Basic Cost Benefit Analysis for the Implementation of CCUS Hub in Greece v2

Athens, December 2024

The project involves the conduction of a Cost-Benefit Analysis to evaluate the feasibility of a CCS Hub for energy-intensive industries in Greece versus the cost of carbon tax on their emissions

Energy Intensive Industries

Energy-intensive industries, such as refineries and cement manufacturers, which rely on processes that cannot be powered by electricity, **generate significant CO_2 emissions**. Under the EU ETS, these industries will be required to pay a **carbon tax for their emissions starting in 2026.**

The scope of work involves conducting a **Cost-Benefit Analysis** to assess the feasibility of establishing a **Carbon Capture & Storage (CCS) Hub in Greece for energy-intensive industries**. This study aims to determine whether implementing such a hub would be more advantageous for these industries compared to paying the carbon tax on their emissions.

Benefits of CCS technologies

Carbon Capture & Storage technologies **enable the CO_2 emissions reduction** and serve as a means for companies to align with environmental regulations. Moreover, industries adopting CCS technologies have the potential to **avoid future "carbon pricing" charges.**

The CCUS procedure involves six distinct steps, forming the foundation for two proposed scenarios for implementing a 5 MTPA Hub possibly in the wider region of Elefsis

CCUS Key Components

1. **Carbon Capture System**
2. **Pipeline Network**
3. **Liquefaction & Storage**
4. **Cargo Handling System** (jetty, loading facilities)
5. **Transport to permanent Storage Facilities**
6. **Permanent Geological Storage**

Capacity of the CCS Hub: 5 MTPA
Possible location: Elefsis

First Scenario
(Short Pipeline Network - SPN)

HELPE AIC: 1.5 MTPA
HELPE EIC: 1.5 MTPA
TITAN (Kamari): 2 MTPA

Second Scenario
(Long Pipeline Network - LPN)

HELPE AIC: 1 MTPA
HELPE EIC: 1 MTPA
HERON II: 0.5 MTPA
PROTERGIA: 0.5 MTPA
ELPEDISON: 0.5 MTPA
TITAN (Kamari): 1.5 MTPA

Step 1: Carbon Capture System – Capex & Assumptions

1 Carbon Capture System

CCS Plant Capacity: 1 MTPA

CAPEX	**€ 150-200 M**	**OPEX**	**€ 70-75 M/year**

Assumptions:

- ❑ Each industry shall install its own CCS Plant and all emitters will install the same technology

Recommended technology:

- ❑ First and second generation oxyfuel & Post combustion cryogenic

Step 2: Pipeline network – Criteria & Assumptions

2 Pipeline network

Preferred: Elefsis

Location Criteria

- Geological and topographical conditions: stable soil, accessible terrain (flat or mild topography)
- Protected areas: pipelines should not cross such areas
- Aquatic ecosystems: crossing of rivers or lakes requires specific studies and permits.
- Cultural & archaeological sites.
- Safety & population density: avoid densely populated areas, urban areas and residential or industrial areas
- Usually, pipelines are sited alongside existing roads, railways or other infrastructures to reduce costs and reduce environmental impact.
- Already existing energy corridors where natural gas or oil pipelines may be used for positioning.

Assumptions

- The cost of expropriation is not included.
- Safety study is necessary – high pressure due to long distance.
- This study does not take into account the location and cost of valve stations.
- Connection between AIC & EIC will be made through offshore pipeline or ship.
- Areas with steep slope (i.e. Thisvi & Aghios Nicholaos) require further analysis and study prior construction.
- Constructability not taken into account.

Step 2: Pipeline network – Capex of two Scenarios

2 Pipeline network

CO_2 Transportation Characteristics:

- **9-12 inches**
- **High Pressure (<25bar)**

Short Pipeline Network (SPN)

- 32 km of pipeline
- **CAPEX:** € 247 M
- **OPEX:** € 5 M/year

Long Pipeline Network (LPN)

- 174 km of pipeline
- **CAPEX**: € 388 M
- **OPEX:** € 8 M/year

Step 3: Liquefaction & Storage & Step 4: Liquefaction & Storage Transport to permanent Storage Facilities – Capex/Opex

3 Liquefaction & Storage

CAPEX	€ 343M – 393M	OPEX	€ 60-87 M /year

4 Cargo handling system (jetty, loading facilities)

CAPEX	€ 20M	OPEX	€ 0,6 M/year

OPEX was estimated with annual O&M cost set at 3% of CAPEX.

