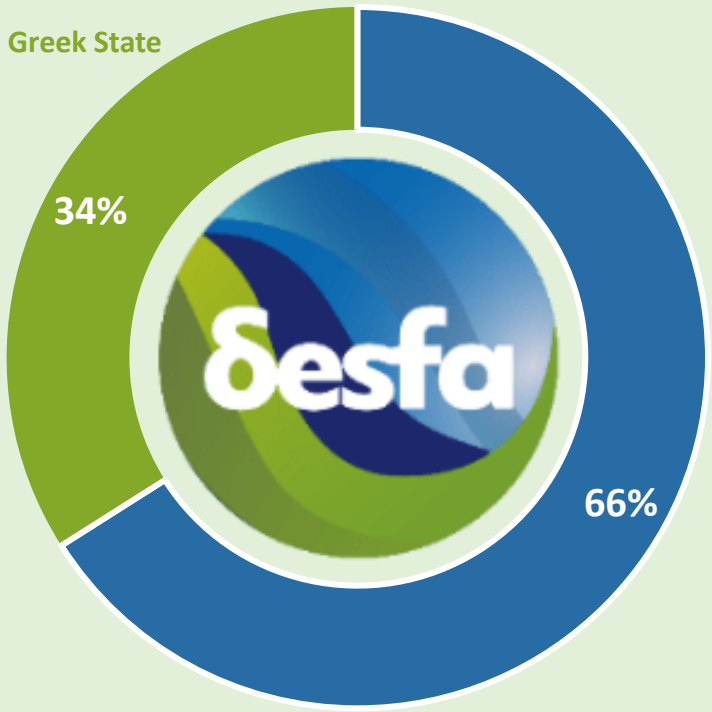
ApolloCO2 – DESFA's CCS PCI Project

IENE Workshop: "The Economics of CCUS Applications in Greece"

March 2025

DESFA counts over 17 years of successful operation



Who is DESFA

DESFA

- Established in March 2007, DESFA owns & operates the Greek Natural Gas System (NNGS), which consists of the National Natural Gas Transmission System & the LNG Terminal in the islet of Revithoussa
- DESFA operates, maintains & develops the Greek NNGS in a safe, reliable, and economically efficient way, offering Third Party Access services in a transparent and non-discriminatory way, as well as a range of other services to a number of national & international clients
- DESFA holds a 20% stake in the Alexandroupolis FSRU Terminal (Gastrade) and a 7% stake in the Hellenic Energy Exchange (HEnEx)

Milestones

2007 Establishment of DESFA

2014 Certification of DESFA as an Independent Transmission Operator under the 3rd EU Energy Package

2018

- Change in shareholding structure and certification of DESFA as Ownership Unbundled Operator
- Participation of DESFA as shareholder (7%) in the Hellenic Energy Exchange (HenEx)

2020

- Participation of DESFA with 20% share in Gastrade for the development of the Alexandroupolis FSRU
- Award with O&M of the KIPIC LNG Terminal in Kuwait

DESFA focuses on three main pillars to address the existing challenges as well as to support EU succeeding in its climate targets

I Natural Gas

Security of Supply

DESFA is implementing a Development Plan with NG investments of utmost importance for Greece's establishment as a hub for the whole SEE Region

II CCS

Affordability

DESFA focuses on being integral part and constituting a vital role of the development of CCUS business in Greece, activated in the transmission, liquefaction and storage part of the value chain

