

# ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA) FOR PRINOS OFFSHORE DEVELOPMENT PROJECT



## Chapter 4 Objective and Rational

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## ABBREVIATIONS

API	American Petroleum Institute
CAPEX	Capital Expenditure
DES	Drilling Equipment Set
EIS	Environmental Impact Study
ELFE	Hellenic Fertilizers
EOR	Enhanced Oil Recovery
ERD	Extended Reach Drill
ERM	Environmental Resources Management Limited
ESIA	Environmental & Social Impact Assessment
FEED	Front End Engineering Design
IOR	Improved Oil Recovery
NTG	Net to Gross
ODE	Offshore Engineering Limited
OWC	Ocean Wildlife Conservation
QRA	Quantitative Risk Assessment
STOIIP	Stock Tank Oil Initially in Place
VSP	Vertical Seismic Profile
WAG	Water Alternating Gas
WWTP	Wastewater Treatment Plant

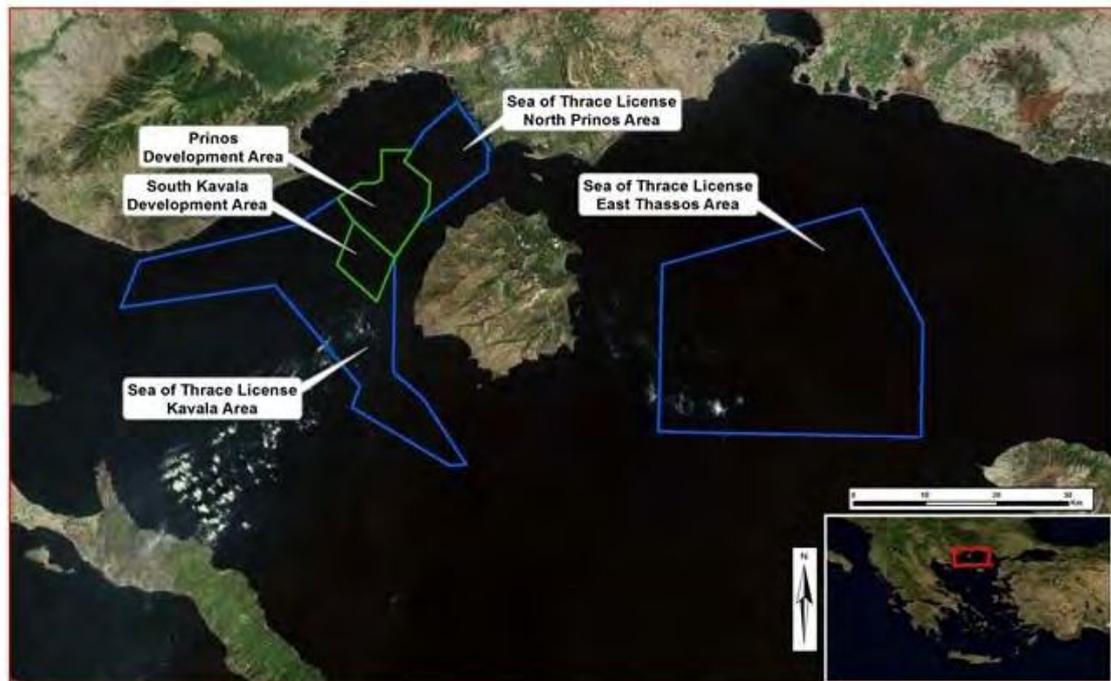
## 4 OBJECTIVE AND RATIONALE OF PROJECT IMPLEMENTATION

### 4.1 BACKGROUND

Energean acquired existing oil and gas assets in the Prinos basin, North Aegean Sea, from the Greek authorities in 2007. It already operates, and plans to develop, a number of small oil & gas fields, including:

- Three (3) oil fields (Prinos, Prinos North and Epsilon);
- One (1) gas field (South Kavala);
- Three (3) discoveries (Zeta, Athos and Delta);
- Two (2) prospects (Alfa and Gamma)
- Two (2) leads (Lamda and South Kavala oil upside)

These fields fall within in the Gulf of Kavala. Energean's licence areas are presented in the map below.



Map 4-1: Energean's licence areas

Associated exploration and production licenses were subsequently extended to allow the company to commence investments.