Step 5: Cargo handling system & Step 6: Permanent Geological Storage - Opex

5 Transport to permanent Storage Facilities

OPEX	€ 15 – 25/tonne CO_2

6 Permanent Geological Storage

OPEX	€ 25/ tonne CO_2

Assumptions of the Financial Model (Discounted Cash Flow Method)

General Assumptions

- The methodology for the development of the CBA is the **Discounted Cash Flow** (DCF) Method
- The model has a duration of 20 years (2026 onwards)
- Cost of *Step 1: CC System* has not been included in the financial model as the companies have received funding for it
- Financial Cashflows for Shareholders are deducted by 22% (Greek tax rate)
- The desired return on equity amounts to 12%

  *Desired return on equity=20year Greek bond rate+beta[1]*Equity Risk[1] Premium for Greece=3,74+1*8,26=12%*

Benefit Assumptions

The price of emission allowances is set at €80 per tonne of CO_2 equivalent until 2030, as outlined in the NECP. For the 2031-2045 period, the corresponding prices are shown in the table below. While the 2035, 2040 and 2045 prices are specified in the NECP, the intermediate prices have been calculated by evenly distributing the difference between each of these specified prices across five-year intervals. More specifically:

Item/Year	2026-30	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Price(€/t)	80	92	104	116	128	140	170	200	230	260	290	318	346	374	402	430

For the benefits (revenues), two different scenarios were used, in the first one all the benefit returns to the investment (100%), while in the second one, only 50% returns to the investment.

[1]NYU Stern data

Assumptions of the Financial Model

Capex Assumptions

Two scenarios and two sub-scenarios have been considered and analysed:

1. **Short Pipeline Network (SPN):** with CAPEX € 247 M and duration of two years *(equally distributed)*

   SPN_{Min}: CAPEX and OPEX Values are at lowest based on assumptions

   SPN_{Max}: CAPEX and OPEX Values are at highest based on assumptions

2. **Long Pipeline Network (LPN):** with CAPEX €388 M and duration of three years *(Pipeline Network is structured in all 3 years equally and other CAPEX components are distributed equally in years 2 and 3)*

   LPN_{Min}: CAPEX and OPEX Values are at lowest based on assumptions

   LPN_{Max}: CAPEX and OPEX Values are at highest based on assumptions

Assumptions of the Financial Model

Capex Assumptions

1 Short Pipeline Network (SPN) CAPEX

SPN_{Min}

#	Item/Year	2026	2027	2028	Total
Step 2	Pipeline Network	123.500.000 €	123.500.000 €	€-	**247.000.000 €**
Step 3	Liquefaction & Storage	171.500.000 €	171.500.000 €	€-	**343.000.000 €**
Step 4	Cargo Handling System	10.000.000 €	10.000.000 €	€-	**20.000.000 €**
	Total	**305.000.000 €**	**305.000.000 €**	**€-**	**610.000.000 €**

SPN_{Max}

#	Item/Year	2026	2027	2028	Total
Step 2	Pipeline Network	123.500.000 €	123.500.000 €	€-	**247.000.000 €**
Step 3	Liquefaction & Storage	196.500.000 €	196.500.000 €	€-	**393.000.000 €**
Step 4	Cargo Handling System	10.000.000 €	10.000.000 €	€-	**20.000.000 €**
	Total	**330.000.000 €**	**330.000.000 €**	**€-**	**660.000.000 €**

Assumptions of the Financial Model

Capex Assumptions

2 Long Pipeline Network (LPN) CAPEX

LPN_{Min}

#	Item/Year	2026	2027	2028	Total
Step 2	Pipeline Network	129.333.333 €	129.333.333 €	129.333.333 €	**388.000.000 €**
Step 3	Liquefaction & Storage		171.500.000 €	171.500.000 €	**343.000.000 €**
Step 4	Cargo Handling System		10.000.000 €	10.000.000 €	**20.000.000 €**
	Total	**129.333.333 €**	**310.833.333 €**	**310.833.333 €**	**751.000.000 €**

