in \mathrm{N}$, $1 \leq \mathrm{i} \leq \mathrm{T}$;

STATEINC is the total income from taxes generated from FSRU during the construction and operating period, without taking into account the taxes of FSRU;
$\mathrm{TAX_{ICC}}$ is the total tax applied to the income generated during the construction period;
$\mathrm{Sal_i}$ is the total yearly wages paid to the FSRU personnel during the operating year i;
$\mathrm{Tax_{Sali}}$ is the total tax applied to the salaries of the FSRU personnel for operating year i;
$\mathrm{Tax_{FSRUEXPi}}$ is the tax applied to the operating and capital expenditures of the FSRU during the operating year i;

$Local_i$ is the total income generated for local society during operating year i;
Tax_{Locali} is the tax applied to the income for local society during operating year i.

After estimating the total income from the taxes, the state may decide whether it is in its interest to proceed with offering tax incentives. Then, the taxes of the FSRU are given by Equation (22), modified according to the below formula:

$$TAXES_i = \begin{cases} tax_i * EBT_i - TAXrelief_i, \text{ if } EBT_i > 0 \\ 0, \text{ if } EBT_i \leq 0 \end{cases} \quad (31)$$

where, $TAXrelief_i$ is the tax relief that the state offers for operating year i.

Finally, the NE, NPV, and IRR are re-adjusted according to Equation (31).

4. Numerical Application Results

Based on above modelling framework for the evaluation of an FSRU Project, the numerical application deals with the development of the new Alexandroupolis FSRU Project. The primary referenced data that relate to the specific characteristics of a FSRU Station, such as basic operating and construction costs, are retrieved from "The Outlook for Floating Storage and Regasification Units (FSRUs)" and "Floating LNG Update-Liquefaction and Import Terminals", both published by the Oxford University for Energy Studies [32,33]. We have also used data from the operating OLT Offshore LNG Toscana FSRU Station located in Toscana, Italy [34].

Subsequently, a sensitivity analysis subject to the FSRU usage rate has to be conducted supporting decisions regarding the authorities' taxation, and in what range a tax reduction scheme or mitigation policies could be increase the capital leverage, providing a win–win risk mitigation scheme between authorities and private funds.

4.1. Economic Assessment of the Alexandroupolis FSRU Station

Economic analysis provides decision-makers with a way of assessing the overall value of a project, including the financial viability and the investment's likely productivity and effectiveness indexes [29,30].

The FSRU of Alexandroupolis is the first FSRU Station being constructed in the Greece territory, characterized as a totally greenfield project, and there are not existing baseline scenarios or data to be used for the economic analysis. The available data have already been addressed, mainly related to FSRU key operational characteristics, such as the Vessel's capacity. Therefore, the analysis structure developed by analyzing all the necessary factors and rates is necessary to be taken into consideration to assess the economic output of the project. For the readers and users of the proposed methodology framework, the formulation provides a dynamic modelling formulation structure, where key assessment variables are adjusted over the project lifecycle, the technical features, the financial market conditions, and the project features.

For the calculations presented in this paper, most of the assessment variables have been retrieved from the literature and relevant bibliography [32]. However, key assumptions are taken, providing the analysis hypothesis, based on the nature of the Station and the local characteristics, without reducing the value of the methodology, the modeling structure, and the application outputs.

4.1.1. Case Study Assumptions

The values we used to run this analysis are:

- The FSRU's average operation period is about 20 years; therefore, T = 20.
- The exchange rate (XR) of USD to Euro has been set to 0.8736 according to the 14 January 2022 exchange rate.
- The construction cost is set to 314,496,000 € [32].
- The owner's cost has been set to 10% of the construction cost, 31,449,600 € [32].
- The contingency ratio has been set to 15% of the construction cost, 47,174,400 € [32].