Focus of this presentation

III Hydrogen

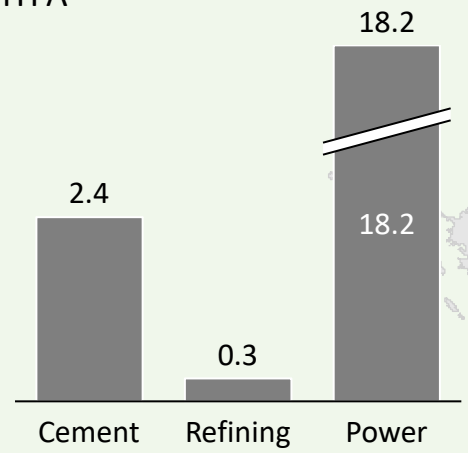
Sustainability

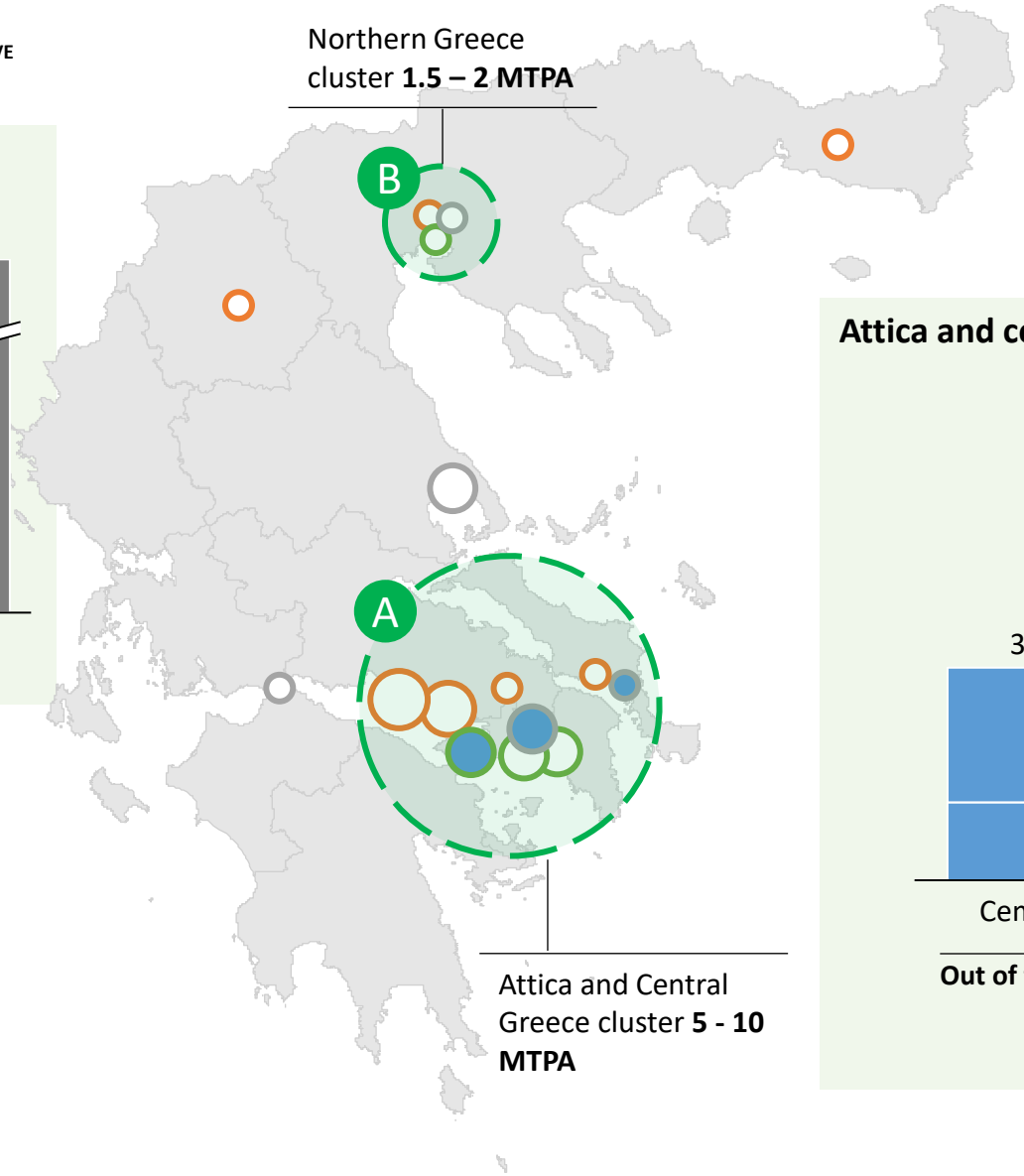
Based on EU targets, the Greek TSO has set as one of its main strategic goals the development of H_2 sector in Greece through the assessment of Smart Gas Grid and H_2 pipelines projects

Focusing on southern Greece, the Attica region includes ~9 MTPA of industrial emissions, of which ~3.5 MTPA has been awarded EU Innovation funding

