



A European  
Union Project  
of Common  
Interest

# **A Trans-European Energy Infrastructure Project**

## **The EuroAsia Interconnector**

A Bridge for Friendship and Prosperity

October 2017

## 1 Introduction

### The EuroAsia Interconnector Project

The EuroAsia Interconnector project consists of a 500 kV DC underwater electric cable and any essential equipment and/or installation for interconnecting the Cypriot, Israeli and the Greek (via Crete) transmission networks (offshore). The project at its full deployment (Stage 2) will have a capacity of 2000 MW and a total length of around 820 nautical miles/around 1520 km (330 km between CY and IL, 880 km between CY and Crete and 310 km between Crete and Attica) and allow for bidirectional transmission of electricity. The laying depth of the cable in some areas between IL and CY is expected to reach 2200 m and the respective depth in some areas between CY and GR is expected to reach 3000 m.

The European Commission, with the support of the Cyprus Government and in agreement with the Greek Government, has appointed EuroAsia Interconnector Limited as the official Project Promoter of EuroAsia Interconnector.



## 2 A European Project of Common Interest

### Strategic Energy Infrastructure Project

The European Commission has drawn up a list of 195 key energy infrastructure projects which contribute to the creation of an integrated EU energy market. These are known as projects of common interest (PCI's). They are essential in completing the European internal energy market and in fulfilling the EU's energy policy objectives regarding the supply of affordable, secure and sustainable energy.

On 14 October 2013, under Regulation (EU) No. 347/2013 the European Commission adopted the first EU list of Projects of Common Interest which includes the electricity interconnection project EuroAsia Interconnector as a cluster of three PCIs with project number 3.10.

In addition, on the 18<sup>th</sup> of November 2015, the European Commission released the revised 2<sup>nd</sup> list of 195 Projects of Common Interest (PCI) across the EU. The EuroAsia Interconnector is included in the list. The list of projects is an update of the first list of projects of common interest, which was adopted in October 2013. The main criteria for projects to continue to be included on the list are the creation of significant benefits in market integration and enhancing competition, the improvement of security of energy supply and the reduction of CO<sub>2</sub> emissions.

Moreover, following the latest Cross Regional Meeting organized by the European Commission in Brussels on 26-28 June 2017 concerning the evaluation process of the 3<sup>rd</sup> list of Projects of Common Interest (3<sup>rd</sup> PCI List), the EuroAsia Interconnector has received a very positive evaluation and high ranking and remains a top priority project of the European Commission.

Further information regarding PCI's is available on the dedicated website:

<http://ec.europa.eu/energy/en/topics/infrastructure/projects-common-interest>

PCI's may benefit from accelerated planning and permit granting, a single national authority for obtaining permits (One-Stop Shop), improved regulatory conditions, lower administrative costs due to streamlined environmental assessment processes, increased public participation via consultations, increased visibility to investors and access to financial support totalling €5.35 billion from the Connecting Europe Facility (CEF) for the period 2014-2020. The funding is intended to speed-up the projects and attract private investors.

### A Regulated Project with an Accelerated Permit Granting Process

The TEN-E Regulation establishes that PCIs are necessary to take forward the EU energy network policies and should be given the greatest priority that is legally possible in the permitting process. To ensure rapid treatment the TEN-E Regulation sets an overall timetable of 3.5 years for the permitting process, with an indicative period of 2 years for the "pre-application procedures" – e.g. preparation of the necessary schedules, concept for public participation and public consultation on PCI proposals – and 1.5 years for determination of applications for "permits. This may include planning permissions, development consent orders, marine licences and works authorisations as appropriate, depending on the type of PCI infrastructure and consenting regimes.

These two periods can be further defined as the pre-application procedure and the statutory permit granting procedure. The pre-application procedure covers the period between the start of the permit granting process and the acceptance of the submitted application file by EuroAsia Interconnector. The statutory permit granting procedure covers the period from the date of acceptance of the submitted application file until the comprehensive decision is taken.