- Given the above and Equation (1), the ICC is estimated at 393,120,000 €.
- The level of ICC supports the assumption that it would not be fully funded by the shareholders' available cash, so we assume that half of the ICC will be funded by the shareholders, whereas the rest will be funded through borrowing. According to Equation (2), E = B = 196,560,000 €.
- This project can be financed by the Investment Bank, which are the commonly used instrument for such infrastructure projects. At the national level, this project would provide higher energy security in Greece by diversifying the ways of NG supply. At the local level, it can boost the local society economy by the direct employment it can offer (around 120 job places) and by creating a large circle of works that the FSRU needs. Thus, we assume that the Project will be financed by the EIB. The loan's interest rate is set to 3%, and the payment period to 20 years. As such, iRL = 3% and n = 20 years. Moreover, it is assumed that the payback of the loan shall start after the start of operation of the project.
- The annual loan installment is calculated via Equation (4) at 1,321,191,949 €.
- The total annual capacity of the vessel (Cv) will be 6.1 billion Nm^3, according to the Alexandroupolis FSRU [25].
- The second and binding market test for the reservation of capacity, conducted from the Alexandroupolis FSRU project initiative, bound 2.6 billion Nm3. This means that the usage rate (uf) can be set to at least 42% [25].
- The tariff of charge rate per Nm3 of NG we used in the analysis is the one that the Toscana FSRU Station uses for the year 2022 [34]. This is because the Toscana FSRU is geographically close to the Alexandroupolis FSRU, and Italy has the same currency as Greece (Euro). As such, we could assume that the tariff could be in the same range.
- The daily power and steam generation was estimated at 72,000 USD per day [32], which means that $PowCost_Y$ = 22,958,208 € per year.
- The rest-operating expenses are estimated at around 2.5% of construction costs. This value represents the OPEX for 100% of the Station's usage rate [32]. As such, $OPEX_{100\%}$ = 7,862,400 €.
- We assume that fixed costs and variable costs are in the same price range. As such, we can set ai = bi = 0.5, for i = 1 to T.
- We assume small annual capital costs at the range of 1% of ICC. As such, ci = 1%, for i = 1 to T.
- According to Greek tax legislation, the depreciation rate for industrial areas and storages is 4%. Due to the fact that we have used straight line depreciation, and the biggest part of the capital costs (initial and annually) refer to heavy equipment and assets, we assume that dcon = dcapexi = 4%, for i = 1 to T.
- After the end of the operation period of the Station, the FSRU's Vessel still has quite a high remaining value, as it can be modified and used in other applications (i.e., LNG carrier). Moreover, the subsea and onshore pipelines are made of steel, which has a high scrap value. For this reason, we assume that the salvage value can be set at 25% of the initial value both for the initial capital cost and the annual capital costs. As such, SALcon = SALCAPEXi = 25% of initial value, for i = 1 to T.
- The nature of the project includes mainly physical assets, instead of intangible assets. This is why we can assume that amortization costs are not applicable to this analysis, and Ai = 0, for i = 1 to T.
- The tax imposed to all companies in Greece for the year 2021 was 22%. In the analysis, we have used the same tax rate, so tax(i) = 22%, for i = 1 to T.

4.1.2. Case Study Results

Applying the above data and values, we get the economic results. The most important of them are presented in Table 1.

Table 1. Results of economic assessment.

Year	Depreciation (€)	EBT (€)	Taxes (€)	Net Earnings (€)	Cash Flow (€)
1	9,529,229	62,795,895	13,815,097	48,980,798	52,654,735
2	9,623,578	63,140,453	13,890,900	49,249,554	52,627,212
3	9,717,926	63,498,179	13,969,599	49,528,580	52,598,240
4	9,812,275	63,869,467	14,051,283	49,818,184	52,567,777
5	9,906,624	64,254,724	14,136,039	50,118,685	52,535,777
6	10,000,972	64,654,369	14,223,961	50,430,408	52,502,195
7	10,095,322	65,068,834	14,315,143	50,753,690	52,466,982
8	10,189,670	65,498,563	14,409,684	51,088,879	52,430,090
9	10,284,019	65,944,015	14,507,683	51,436,332	52,391,469
10	10,378,368	66,405,660	14,609,245	51,796,415	52,351,066
11	10,472,717	66,883,986	14,714,477	52,169,509	52,308,829
12	10,567,066	67,379,492	14,823,488	52,556,003	52,264,701
13	10,661,414	67,892,693	14,936,392	52,956,301	52,218,628
14	10,755,763	68,424,121	15,053,307	53,370,814	52,170,549
15	10,850,112	68,974,322	15,174,351	53,799,971	52,120,405
16	10,944,461	69,543,860	15,299,649	54,244,211	52,068,134
17	11,038,810	70,133,314	15,429,329	54,703,985	52,013,673
18	11,133,158	71,106,006	15,643,321	55,462,684	51,877,155
19	11,227,507	71,747,985	15,784,557	55,963,429	51,815,719
20	11,321,856	72,412,055	15,930,652	56,481,403	51,751,817

Continuing the analysis, we proceed with the calculation of the economic indicators of NPV and IRR, using the Equations (27) and (28). We set the discount rate at 4.9%, as was given for Greece from the European Commission for 1 January 2022, and we consider that the construction period will last for 2 years. Given the above, the NPV and IRR are calculated as follows:

- NPV = 214,463,908 €;
- IRR = 9.46%.