NOT EXHAUSTIVE BUBBLES SIZE INDICATIVE

Rest of Greece emissions, MTPA

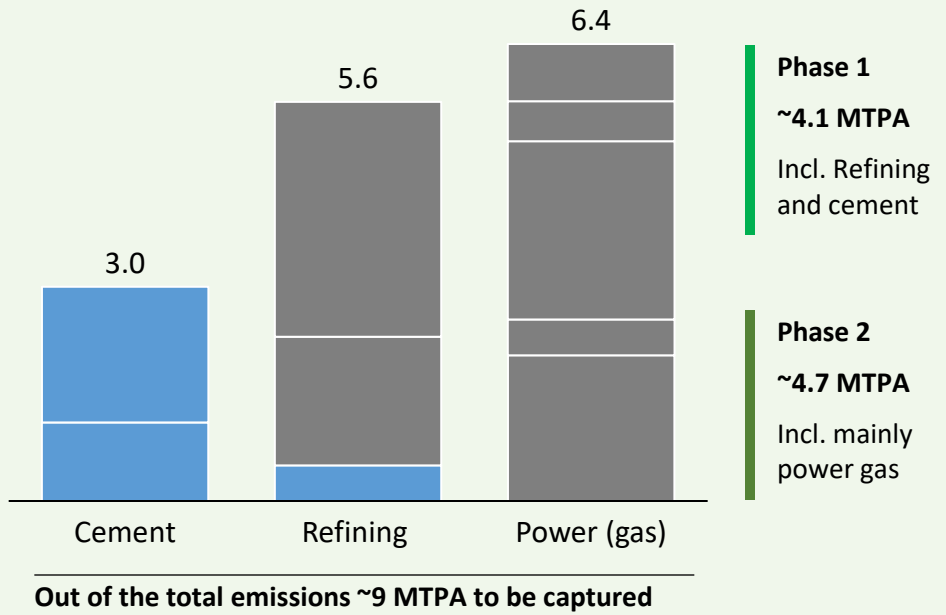




Industries Refining Cement Power-Gas

Emissions for which EU IF grant was awarded

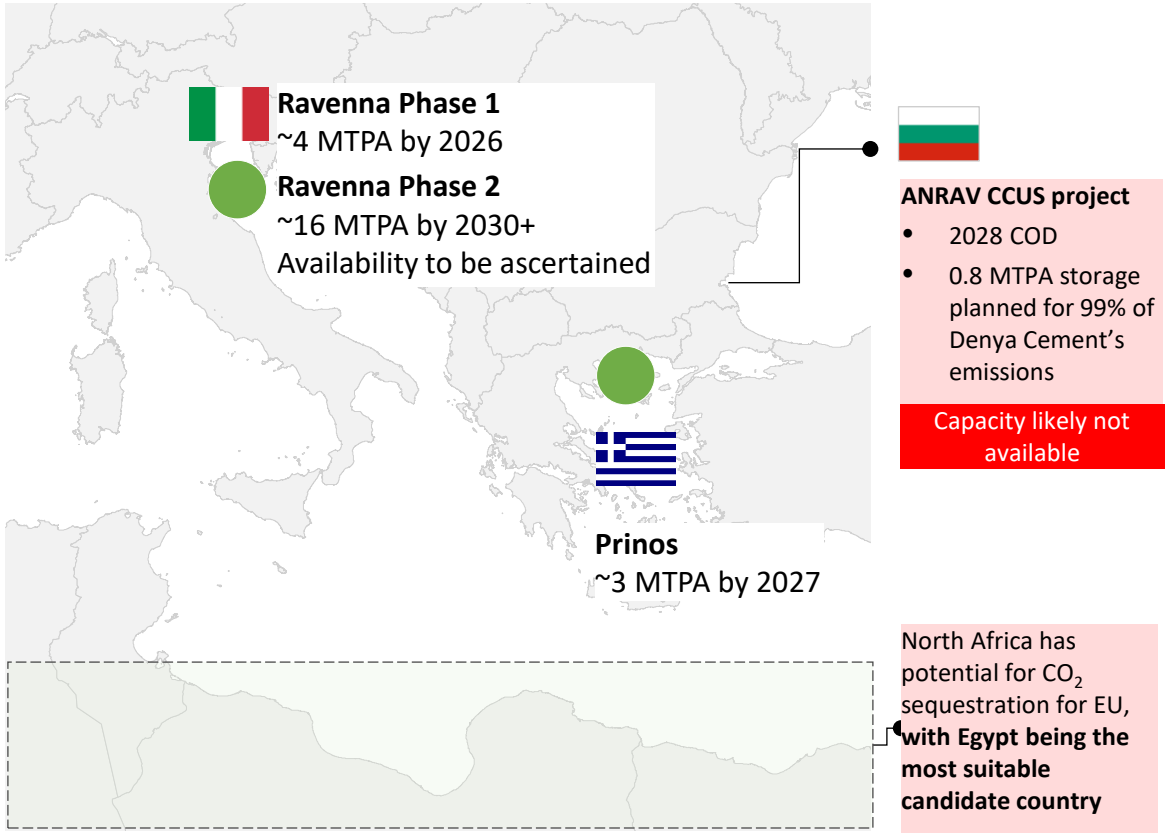
Attica and central Greece cluster emissions, MTPA