Links for Permit Granting Manuals of Greece and Cyprus:

Greece, [https://www.ependyseis.gr/sub/strategic/files/egxeiridio\\_diadikasion\\_220716.pdf](https://www.ependyseis.gr/sub/strategic/files/egxeiridio_diadikasion_220716.pdf)

Cyprus, [http://www.mcit.gov.cy/mcit/mcit.nsf/0/E1E4CA54A5B0FF7EC2257C980047EB61/\\$file/MANUAL\\_PCI\\_Permitting\\_Process\\_v1\\_1\\_EL.pdf](http://www.mcit.gov.cy/mcit/mcit.nsf/0/E1E4CA54A5B0FF7EC2257C980047EB61/$file/MANUAL_PCI_Permitting_Process_v1_1_EL.pdf)

### 3 Public Consultation

#### Public Consultation-An Integral Part of PCI's

Public consultation and participation has a dual purpose. On one hand it offers the necessary education and awareness-raising for the people of concern and on the other hand it empowers them with the knowledge to express their opinion and recommendations on a proposed project/scheme. It is important to recall the ethical reasons for transparency and public participation. Citizens have a right to voice their concerns on decisions that will affect their environment and quality of life. This is the principle behind the Aarhus Convention, which was signed in 1998 and ratified by the EU and its member states. It establishes a number of citizens' rights on access to information, public participation and access to justice with regards to the environment.

Public participation may have positive impacts beyond single issues. It may help to build up public trust in decision-makers such as local politicians or company representatives, create a better understanding of different opinions and enable different stakeholders or the unaligned public to become involved in the decision-making processes. The legitimacy of a participatory process may be undermined if it does not reflect the interests of all actors involved in a society. Target groups will include both the citizens and unaligned public but also the specific stakeholders for whom this project is of greater concern.

The interconnection of four regions with the globally deepest and longest subsea cable system along with its associated conversion equipment is a highly complex matter both from the design and engineering aspect but also from the permit granting viewpoint. Many citizens and local initiatives do not have the resources and time to read and understand complex and specialized material regarding interconnection projects. EuroAsia Interconnector Ltd feels obligated to offer a comprehensive, understandable and accessible set of information enabling a high level of transparency for the public.

Transparency helps create trust and establishes a fair decision-making process. Some recommendations include:

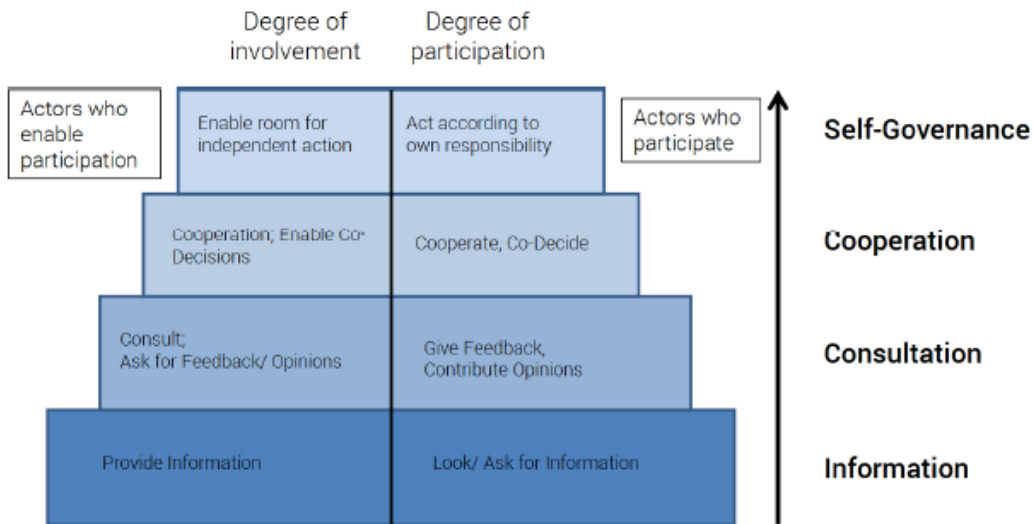
Having the information easily accessible and proactively spread, whenever possible, on the Internet and the EuroAsia Interconnector's webpage, and identifying other suitable communication channels.

Promoting a simplified process: provide an overview, announce consultations and events well in advance in a clear communication manner

Providing transparency about the matter at hand: status of the project, costs and benefits and how will these be distributed, design choices, involved actors, and environmental, economic and health impacts

The EuroAsia Interconnector's interaction with the public is continuous and dynamic and this has been a priority from the very first days of conceiving the project idea. Presentations and announcements on the web and in the media, has aided in informing the involved stakeholders adding to this ongoing process. Even though this document signifies the commencement of the public consultation process a lot of ground has already been covered by arranging meetings and giving presentation to the authoritarian bodies of the involved countries and by keeping an updated project website (<http://www.euroasia-interconnector.com>) The public can view updates and keep on track with the progress of the project by visiting the website and by reading the publicised leaflets.