Figure 2 depicts the NPV for the Alexandroupolis FSRU.

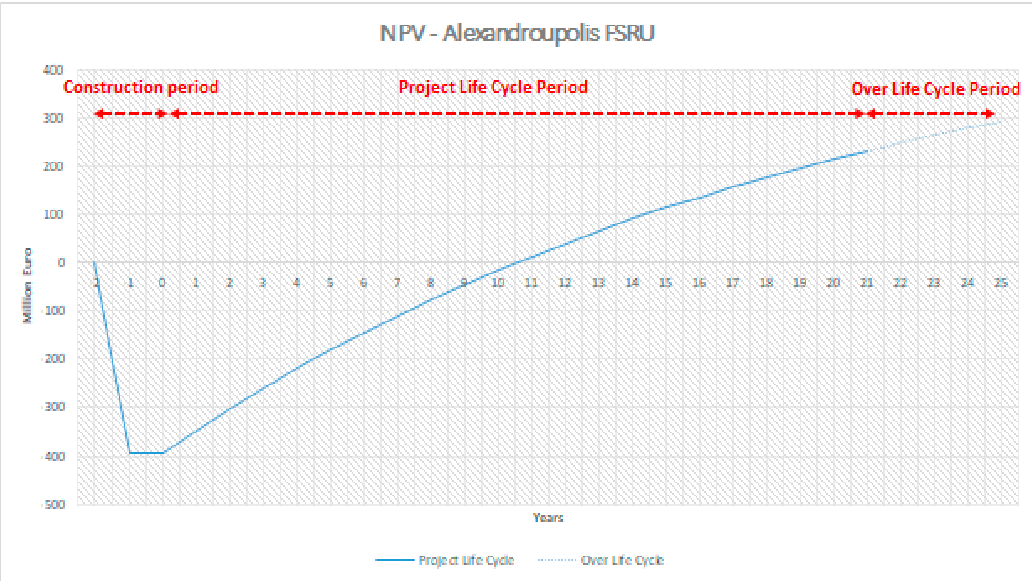


Figure 2. NPV for the Alexandroupolis FSRU Project.

Finally, with the help of Equations (15) and (17), the remaining value of the assets of the Station are calculated at 168,884,352 €.

Discussing the results of the analysis, we can ascertain that the economic output of the Project, given the assumptions we made, can definitely be positive and profitable. The net earnings, even after the taxes and expenses, can attribute to a very high profitability, which makes the project attractive enough to investors. The NE of the 1st year of operation reaches 12.46% of the ICC. This means that in only a few years, the ICC can be recuperated.

Evaluating the assessment using the economic indicators of NPV and IRR, the Project is also characterized as profitable and viable. The NPV at the end of operation period is not only positive, but has reached around 214 million €, which is 54.55% of the ICC. This means that, even estimating the discount rate of money for all 20 years of operation, the investment can give a high percentage of profit. As far as it concerns the IRR, it reaches 9.46%, which is 1.93 times higher than the discount rate of Greece (4.9%) at this time.

Last but not least, the remaining value of the assets at the end of the operation period, including both initial capital cost and capital costs during each year of operation, is still high enough, giving the investors the opportunity to gain high profits during the decommissioning period also.

4.2. Sensitivity Analysis

The above results were calculated using a relatively small usage rate of 42% of the FSRU. This means that there are bigger profit margins if this rate increases. On the other hand, if it drops even more, there is a doubt if the Project can remain economically viable or not. The same questions will be raised if other rather unstable parameters, such as USD/EUR exchange rate or tariff price, change. In this section, a sensitivity analysis is conducted to fully understand and highlight the dependence of the Project's profitability in relation to various parameters of the FSRU.