Out of the total emissions ~9 MTPA to be captured

On the storage side, Prinos is the prominent storage option, however additional capacity will most likely be required

Regional sequestration options



ANRAV CCUS project

- 2028 COD
- 0.8 MTPA storage planned for 99% of Denya Cement's emissions

Capacity likely not available

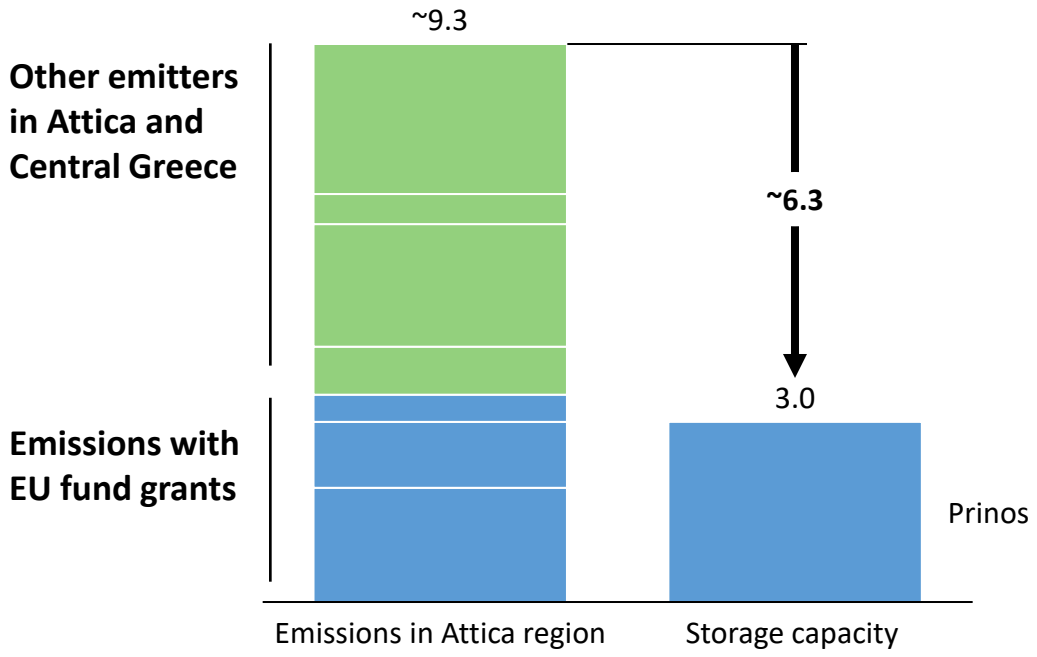
North Africa has potential for CO_2 sequestration for EU, **with Egypt being the most suitable candidate country**

Other options, e.g., Egypt, other targets in Greece, should be further explored, but this seems a far-reaching option today