## Pyramid of public participation



The four levels of participation

## Tools Used Enabling Stakeholder Engagement

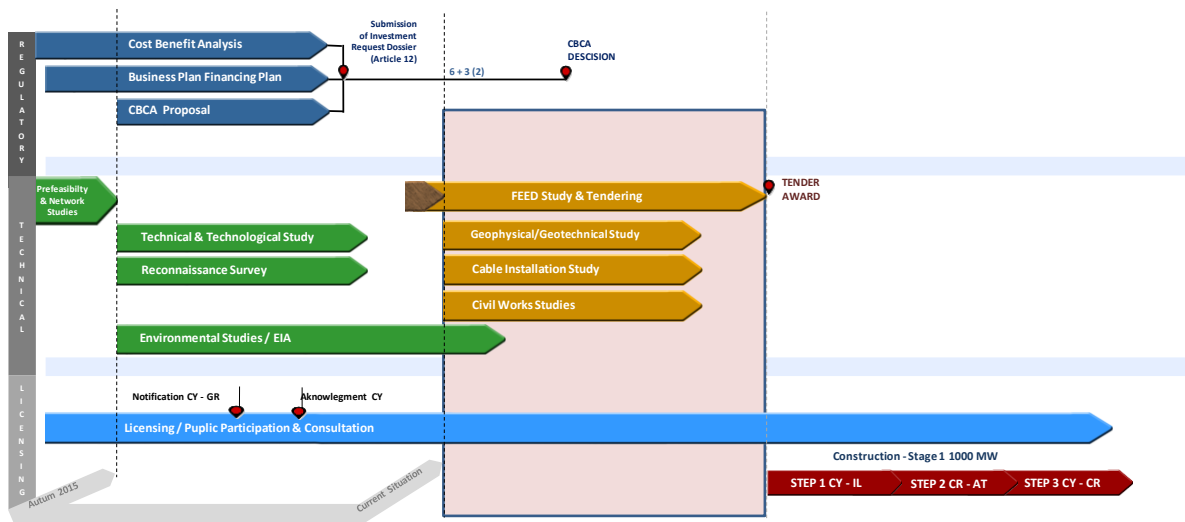
The stakeholder engagement has to be as diverse and broad as possible so that it offers a dynamic interaction with all involved parties and provides a comprehensive update on the project status and progress. Several different means of informing the public are used and these can be visualized as tools aiding in constructing a sound consultation scheme. Namely:

- **Local Media**  
Press releases will be issued where details and updates will be given on milestones of the project's timeline and the general progress
- **Face to Face Forums**  
In the case where a particular stakeholder group wishes a presentation, exhibition or a Q & A session, EuroAsia Interconnector Ltd is willing to make all necessary arrangements to satisfy these needs
- **Website**  
The website is updated throughout the project and will include all publicized information, progress status timelines and will be an important bridge of communication between the public and the company
- **Remote briefings**  
Publications and briefings of a remote character will aid in informing a broader audience. The leaflets issued will be available both on the website and in hard copies

## High-level Implementation Plan – Status

The Project Promoter has performed all necessary actions within its ability to bring the Project to its current level of maturity which warrants consideration by the involved NRAs in the context of an Investment Request. The Investment Request for obtaining a CBCA decision has been submitted in July 2016.

The Project Promoter has procured on 16 July 2016 the final pre-work studies, namely the Front End Engineering Design (Feed), the Detailed Offshore Geophysical/Geotechnical Study, the Submarine Power Cable Installation Study and the Civil works study. The Front End Engineering Design (Feed) and the Submarine Power Cable Installation Study have been awarded in July 2017 and the two remaining studies will be shortly awarded.



## Commissioning Dates of EuroAsia Interconnector

- Interconnection Crete-Attica 2020
- Interconnection Cyprus – Crete 2021
- Interconnection Cyprus – Israel 2022

## 4 Infrastructures Overview

### Technical Description of the Project and Rationale Behind the Choice of Technology

#### Project Phases

The EuroAsia Interconnector will be developed in different Stages and steps. When fully deployed (Stage 2), the Interconnector will have a 2000 MW capacity with 1000 MW becoming available at final Stage 1 deployment. The stages and the steps are described below.

- **Stage 1**

**Stage 1 – Step 1:** 1.000 MW converter stations both in Cyprus and Israel, connected through a 330 km cable bipole with 1.000 MW capacity.

**Stage 1 – Step 2:** 1.000 MW converter stations both in Attica and Crete, connected through a 310 km cable bipole with 1.000 MW capacity.

**Stage 1 – Step 3:** 880 km, 1.000 MW cable bipole between Crete and Cyprus.

The order of implementation of each step can change, depending on the progress of each location.