The company's focus between 2007 and 2013 was quantifying the remaining potential of the

mature Prinos field, which represents the largest discovery in the basin, and Greece, to date and determining whether discovered satellite fields could be commercialised. Production decline, which commenced in the mid 80's, was halted by implementation of a sequence of well intervention and work-over activities coupled with the re-start of water injection. A small number of new wells (approximately 1 per year on average) were completed. Drilling efforts focussed on demonstration of upside potential thus allowing new reserves to be booked. Undeveloped primary oil was demonstrated in the deeper/tighter B and C reservoirs of the Prinos field, bypassed oil due to poor sweep in the primary A layers, production recommenced from the Prinos North satellite and the Epsilon field successfully appraised by an ERD well. Work to date has been executed through existing permits granted by the Greek authorities.

In 2007 only 1 mln bbls of reserves were associated with the Prinos area fields. By the end of 2013 Energean had undertaken sufficient activities to increase 2P reserves to approximately 30 mln bbls and 2C Contingent Resources to a similar level. Initial study work to unlock further resources considered unrecoverable (via implementation of additional IOR and EOR techniques) had commenced.

In 2014 Energean commenced activities designed to monetise its booked Reserves. In July 2014 the company acquired a 2<sup>nd</sup> hand, 2000 HP, tender assisted drilling rig, from KCA-Deutag. This rig was transported to Greece where it was overhauled bringing the barge and rig back into certification. In parallel the company upgraded the Prinos Alpha platform to allow it to accommodate the Drilling Equipment Set (DES) of the rig (the 'Energean Force'). Purchase of an in house drilling resource has allowed the Company to significantly reduce the cost of each required side track and development well. Mature fields like Prinos need continuous infill drilling to maintain production rates. Marginal satellites such as Epsilon require many, cheap wells to ensure commerciality and maximise production rates/reserves. With the Energean Force the Company is equipped with an asset that can drill wells at a cost marginally higher than equivalent onshore wells.

An 8 to 10 well drilling programme commenced on Prinos Alpha mid-2015. This will be completed by early 2017. In parallel with the rig refurbishment project Energean has undertaken conceptual studies to determine the best way of developing the Epsilon field as well as the fields and exploration prospects in the Prinos North area. All potential development options were identified and screened against typical factors (cost, schedule, operability, flexibility, local content and of course safety and environmental risk levels). The selected option, further described below, was taken through FEED during the first half of 2015. The intent of the Company was to develop a design that would work for both initial locations, and potentially at other locations at a later date. This "design one, build many" approach is a well proven technique in the industry. In parallel with FEED, Energean commenced preparation of a detailed EIS for the new platform developments.

After consultation with the Greek authorities the scope of the EIS was expanded to include the existing offshore facilities and platforms in the Prinos basin. The new platforms form an integrated expansion of the existing infrastructure and hence the authorities required all facilities

be covered by a single permit. To grant a permit covering an enlarged portion of the acreage an EIS in line with current European and Greek legislation was requested.

As the onshore facilities are permitted separately the authorities did not require the EIS to cover these. Existing EIS and permits were considered satisfactory, as the planned project does not impact the design intent or operation of these facilities.

Detailed design contracts for the Epsilon development project were awarded in Q3 2015. Quantitative Risk Assessment (QRA) models of the new facilities and pipelines have been developed by the topside/SURF detailed design contractor – ODE. A contract was awarded to ERM to develop a QRA model of the existing facilities including the brownfield tieback scope. This work has allowed major incidents with the potential for environmental harm to be quantified. LDK were contracted to prepare the overall EIS, using input provided by the Company, ODE and ERM.

### 4.1.1 Prinós field

The Prinós field comprises three main stacked accumulations composed of turbiditic sandstones of Miocene Age. The primary reservoir is approximately 300m thick and is characterized by moderate to good porosity ranging from 12% to 22%, average net to gross ratio (NTG) of about 60%, and permeability up to 440mD. The reservoir has been divided into three main intervals: A, B and C (youngest to oldest). The A reservoir, often subdivided to A1 and A2, contains approximately 82.5% of STOIIIP and has produced the majority of the oil to date. B and C reservoirs are underlying the A reservoir and are less developed. The oil from Prinós Field is moderately heavy (27-28° API), under-saturated and sour with a dissolved gas content of 674scf/bbl (120m<sup>3</sup>/m<sup>3</sup>) and up to 60% mole H<sub>2</sub>S in the gas phase and a high wax and asphaltene content. The field was originally over pressurized, the main seal being a basin wide sequence of salts and evaporates up to 1km thick. Seawater has been used for partial pressure support.