4.2.1. Usage Rate

Implementing infrastructure projects, the demand curves are essential and critical to assess feasibility and economic viability. Therefore, the sensitivity analysis should keep all the values stable, and change the demand of the Station, which is expressed by the usage rate. Applying a series of usage rates, the NPV, IRR, and net earnings using the methodology of Section 3 are calculated. The usage rate that was adopted during the presented (basic) scenario, based on values resulting from a market sounding survey conducted before the COVID-19 pandemic by the FSRU investors, constitute the most reliable scenario. Furthermore, higher demand scenarios, even it seems too optimistic for a greenfield energy infrastructure project, are considered in this numerical application, taken into account the new conditions in European energy market where new infrastructure for LNG supply is in major attention. However, the recent conflicts in North-East Europe where Russia is acting may provide a great opportunity for new business, and generate additional demand.

Initially, in the analysis, the hypothesis of a light volatility around the regular scenario's usage rate value was taken into consideration. Assuming that the volatility will be 20%, the values of usage rate to be examined are 33.6% for the high-risk scenario, and 50.4% for the positive market reaction scenario. Furthermore, the calculation assumed the hypothesis of a high increase for LNG demand that increases the demand 1.5 times higher than the regular scenario demand, forming the usage rate at 63%.

The results issued for each scenario are presented in Table 2.

Table 2. Results of demand-usage rate sensitivity analysis.

Scenario of Usage Rate	IRR	Change of IRR Compared to Regular Scenario	NPV (€)
Regular scenario—42%	9.26%	-	214,463,908
High Risk—33.6%	6.03%	−34.9%	47,946,786
Positive Market—50.4%	12.02%	29.8%	361,721,600
LNG High Demand Increase—63%	15.60%	68.4%	597,052,711

Moreover, Figure 3 presents the NPV during the operation period for each scenario.

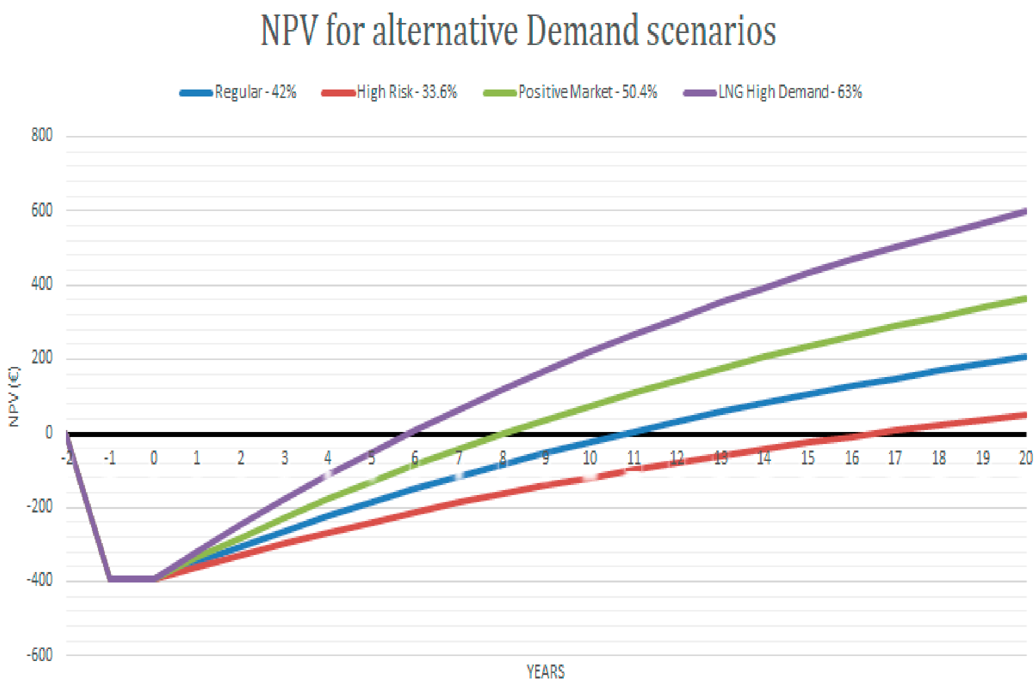


Figure 3. NPV during operation period for alternative usage rate scenarios. (NPV in millions Euro).