End of Stage 1: Four terminals, 1.000 MW bipolar scheme with one 1.000 MW HVDC converter station in each of the four terminals.

- **Stage 2**

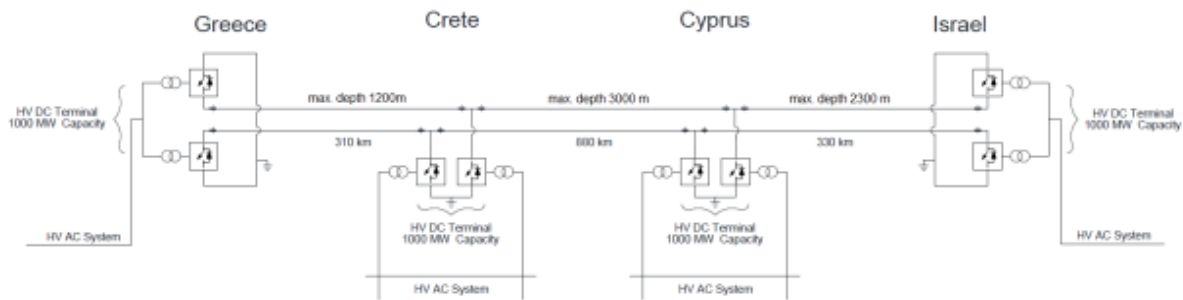
Additional 1.000 MW converter stations in Attica and Israel plus one complete additional 1.000 MW bipole cable Israel-Cyprus-Crete-Greece. Completion of Stage 2 leads to the final configuration. This Stage leads to an increase of the link transfer capacity to 2.000 MW.

#### EuroAsia Interconnector Configuration for Stage 1

At Stage 1 it will consist of one bipole rated 1000 MW with a DC voltage level of  $\pm 500$  kV. The whole submarine cable route is about 1520 km long with a maximum depth of 3000 km (Crete – Cyprus section).

The EuroAsia Interconnector configuration for Stage 1, which is the subject of the Investment Request, is shown in Figure 2: it is made up of four 2x500 MW VSC converter stations and one cable bipole at  $\pm 500$  kV, rated 1000 MW.





*Figure 2: Conceptual diagram of EuroAsia Interconnector (Stage 1)*

The final general Technical Description of the Project is included in the Investment Request Dossier Part 2. The map of the planned route is shown in Figure 5 of this document.

### General description of the configuration of Stage 1

The EuroAsia Interconnector project provides a substantial electricity highway in the South East part of EU, interconnecting EU with Israel, thus ending the energy isolation of both Cyprus (as an EU member state) and Crete. It operates with power transfers in both directions in all its three subsections (Israel-Cyprus, Cyprus-Crete and Crete-Attica). The interconnector very basically comprises of four Converter Stations in bi-polar arrangement, interconnected through double DC cable links, converting the DC transmitted power to the grid AC and vice-versa, as the operational needs dictate at any time.

More specifically, the Interconnector main components are described below:

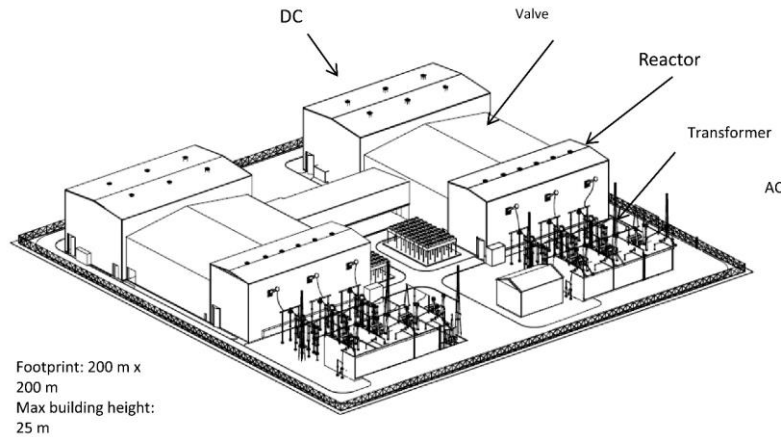
- The Converter Station, each comprising of two  $\pm 500$ kV poles, each rated at 500MW
- The Subsea and Land DC cabling pairs interconnecting the Israel – Cyprus – Crete and Attica Converter Stations, rated at  $\pm 500$ kV and 500MW each
- The Sea Electrodes and the Medium Voltage (MV) DC cables interconnecting the neutral points of the Converter Stations, linking those between Israel-Cyprus, Cyprus-Crete, Crete-Attica.