The field was developed between 1979 and 1981 with 24 wells, 12 from each drilling platform (Alpha and Beta). Up to 2013, a total of 54 wells have been drilled (including side tracks), 11 of which are currently on production, 3 are injecting seawater and the rest are suspended or abandoned. “Spare” slots will be recovered and used for the planned infill campaign. Further infill drilling, beyond the scope of the current project, will likely require installation of a third drilling platform, bridge-linked to the existing complex.

Crude production commenced in early 1981 at initial rates of 9,000bopd and peaked at about 28,000bopd between 1982 and 1986. Production has since declined and reached an average oil rate of 840bopd (134m<sup>3</sup>/d) from 10-12 wells during 2010. Energean increased oil production to above 2,000 bopd by end 2013. Approximately 110MMb of crude oil have been produced from the field.

Prinós field STOIIIP has recently been estimated at approximately 290 mmbbls. The average recovery factor to date is therefore 38%.

Although the Prinós Field is relatively mature, there is significant scope for extracting additional

value from the area through immediate production optimization, infill drilling, side tracking, recompletions, optimization of existing water flooding and in the medium term implementation of appropriate enhanced oil recovery processes. Although the Prinos field is located offshore its shallow water situation, short distance from the mainland, thick, good quality, compact reservoir structure coupled with favourable tax terms make it an excellent candidate for application of EOR processes.

### 4.1.2 Epsilon field

The Epsilon discovery is located in the northern part of the Aegean Sea between 2 and 5km northwest of Prinos. Water depth over the field is 35-55m. The Epsilon Oil Field is a fault, dip and stratigraphically closed anticlinal structure, covering an area of approximately 4 km<sup>2</sup>. The penetrated reservoir is 70-85 m thick and is characterised by 9% porosity, NTG of 40-90% and permeability (assessed from core) ranging from 1-100mD. The reservoir penetrated to date is the equivalent of the A1 sand in Prinos.

Crude oil from the Epsilon has a light gravity of 36° API, H<sub>2</sub>S of 8-14% and a dissolved gas content of 349scf/bbl (62.1m<sup>3</sup>/m<sup>3</sup>). Exploration in the Epsilon Area began in the early 1990s.

The Epsilon structure is covered by two partially overlapping 3D seismic surveys, which were acquired in 1993 and 1997. A new basin wide 3D survey has recently been completed and processing of the data has commenced. This new survey will be used to optimise drilling locations for Epsilon wells in 2016. The field was discovered in late 2000 with Epsilon-1 well, which was later successfully sidetracked down-dip along the structure (Epsilon-1As well). Neither well identified an OWC. To date only the equivalent of the Prinos A1 sand has been penetrated. The potential of deeper (A2, B and C) sands has yet to be demonstrated. High gas readings were noted at TD in both exploration wells. Calculated P50 STOIP in the A1 equivalent sand is some 39mln bbls. Deeper potential could increase this to 59 mln bbls.

Following a period of inactivity, Energean appraised and partially developed Epsilon with an ERD well (EA-H1). This well was completed in 2010 and production commenced at a rate above 2,000bopd. Production declined due to what was thought to be asphaltene precipitation but a work-over subsequently demonstrated that actually the well had suffered a casing collapse. Attempts to sidetrack the well failed. Some 350,000 bbls were produced from this horizontal appraisal well and the data has been critical in modelling the planned field development wells.

### 4.1.3 Prinos north area fields

The Prinos North field is located 3km north of Prinos, covering an area of about 1.5km<sup>2</sup>. The Prinos North structure was identified as a potential exploration opportunity in 1976, when the Prinos-4 delineation well encountered oil (the Zeta discovery) on the north side of the main fault separating the Prinos and Prinos North structures. This led to the acquisition of 3D seismic in 1993 and the drilling of two Prinos North exploration wells. These identified oil in the main Prinos

North field plus the deeper Delta horizon.