Assessing the above results, it can be highlighted that the project profitability is very sensitive to the demand curves (usage rate). A small increase in the demand annual volume from the level of 42% (regular scenario) to 50.4% can improve essential the IRR to a level above 12%, stimulating the investors' interest. Furthermore, in the LNG high-demand scenario, where the demand increases to a 63% usage rate, the IRR reached the level of 15.6%. On the contrary, in the high-risk scenario, where the demand reduces to 33.6%, the IRR can drop to levels close to the discount rate, leading the investment to be non-profitable enough. It is noteworthy that although the change in demand is the same (20%) in both the high-risk and positive market scenario, the variation of IRR is bigger when the demand decreases (34.9% to regular scenario), compared to when the demand increases (29.8% to regular scenario).

The same conclusions also apply for the NPV. In the LNG high-demand scenario, NPV turns positive after only 6 years, which in an operation period of 20 years, can lead to extremely high profitability. In the case of the high-risk scenario, where a small decrease occurs, NPV remains negative for a long period, until it turns positive near the end of operation period at around 17 years.

4.2.2. USD/EUR Exchange Rate

For the second part of the sensitivity analysis, the fluctuation of the USD to Euro Exchange Rate (XR) is taken into consideration in the analysis. This rate is affected by exogenous issues to the project e.g. accidents, political instability, etc.) and changes in energy market result higher price volatility on one hand; and higher construction and operational cost on the other.

The exchange rate values for this analysis tracked, by extrapolate, the historical data of XR from the commencement of the Euro circulation in 2000 until 2021, where:

- The highest rate recorded in 2001 (USD/EUR XR: 1.11);
- The lowest rate recorded in 2008 (USD/EUR XR: 0.68);
- The average rate during the 2000–2021 period (USD/EUR XR: 0.83).

As we can notice, the average rate (0.83) is close enough to the rate that we used during our regular scenario (0.87). The results for each scenario are presented in Table 3, and the NPV during the operation period is given in Figure 4.

Table 3. Results of USD/EUR exchange rate sensitivity analysis.

Scenario of USD/EUR Exchange Rate (XR)	IRR	Change of IRR Compared to Regular Scenario	NPV (€)
Regular scenario—0.87	9.46%	-	214,463,908
High XR—1.11	5.51%	−40.55%	32,147,103
Low XR—0.68	13.70%	47.90%	362,865,064
Average XR—0.83	10.31%	11.36%	248,027,423

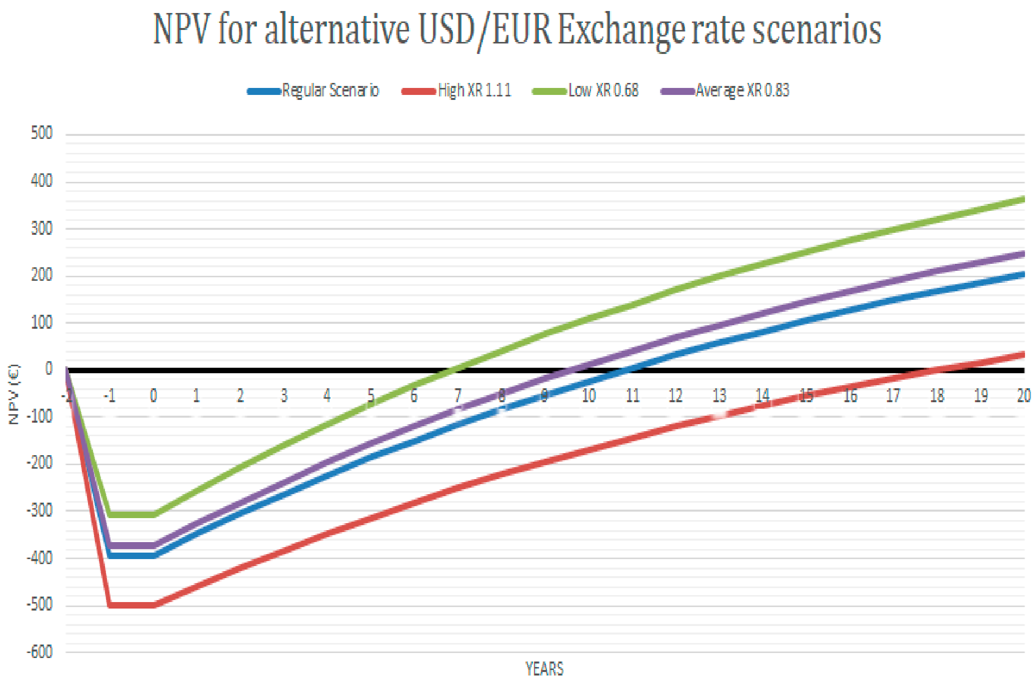


Figure 4. NPV during operation period for alternative USD/EUR exchange rate scenarios. (NPV in million Euro).