The AC switchgear interconnecting each Converter Station to the Grid of each of the four locations.

A pair of HVDC cables will be connecting the whole system running both along the sea bottom and onshore, terminating at the converter station locations. At each country/region a converter station will receive the overseas power through the cable pair and subsequently inject the converted power into the grid. It should be noted that the whole system can run in a bidirectional manner enabling each region to either be an exporter or an importer of electricity depending on the demand and the economic balances. The cables will run in underground trenches along the land route and will be protected where needed in the subsea environment. Underground jointing pits will be housing the cable joints and provide the necessary transition “from sea to land” at the beach. Additionally, sea electrodes will be placed across the seabed at a distance of several kilometers from shore in order to be used as the return path technology in case of a cable / converter station pole fault.



## Converter Stations



**Figure 3: Typical VSC Station Layout Bipolar  $\pm 500$  kV, 1000 MW VSC Converter Station**

All the converter stations will be of the Voltage Source Converter (VSC), made up of two converter bridges (half bridge configuration) rated 500MW each. The DC side voltage will be  $\pm 500$ kV in each terminal. Figure 3 shows a typical VSC station layout.

## Alternative Configurations Examined

The following alternative configuration has been examined, made of one bipolar 2x500 MW VSC Converter Station in Attica and 2 bipolar 2x250 MW VSC Converter Stations in the other locations (Crete, Cyprus and Israel).

The main reasons for rejecting this Alternative are considerations due to reduced operational and reliability issues, such as a simpler control scheme and easier operation if all Converter Stations were the same, reduction and simplification of the DC side equipment for Israel, Crete and Cyprus Converter Stations for the one bipolar 2x500MW, avoiding installation of disconnectors, switches etc. in order to shift the DC cable from one 2x250 MW station to the other, thus improving reliability and substantially reducing the possibility of faults.

The overall investment cost of one bipolar 2x500MW, instead of two 2x250MW, is reduced due to the overall cost reduction of the HVDC stations. This is because of reduced land cost of the stations, issuing a single bid for all identical Converter Stations, reduced number of spare parts, reduced O&M costs. In addition, the reduced impact on the environment is also taken into consideration.

## Cables and Electrodes

The HVDC converters at each site are linked to the DC cabling through suitably rated 500kV terrestrial and undersea cables. The land cables terminate at a transition jointing underground enclosure located by the sea shore, where they are jointed with the 500kV sea cables. For Stage 1, two such HVDC cable combinations will originate from the Israeli converter station to enter the Cypriot converter station. There,

two additional HVDC cables will link Cyprus and Crete, with two entering the Crete converter station and two exiting it to link with the Attica converter station.

The use of two HVDC cables will provide the link between all four sites. The use of two cables constitutes the bipolar operation of the project. A return path through earth, however, is provided in order to allow for the reinstatement of rated or half-rated power transfer through converter switching, in case of faults and disconnections of one of the two 500MW elements of the converter, or one of the two HVDC cable links. This is succeeded by using an additional DC cable link, rated at medium voltage, say 20kV, between the converter neutral connection and an electrode installed on the sea bed, located at a suitable distance and depth from the shore. The distance is dictated by applying rules that safeguard against corrosion issues due to DC current flowing in the area surrounding the electrode.

## Submarine Cables

The submarine 500kV HVDC cables will be of the extruded type. In order to minimize costs such as spare cable needed, time for delivery and number of joints, the same cable will be installed in all the portions of the link, irrespective of the different water depths. Considering the maximum water depths foreseen for the project (3000m) the only feasible solution for the high depth sections is the extruded one; for mechanical reasons (high weight) mass impregnated cables cannot be laid (up to now) with water depths greater than 2000m.

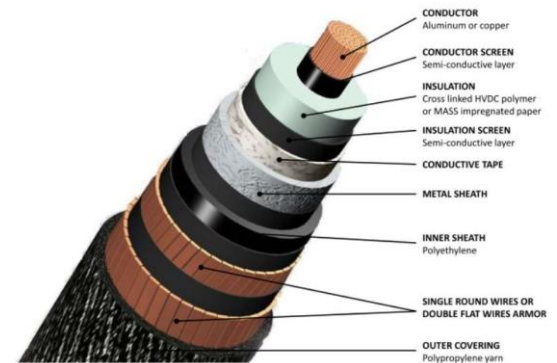
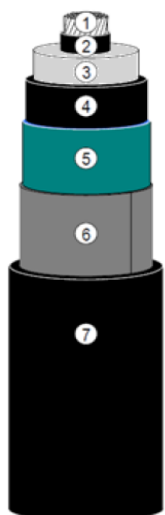