Prinos North was appraised and partially developed by an extended reach horizontal well in 1996. PNA-H1 well was produced intermittently until 2004. The well was eventually shut-in due to low rates and high water-cut. A second (up-dip) extended reach horizontal well was drilled in 2009 and has remained in production to date. Total Prinos North production was 3.9 MMb of oil by the end of 2013.

The Prinos North oil field is a three-way fault and dip-closed structure sitting on the northern side of the main Prinos fault, with hydrocarbons in Miocene stacked turbiditic sandstones at depths of between 2,125m and 2,335m TVD SS. Oil is moderately heavy (17-24° API), sour, with a dissolved gas content of 253scf/bbl (45m<sup>3</sup>/m<sup>3</sup>), 20-30% H<sub>2</sub>S and a high wax and asphaltene content. The field is in contact with a moderately strong, highly saline aquifer. Whilst the aquifer has provided some pressure support, pressures have declined and influx of the highly saline water has caused continuous salt deposition problems in the production tubing leading to significant lost oil and opex spend on routine interventions.

It is planned to drill at least one additional well in the Prinos North field up-dip of the existing horizontal ERD well exploiting remaining reserves in the mapped crest of the field. Current plans are for this new well to be drilled from either the Lamda platform or as a sidetrack of the PN-H3 well on Prinos Alpha.

Energean is currently considering the potential for installing a second new platform between the Prinos and Prinos North fields. This platform, to be called Omicron, would reduce the complexity and cost of Prinos North Development wells, increasing the number that could be justified, and hence the ultimate recovery from this small field. A platform in the location would also allow appraisal wells to be drilled into the Delta and Zeta discoveries and enable other fault blocks in the area to be explored at a low cost. The Zeta discovery will be re-drilled down dip of the initial exploration well from one of the wells included in the Prinos Alpha campaign. A positive result would increase the likelihood of a second platform being installed. This further expansion is fully covered by this ESIA and the associated environmental permit.

## 4.2 OBJECTIVES & RATIONALE

Energean's development plans are based upon the following strategy for fully exploiting the hydrocarbon resources in the Prinos basin. The objective of the company is to maximise production from the discovered fields whilst progressively exploring the basin's remaining potential. Existing fields, once successfully appraised, plus new discoveries would be gradually tied back to the Prinos complex via the satellite facilities covered by this ESIA. By fully exploring and developing the resources of the Prinos basin the Company will extend the duration of its operation and hence secure employment in this industry for the people of Kavala and Thasos.

Energean's strategy can be summarised as:

- Develop an internal drilling capability (tender assisted drilling rig) to allow well costs to

be significantly reduced and to maximize the use of existing work-over rig staff – this has been achieved following the mid-2015 start-up of the Energean Force;

- Use the new drilling rig ('Energean Force') to significantly increase the number of infill wells drilled into the Prinos field. Primary drilling targets will be:
  - ⇒ Poorer quality reservoir layers where bypassed oil has been identified in recent infill wells;
  - ⇒ Field extension areas identified from improvements in 3D seismic (reprocessing, new seismic, VSP's).
- Gather subsurface data whilst drilling these Prinos infill wells to identify opportunities to further promote contingent, prospective and unrecoverable resources sequentially to reserves, namely:
  - ⇒ Assess the potential of the deeper D sand known to be hydrocarbon bearing over parts of the field;
  - ⇒ Re-penetrate the Zeta discovery, gather a new data set (including core) and undertake long term production test – should mobile oil be discovered – to allow a plan to commercialise this 20+ mln bbl STOIPP discovery
  - ⇒ Gather new core and log data to allow EOR studies to be further progressed and hence promote unrecoverable hydrocarbons to contingent resources. Focus of EOR studies is on low-salinity injection, surfactant floods, miscible gas injection (with CO<sub>2</sub> and/or H<sub>2</sub>S) and miscible WAG.
- Fully develop, appraised, and partly developed near field satellite discoveries by installation of simple wellhead platforms connected to the main Prinos complex via multiphase production, gas lift and water injection pipelines and utility umbilical cables. Key features:
  - ⇒ Minimise the number of complex ERD wells by shifting to simpler, satellite-platform wells to reduce drilling risk and costs and hence allow more wells to be drilled per development. Increase recovery factors compared with earlier development concepts;
  - ⇒ Employ platform and pipeline fabrication and installation concepts and technologies that allow maximum use of internal resources, maximizes spend in Greece whilst minimizing overall costs, shortening schedules and reducing overall installation risks.
- Obtain a new basin-wide 3D seismic data set to allow un-appraised discoveries to be better mapped, validate/de-risk existing leads and prospects and generate new leads and prospects with a greater focus on stratigraphic rather than structural plays as well as deeper basin potential
- Justify and execute a new exploration/appraisal campaign to fully quantify the basin potential and mature a sequence of development projects that will maintain production at a new plateau level.