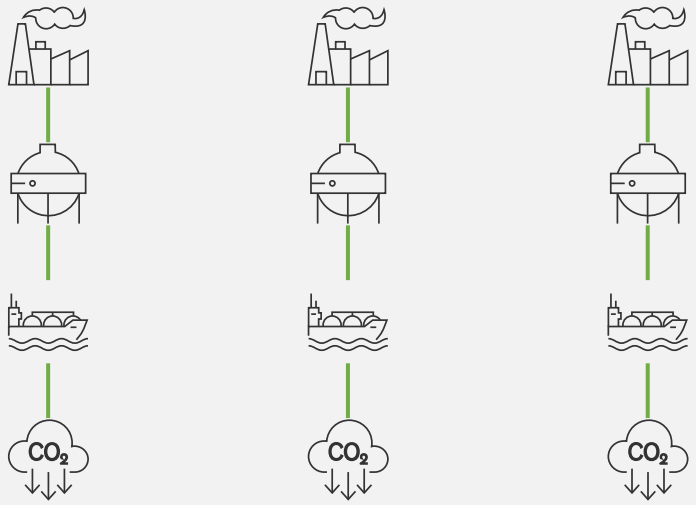
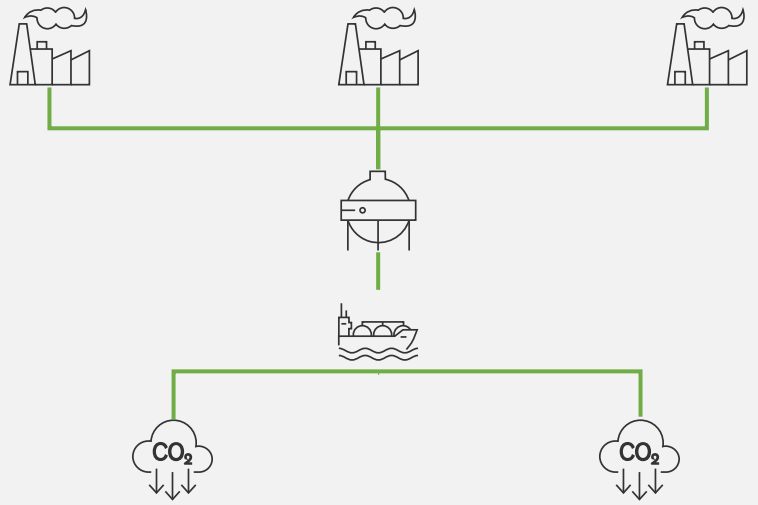
Emissions and sequestration capacity in Greece, MTPA

Indicative storage shortfall of up to ~6.3 MTPA

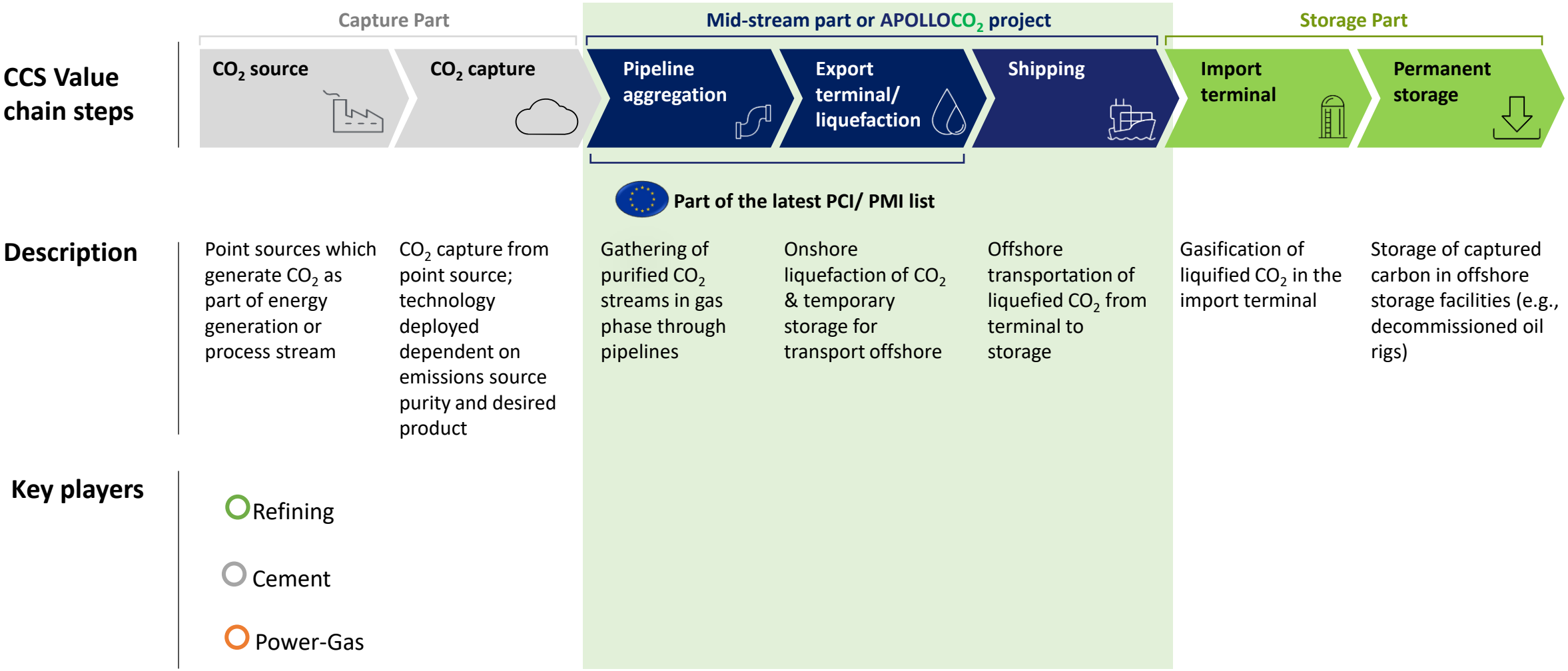
Alternative storage options will need to be unlocked