Figure 4a: Example of Single Core (XLPE) for DC technology (courtesy of Europa cable)

## Land DC Cables

The land 500 kV HVDC cables will be of the extruded type. The main characteristics of the cable are:



Legend	
1	Conductor
2	Internal semiconductive layer
3	Extruded insulation
4	External semiconductive layer
5	Water blocking tape
6	Laminated aluminium sheath
7	Outer polyethylene sheath

- HVDC land cables
- The land 500kV HVDC cables will be of the extruded type. The main characteristics of the cable are:
- conductor: copper, 1600 – 2000mm<sup>2</sup> section;
- extruded insulation;
- bedding made of SC fabric tape including embedded thin copper wires;
- smooth aluminium sheath with a special hot melt glue.

Figure 4b: Example of Single Core (XLPE) for Land DC cable technology (courtesy of Europa cable)

## Submarine and Land Medium Voltage DC Cables

The submarine Medium Voltage Direct Current (MVDC) cables, used to connect the sea electrode to the land MVDC cable, will have extruded insulation. Each electrode will be connected through two circuits, each

one made of three cables with 400 mm<sup>2</sup> copper cross-section (or similar). The voltage level, together with all details, will be defined during the detailed engineering phase.

The land MVDC cables (electrode cables) will be of the extruded type. In order to avoid the building of an MV switching station near the sea/land transition pit, the MV land connection will be made of two circuits, each one made of three single core cables; each circuit will be designed so as to be able to carry 1000 A. Using such kind of solution, the MV switching station (needed to disconnect the different sections of the electrode) can be installed inside the converter station, thus minimising the environmental impact on the shore.

## Electrodes

The main types of electrodes for linking the DC Converter Stations through the sea, in the case of the EuroAsia Interconnector project, are Land electrodes (horizontal or vertical) or Marine electrodes (coastal or shore or pond or submarine).

Sea electrodes should be located at least 100 m offshore, in direct contact with seawater. They should be made up of the prefabricated electrode modules (titanium mesh). The modules are to be placed on the sea floor and then connected to separate feeding cables. The size of each module is around 8x10 meters at a distance of one module from the other of 3 meters. Up to 10-12 modules should be considered and the final design could consider the subdivision in minimum 2 sub electrodes. A laying area of suitable dimension should be identified. The laying area is preferred to have a sandy seabed and the electrode should be placed at the maximum possible distance from the shore; the normal laying depth is not normally exceeding 50-60 meters, in order to reduce installation and maintenance costs. For difficult cases and in order to avoid any corrosion problems to crucial metal infrastructures in the vicinity, laying depths as deep as 150-200 meters could be considered at a substantially higher cost for installation, maintenance or replacement of parts, as required for financing divers or ROVs.

For the specific case of the EuroAsia Interconnector, in which distances between HVDC converter stations and the sea are in the range 0-15 km, only marine electrodes are considered viable and in particular the coastal pond and/or submarine (offshore).

Thus, four sea electrodes need to be adopted, one at each side. All four will be of the reversible type (i.e. they can be used as anode and as cathode), with a foreseen lifetime of 40 years.

The current rating of each electrode will be 1000 A. The electrode will be fully redundant, i.e. the electrode will be able to disperse twice the rated current: this implies that the electrode must be able to carry the rated current with half of its elements out of service. A relevant current flow in the electrode will take place only in case of faults. During normal operation of the link, only the imbalance current between the two poles will flow through the electrode (approx. 10A, which is a negligible value). It is proposed to install a modular sea electrode made up of many sections (e.g. 6 sections), half of which must be able to disperse the rated current as mentioned above. The electrochemical phenomena in the sea water produce chlorine, corrosion and electrical field in the electrode neighbourhood, thus electrode placing need to be done after a careful and rigorous study.

To avoid interference with the HVDC converter station, the sea electrode must be placed at a certain distance from the HVDC station; this distance is affected by many factors and has to be evaluated carefully. No limits exist for longer distances (apart from cost/permits for long electrode line). Further, in placing the electrode, other metal based infrastructures in its vicinity must be carefully taken into consideration in order to avoid corrosion problems.