Appreciating the above data, we can comprehend that the Project's economic rates are volatile enough to the XR's changes. Both IRR and NPV fluctuate in large ranges that could threaten the Project's viability. The IRR ranges between 5.51% and 13.70%, whereas the NPV ranges from 32 mil € to over 362 mil €. Especially in the high XR scenario, the NPV remains negative for almost all of the operation period of the Project.

4.2.3. Tariff Price—Sensitivity Analysis

Finally, a tariff price sensitivity analysis is conducted. The tariff is a parameter that, although it is determined by the FSRU, also takes into consideration exogenous factors, such as the competition, the demand, etc. In this analysis we try to set the boundaries where the tariff price may range, and where the Project will still be economically viable. This is why we have chosen decreased values compared to the regular scenario. The used tariff price's values are for a 10% decrease, 20% decrease, and 30% decrease.

The results for each scenario are given in Table 4, whereas the NPV during the operation period is depicted in Figure 5.

Table 4. Results of tariff price sensitivity analysis.

Scenario of Tariff Price	IRR	Change of IRR Compared to Regular Scenario	NPV (€)
Regular scenario	9.46%	-	214,463,908
Decrease 10%	7.72%	−16.66%	125,598,776
Decrease 20%	5.79%	−37.48%	37,453,644
Decrease 30%	3.58%	−61.33%	−5,105,148,745

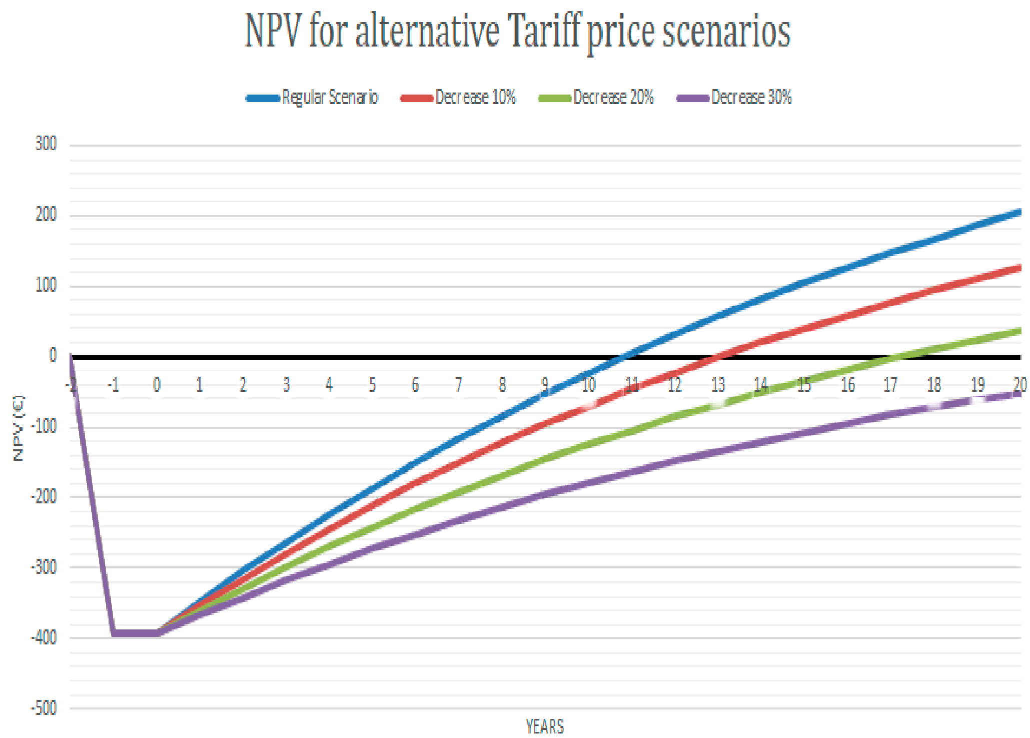


Figure 5. NPV during operation period for alternative tariff price scenarios.