Two potential pathways for the development of CCS in Greece

Pathway/ Schematic	1 Separate standalone projects	2 Integrated CCS hub
Emitters, Terminal, Shipping, Storage		
Description	**Separate standalone CCS value-chains developed and operated independently**, with no system orchestration; potentially resulting in disjointed value-chain & some stranded emitters	**Integrated end-to-end CCS system** with regional coordination across the value-chain aiming to embed relevant emitters across e.g., Attica region APOLLOCO$_2$ concept

In line with Greece's climate targets and through ApolloCO2 project, DESFA takes the opportunity to orchestrate the midstream part of CCS ecosystem



The design and techno-economic aspects of the APOLLOCO2 CCS hub in a nutshell

APOLLOCO_2 CCS hub

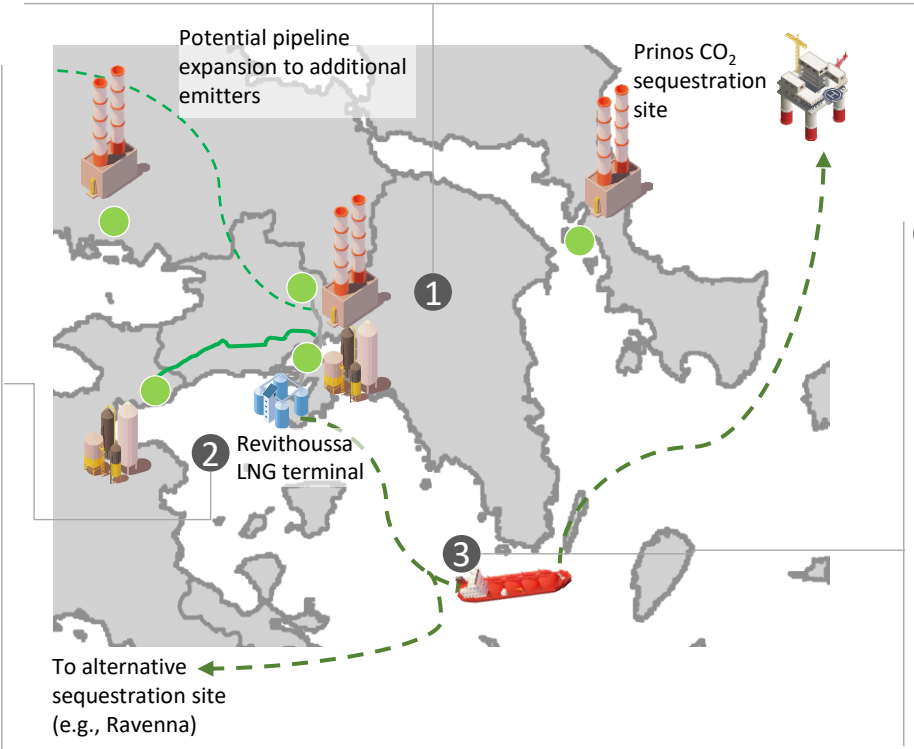
Industrial emitters — CO_2 pipeline — LCO_2 shipping -- Potential expansion of CO_2 pipeline