### Converter Station Connections with the AC Grid

The solution to be adopted in order to connect the Converter Transformers to the external AC network at each location will depend on the distance between the Converter Station and the AC substation. In case of having the Converter Station and the AC substation close to one another (i.e. approx. distance 2 km or less) the AC Switchgear within the Converter Station can be avoided and the incoming AC feeders can be directly connected to the Converter Power Transformers. In Attica the Converter Station transformers are expected to be connected directly to the open-air conventional (air insulated) 400kV switchgear in the existing yard. In Israel it is expected to adopt 400kV GIS Switchgear enclosed in a building within the Converter Station yard as the distance is just exceeding the 2km limit (the final design, however will be as proposed by IEC). In Cyprus, EAC is proposing to upgrade its own common border Substation, as described in the approved by the Regulator in the spring of 2016 ten-year Transmission Network Development Plan, using an open-air 132kV GIS switchgear. Thus, the power transformers will be directly connected to this switchgear. In case of having the Converter Station and the AC substation at a distance between them as in Crete, AC switchgear at the Converter Station must be installed, opting initially for the lower cost open-air switchgear technology.

## Locations and Cabling

### Location of Converter stations

The area identified to host the converter station is calculated in general at approximately 4 hectares.

- **Cyprus** - The Cypriot converter station will be located near the village of Kofinou, in the Larnaca district, adjacent to the South-West corner of the existing Kofinou 132kV transmission substation of the Electricity Authority.



Figure 5: Cyprus converter station location

- **Cyprus**- The Land HVDC cables will cover a distance of 11km between the location of the transition pit and the converter station





Figure 5α: Cyprus – Route of Land HVDC Cable

- **Crete** -The Cretan converter station will be in Damasta area. Converter station approximate coordinates are  $35^{\circ} 21.597'B$ ,  $24^{\circ} 56.579'A$ .The area identified to host the converter station is shown in the following picture: the total size of the occupied area will be approximately  $40000 \text{ m}^2$ .

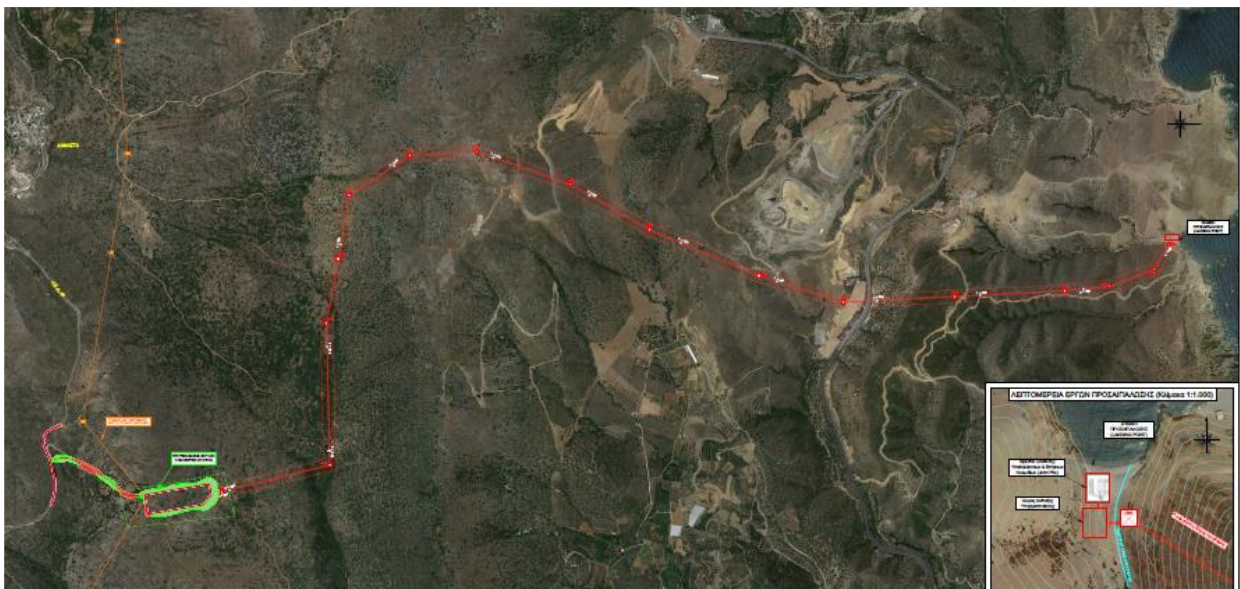


Figure 6: Cretan converter station location

- **Crete** - The Cretan DC cables route will run for approximately 6km from the transition pit to the converter station (overhead lines).