As we see from the analysis's results, in the first scenario, although the decrease is in the range of 10%, the Project can still produce satisfied earnings with 7.72% IRR. When the decrease goes to 20%, the NPV remains marginally positive, but with an extremely small amount of earnings. On the contrary, when the tariff's decrease reaches 30%, the Project turns undoubtedly unviable.

The analysis proves that the FSRU may decrease its tariff price until around 10% and still maintain satisfactory earnings. If the external circumstances require a bigger decrease, then the Project will either lose much more of its economic efficiency or will be economically unviable.

The extremely high sensitivity of the investment to all the checked parameters indicates that before the final investment decision is taken, the shareholders group must acquire not only all the necessary data that concern the FSRU, but also be sure that the external factors, such as the USD/EUR exchange rate, are in favor of the Project.

4.3. Project Incentives

Based on the formulation of Section 3.9, the extra tax income the state could gain from the FSRU Project is estimated by using Equation (30) under the following data and assumptions:

- The construction cost has been set at 314,496,000 €, as mentioned above in Section 4.1.
- The tax rate during the construction can be set at 22%, which was the tax rate for companies in Greece for 2021.
- The FSRU employs around 120 people. If we consider that the average wage will be 1500 € per month, which is an average technical wage for Greece, then the total yearly salaries of FSRU shall be 2,520,000 €. In this amount, we have also included two extra wages for the Christmas and summer periods.
- The tax rate for the wage of 1500 € in Greece is around 25%. Assuming also that the employees will spend 2/3 of their income on purchases and services, they will generate extra turnover which is taxed by 24%. This way, they produce extra taxes in the amount of 12% of their wage. Therefore, the employees generate a total of 37% taxes out of their wage.
- Using the data of Section 4.1, the total turnover generated by the annual operating and capital costs of the FSRU during the operating year i, expressed by Equation (29), is estimated at 6,207,264 €. The tax rate for these expenses is set at 22%, which was the tax rate for companies in Greece for 2021.
- The usage rate of 42% means that during each operating year, 150 LNG carriers will visit the FSRU. The income that the FSRU will generate for the local community from the above number of carriers, and the other visitors that will visit Alexandroupolis (i.e., technical expertise from abroad), can be set at around 250,000 €. The tax rate for this is set at 24% according to Greek legislation for the taxation of goods.

Applying these data to Equation (30), the total state income from these activities is 116,349,082 €, as shown in Table 5.

Table 5. Taxes generated by FSRU Project over years.

Activity	Expenses Generated during Construction Period (€)	Expenses Generated during Each Operation Year (€)	Tax Rate Imposed	Tax Gained during Construction Period (€)	Tax Gained during Operation Period of 20 Years (€)
Construction period costs	314,496,000	-	22%	69,189,120	-
Employees' wages	-	2,520,000	37%	-	18,648,000
Operation and capital expenditures	-	6,207,264	22%	-	27,311,962
Other activities	-	250,000	24%	-	1,200,000
			Total income during FSRU Project	116,349,082	

The state should carefully consider how to use this amount. The state may decide to give the entire amount back to the FSRU, or a big or a small part of it. It may decide to give it back all at once during the first years of operation, or give it back gradually with a small amount every year. Furthermore, the state, knowing that they will gain extra income, may decide to finance the Project, or to become a shareholder by acquiring a percentage of the investment.

In the analysis, the project implementation incentives by the state in terms of tax relief over the years, are examined. This way, if the operating period is 20 years, the state may offer a tax relief of 5,817,454 € for each operating year, and the taxes that the FSRU must pay are given by Equation (31). Using these taxes, the NPV and IRR are recalculated using the equations of Section 3.8, and the adjusted results reach the values of 280,909,698 € for NPV and 10.67% for IRR. Compared to the results of the regular scenario, the increase is 30.98% for NPV and 12.79% for IRR, respectively.

5. Discussion

When it comes to investing in an energy project, the decision is not easy, and other than the technical restrictions and environmental considerations, a series of business and economic risks need to be taken into consideration. In real-life applications, a group of alternative scenarios needs to be appropriately developed to evaluate project risk, and promote measures to mitigate them. In this frame, the paper structure and the application results presented to support decisions and assess risks over the project lifecycle have taken into consideration changes driven by operational and external events. Based on the proposed analysis developed in this paper, the framework for developing alternative scenarios is given towards decisions on equity funding schemes and the added value on assets over time.