1 Pipeline network to integrate key emitters in South Greece

- Aggregates ~50% industrial emissions in Attica with expansion to Viotia
- From the very beginning, pipeline will be constructed to transfer up to 10 MTPA in case of expansion to additional emitters

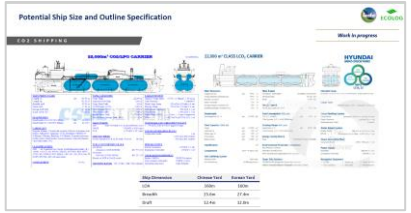
2 CO_2 liquefaction facility with synergies with Revythoussa LNG terminal

- Scalable solution able to accommodate several emitters (expandable up to 10 MTPA)
- The facility will include an onshore and an offshore part i.e., FLSU for the temporary storage and back-up liquefaction of the CO_2
- Cost efficient CO_2 liquefaction, leveraging cold energy with LNG (~65% OpEx savings)



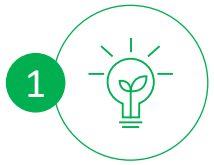
3 Large-scale liquid CO_2 vessel (22-40k cbm)

- Optimised vessel size and routes, considering draft limitations around Attica
- Up to ~60% cost savings from scale and maximising utilisation



Project of common interest

APOLLOCO2 can deliver value for Greece across four pillars



Platform to decarbonize Greece

- **Inclusion of all Greek emitters** to the CCS hub, aim for no stranded assets
- **Open-access CO2 network** in line with the EU's vision for a single CCS market
- **Synergies with low carbon value chains**, e.g., blue hydrogen

Scale effects

- **Cost savings** from economies of scale and synergies with Revythoussa LNG terminal (over project life including grants)
- **Access to a broader set of storage options** enabled by larger LCO_2 vessels which can cover greater distances