LPN_{Max}

#	Item/Year	2026	2027	2028	Total
Step 2	Pipeline Network	129.333.333 €	129.333.333 €	129.333.333 €	**388.000.000 €**
Step 3	Liquefaction & Storage		196.500.000 €	196.500.000 €	**393.000.000 €**
Step 4	Cargo Handling System		10.000.000 €	10.000.000 €	**20.000.000 €**
	Total	**129.333.333 €**	**335.833.333 €**	**335.833.333 €**	**801.000.000 €**

Assumptions of the Financial Model

Capital Structure Assumptions

Two scenarios for capital structure have been considered and analysed:

Scenario with Grant

- 40% Grant
- 30% EIB Loan
- 30% Equity

Scenario without Grant

- 0% Grant
- 30% EIB Loan
- 70% Equity

Assumptions of the Financial Model

OPEX/Costs Assumptions

- Liquefaction & Storage amount to 60 M €/year in min scenarios 87 M €/year in max scenario
- Cargo handling OPEX amount to 600k. € per annum
- Permanent Geological Storage amount to 25€/ tonne CO_2
- Ship Transportation amount to 15€/ tonne CO_2 in min scenarios and 25€/tonne CO_2 in max scenarios
- Costs are inflated with a rate of 2%

Debt/Loan Assumptions

- Duration of Loan: 20years
- Interest Rate: 3,5%
- Grace Period: 5years
- VAT Loan has a duration of 1 year and is repaid in the next year with interest rate 4,5%
- VAT Loan interest payments are capitalized until the end of the Grace Period

Results of the Financial Model for Scenario 1

1 Short Pipeline Network (SPN)

#	Subscenarios	Payback Period	NPV	IRR
SPN1	100% Revenues, SPN_{Min} Capex and Opex, with grant	4 years	1.733.705.811,17 €	41,76%
SPN2	100% Revenues, SPN_{Min} Capex and Opex, without grant	6 years	1.527.519.586,68 €	29,90%
SPN3	100% Revenues, SPN_{Max} Capex and Opex, with grant	7 years	1.294.867.434,75 €	30,68%
SPN4	100% Revenues, SPN_{Max} Capex and Opex, without grant	8 years	1.071.780.700,05 €	23,31%
SPN5	50% Revenues, SPN_{Min} Capex and Opex, with grant	13 years	-61.020.381,50 €	10,92%
SPN6	50% Revenues, SPN_{Min} Capex and Opex, without grant	14 years	-267.206.605,99 €	8,25%
SPN7	50% Revenues, SPN_{Max} Capex and Opex, with grant	17 years	-568.548.797,98 €	3,1%
SPN8	50% Revenues, SPN_{Max} Capex and Opex, without grant	18 years	-791.635.532,68 €	1,68%

- The investment is marginal in the case where revenues are shared 50% with industries. Further sensitivity analysis is needed to determine a realistic percentage of revenues.

Results of the Financial Model for Scenario 2

2 Long Pipeline Network (LPN)

#	Subscenarios	Payback Period	NPV	IRR
LPN1	100% Revenues, LPN_{Min} Capex and Opex, with grant	6 years	1.549.136.862,02 €	34,57%
LPN2	100% Revenues, LPN_{Min} Capex and Opex, without grant	7 years	1.315.330.602,90 €	25,97%
LPN3	100% Revenues, LPN_{Max} Capex and Opex, with grant	8 years	1.151.975.899,15 €	27,22%
LPN4	100% Revenues, LPN_{Max} Capex and Opex, without grant	9 years	903.079.898,79 €	21,02%
LPN5	50% Revenues, LPN_{Min} Capex and Opex, with grant	14 years	-124.546.769,74 €	9,83%
LPN6	50% Revenues, LPN_{Min} Capex and Opex, without grant	15 years	-358.353.028,85 €	7,06%
LPN7	50% Revenues, LPN_{Max} Capex and Opex, with grant	17 years	-577.538.952,42 €	2,65%
LPN8	50% Revenues, LPN_{Max} Capex and Opex, without grant	17 years	-826.434.952,78 €	1,03

- Complementary to the conclusion of the SPN scenario, it is clear that for the LPN scenario, a project subsidy of at least 40% is required.