To mitigate the investment risk and to increase the financing leverage, an introduction of governmental or authorities' incentives are discussed. Taking into consideration the investment condition of the FSRU Alexandroupolis case study, a tax substitute incentive measure was discussed as a risk-sharing tool to boost the project implementation. The numerical application results could be essential drivers for decisions in similar cases, and illustrate comparisons with other case studies.

Finally, considering the geopolitical conditions and the new LNG energy strategy discussed in Europe, and the implementation of flexible offshore LNG terminal facilities in the European territory, it shall be extremely interesting to evaluate their economic performance, providing results on the viability and investment attractiveness of such projects in the European continent. The existence of real data also assists us to get an accurate economic result. Moreover, this framework application shall be useful to the research community, getting it compared to similar projects from all over the globe.

6. Conclusions

This paper deals with the feasibility appraisal framework from an economic point of view, dedicated to FSRU greenfield (new) energy projects. The decisions for such projects vary from a very short period up to many decades, due to the complexities driven by the stakeholders' expectations, the long-term payback period, the availability of capital, and the energy demand volatility raising business risks. The appraisal modelling structure provides an easy-to-handle tool to support energy project initiatives and prioritize energy investment decisions.

The modelling structure set a dynamic project appraisal modeling framework for the economic assessment of the FSRU projects that could support the involved parties to initiate project implementation. The proposed modelling structure is recommended to be used even for evaluating the project feasibility in the planning (initiative) stage even as a tool for monitoring project performance over time. The methodology section set an analytical, coherent, detailed, easy-to-use modeling framework dedicated for new FSRU projects. By breakdown, the project implementation, delivery, and operational characteristics of all the variables dealing with the project economic performance are taken into consideration. The modelling structure is depicted appropriately for planners and managers to support analysis in both: (a) to assess the investment, and comprehend and evaluate how each variable contributes to the project economic performance over time; and (b) to strategically appraise the future course of the project or to re-assess the performance into changed energy market (demand) or financial (investment) conditions.

Furthermore, the results of a sensitivity analysis are analyzed to discuss the level of dependency of FSRU projects to the demand and financing parameters, providing key messages regarding the FSRU projects risks, viability, and attractiveness. It is noteworthy that in terms of business risk mitigation, some key incentives are evaluated and highlighted, illustrating a risk-sharing mechanism that may increase the investment attractiveness, or share risk and benefits between involved parties.

The numerical case study is the Alexandroupolis FSRU Project, and we have pointed out the conditions and the frame in which this investment can become viable and profitable, considering the Project's internal and external conditions representing the appraisal modelling variables. The numerical application evaluates the project performance for a basic scenario, promoting key messages to decision makers regarding the project risks and estimations uncertainty. The sensitivity analysis evaluating the project outputs over time for different demand scenarios and project financing features (equity mix, currency and exchange volatility) highlighting key messages for similar projects. Nevertheless, the case study outputs could provide an essential background for comparisons in similar projects, and illustrate key messages to decision-makers for the feasibility of such a project due to energy market turbulences affecting Europe and other regions. The growing opportunities, and the investment attractiveness for implementing new LNG projects due to the North-East Europe conflicts, is an interesting issue, which is highly recommended for further investigation. The governmental incentives and the conditions to be affected to mitigate the investment risks should also be an interesting issue for dedicated research analysis.

This research received no external funding.

Author Contributions: Conceptualization, D.D.; methodology, D.D. and P.Z.; software, P.Z.; validation, D.D. and P.Z.; formal analysis, D.D.; investigation, P.Z.; resources, D.D.; data curation, P.Z.; writing—original draft preparation, P.Z.; writing—review and editing, D.D.; visualization, P.Z.; supervision, D.D.; project administration, D.D.; funding acquisition, D.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: The paper uses a conceptual analysis framework, case study inputs, and analysis outputs developed in the research project "ENIRISST–Intelligent Research Infrastructure for Shipping, Supply Chain, Transport and Logistics", implemented in the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014–2020), and co-financed by Greece and the European Regional Development Fund.

Conflicts of Interest: The authors declare no conflict of interest.

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