## 4.3 FINANCIAL DATA

### 4.3.1 Approximate budget for project implementation

The following table summarises the point forward CAPEX of the projected Prinos area development project:

Table 4-1: Prinos area development project cost estimate

Category	Description	Cost (\$mIn)
Wells <sup>1</sup>	Prinos infill wells (9 sidetracks)	70.8
	Prinos North up dip well (1 sidetrack)	8.2
	Epsilon development wells (7 new drill)	56.4
	Omicron development wells (6 new drill)	48.3
	Data gathering for IOR/EOR studies	3.2
Facilities	Prinos Delta modifications	3.3
	Lamda topsides	12.6
	Lamda substructure	8.5
	Lamda installation	4.8
	Omicron topsides	12.6
	Omicron substructure	8.5
	Omicron installation	4.8
Subsea	Lamda Pipelines and umbilical cables	7.2
	Lamda SURF Installation	2.7
	Omicron Pipelines and umbilical cables	5.7
	Omicron SURF Installation	2.7
Overheads	Design	7.1
	Project Management	5.2
	Others	4.7
<b>Total</b>		<b>277.4</b>

### 4.3.2 Financing method of the development and operation of the project

The project will be funded by a mixture of existing shareholder equity, cash flow from revenues

<sup>1</sup> Wells cost exclude all variable costs related to spread, rig maintenance and staff and only include tangible and intangible costs

and new debt. Initial Prinos infill drilling and detailed design work associated with the Epsilon development project is funded from existing shareholder funds. Later Prinos infill drilling will be funded by cash flow from increased oil and gas production. Fabrication, construction and installation of Lamda platform and associated pipelines and umbilical will be funded by debt. Epsilon development wells will be funded partly by debt and partly from cash flow. The European Bank for Reconstruction and Development is considering providing finance to the Project

## 4.4 CORRELATION OF THE PROJECT WITH OTHER PROJECTS

The only facility directly linked in terms of the offshore facilities operations, is the onshore plant facilities so-called Sigma. Apart from this, the project is not directly or indirectly linked or related to other projects in the wider area of study.

However, in the Kavala gulf there are a number of activities such as:

- Kavala ports ('Philippos II' commercial port and 'Apostolos Pavlos' passenger port)
- Keramoti passenger port
- Hellenic Fertilizers (ELFE), originally founded in 1961 (as Phosphoric Fertilizers Industry SA (PFI) and started operation at Nea Karvali since 1965. Facilities include:
  - ⇒ Ammonia production unit;
  - ⇒ Production unit of nitric acid and nitric fertilizers;
  - ⇒ Sulphuric acid production unit;
  - ⇒ Phosphoric acid production unit;
  - ⇒ Compound fertilizer production unit
- Wastewater treatment plants (WWTPs)
  - ⇒ Kavala WWTP (GR115001016) with sea outfall
  - ⇒ Palaio Tsifliki WWTP (GR 11500101117) with sea outfall
  - ⇒ Philippoi WWTP (GR 1150100118) with stream discharge
  - ⇒ Nea Peramos WWTP (GR 1150030115) with stream discharge
  - ⇒ Chryssoupoli WWTP (GR 115011018) with stream discharge
  - ⇒ Limenas Thasou WWTP (GR 1150040116) with sea outfall

The aforementioned projects are neither directly nor indirectly linked with Energean's facilities, however, they operate within the project broader area of study and therefore they are considered as potential contributors to overall environmental pressures in the Gulf. Therefore those are essential to be referred and assessed as such.