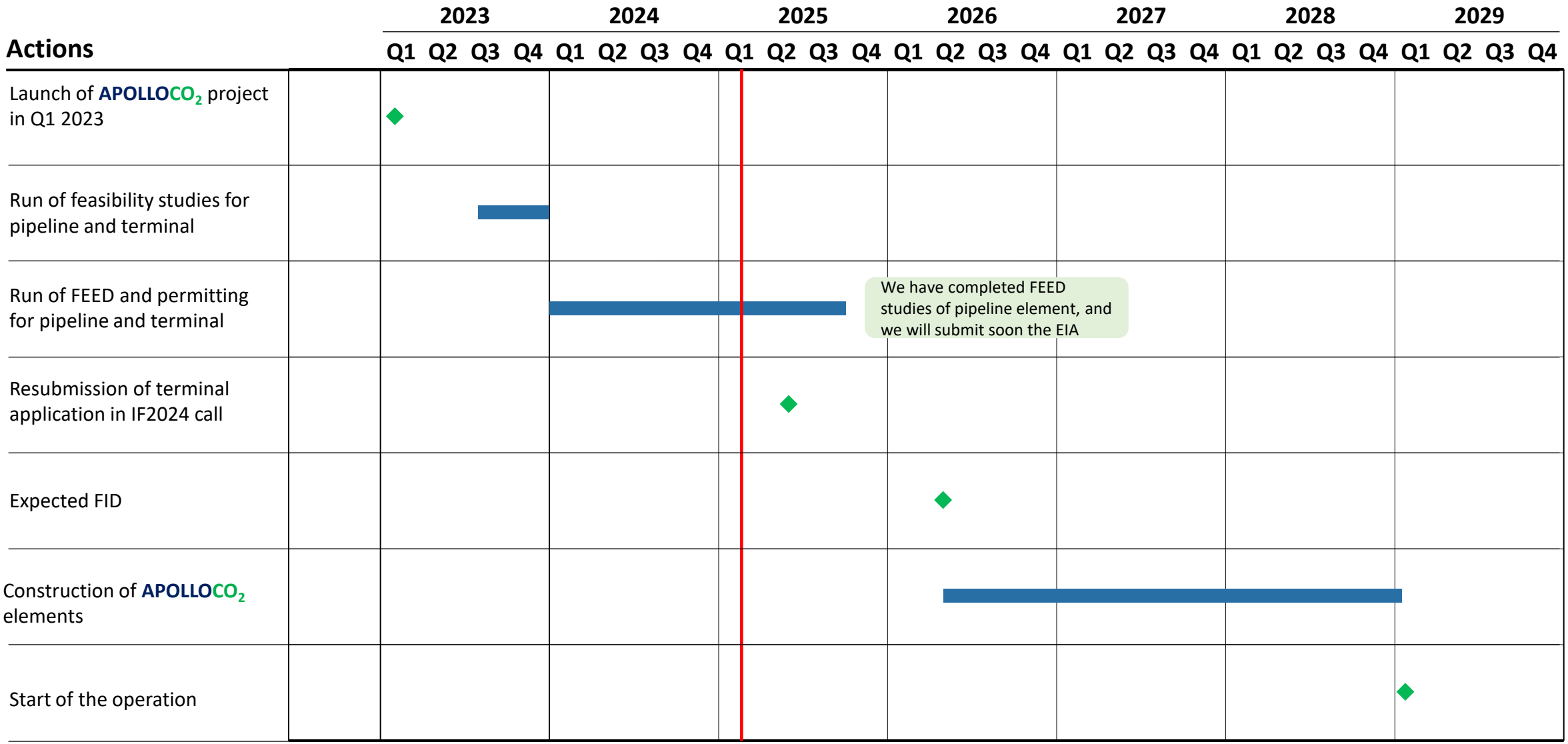
Efficient use of EU and national funding

- **Higher absorption of EU funding** due to larger infrastructure and PCI status – APOLLOCO2 is applying for additional EU grants
- **Lower burden for national funding** of infrastructure for later-stage emitters

Simplified "one-stop shop" solution

- **Facilitated permitting and regulatory compliance** by a single JV cooperating with Government
- **Streamlined risk allocation** from emitter fence line to sequestration site
- **Resilient network with built-in flexibility** to manage disruptions

APOLLOCO$_2$ Timeplan



DESFA supports and is aligned with IENE's "Implementing CCUS Hubs in Greece - A Cost-Benefit Analysis" study

	IENE study's takeaways	ApolloCO2 approach
Benefits of CCUS hubs 	• Attica-based hub would initially target key emitters such as refineries, cement plants, and power facilities, **optimising infrastructure efficiency and lowering per-tonne transportation costs** through economies of scale.	• ApolloCO2 is designed upon the same principles, aiming to additionally benefit from the **synergies with the LNG availability in Revithoussa to further decrease the liquefaction costs** benefitting the viability of the entire value chain.
Funding 	• Preliminary results suggest that **significant grant-type funding is required to overcome high CAPEX and initial operational costs**. Continued access to EU funding mechanisms and innovative financing solutions will be vital to bridge the economic viability gap.	• **Grants are essential to achieve competitiveness for the CCUS projects**, also considering the relatively low ETS price until today and the cost intensive nature of the required infrastructure.
Storage access 	• While Prinos offers a local geological storage solution, future infrastructure plans should include assessments for alternative domestic storage sites and potential overseas partnerships to ensure long-term storage capacity and flexibility.	• One of the key bottlenecks for the development of CCS projects is the **lack of access to CO2 storage sites**. Considering the limited storage availability in the SE Europe, it is important that **CO2 storage in third countries (e.g. Egypt) is recognized by the ETS**.
Shipping transportation 	• The ship-based transportation method must be scaled up, with incentives to promote investments in new CO_2 carrier fleets, ensuring reliable and cost-effective transport logistics.	• The selection of Revithoussa for the development of the CO2 Liquefaction and Export Terminal, along with its low-pressure design, can significantly **reduce the sea transportation costs by allowing larger vessels to load LCO2.**


Thank you!
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