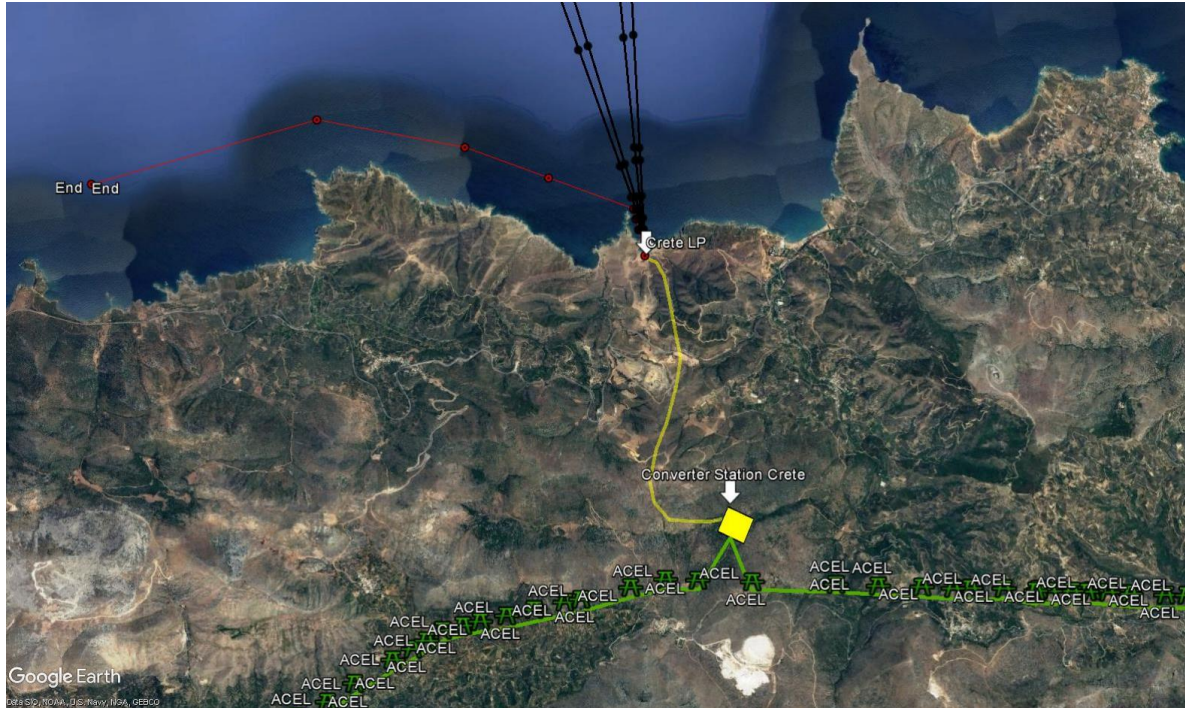


Figure 6a: Crete – Land route of HVDC cable

- **Attica** - The converter station in Attica will be located near the existing Koumoundourou AC substation of the Public Power Corporation. The converter station in Attica will be located near the existing Koumoundourou AC substation: converter station coordinates are 38°2.070'N; 23°37.156'E. The area identified to host the converter station is shown in the following picture: the total size of the occupied area will be approximately 40000 m<sup>2</sup>.





- **Attica** - The DC cable route from the landing point in Pachi to the converter station location is about 30 km long.



Figure 7: Converter station location in Attica

- **Israel** - The HVDC land cables in Israel will run for about 2km from the transition pit to the converter station.
- **Israel** - The Israeli converter station will be located in the North West part of the city of Hadera, in the Haifa district.

The MVDC (electrode) land cables will be laid in the same trenches as the HVDC ones: their route therefore will be the one previously described.

### Routes for Submarine HVDC and Land MVDC Cables

#### MVDC Land Cables

Location	Length [km]
Attica	36
Crete	approx. 1,5
Cyprus	11
Israel	2



## HVDC Cables

The following table summarises the main characteristics of the different marine cable sections of the EuroAsia Interconnector Project.

		Depth ranges (m)							Tot Km per link
		<300	300- 500	500- 1000	1000- 1500	1500- 2000	2000- 2400	>2400	
Km per depth ranges	Israel -Cyprus	33.6	13.1	44.3	43.2	98.8	81.1	0.0	314.1
	Crete-Cyprus	25.6	87.5	139.0	81.5	20.8	29.3	510.3	893.9
	Crete-Attica	95.7	17.2	179.3	40.6	0.0	0.0	0.0	332.8
Total Km per depth ranges		154.9	117.8	362.6	165.3	119.6	110.4	510.3	

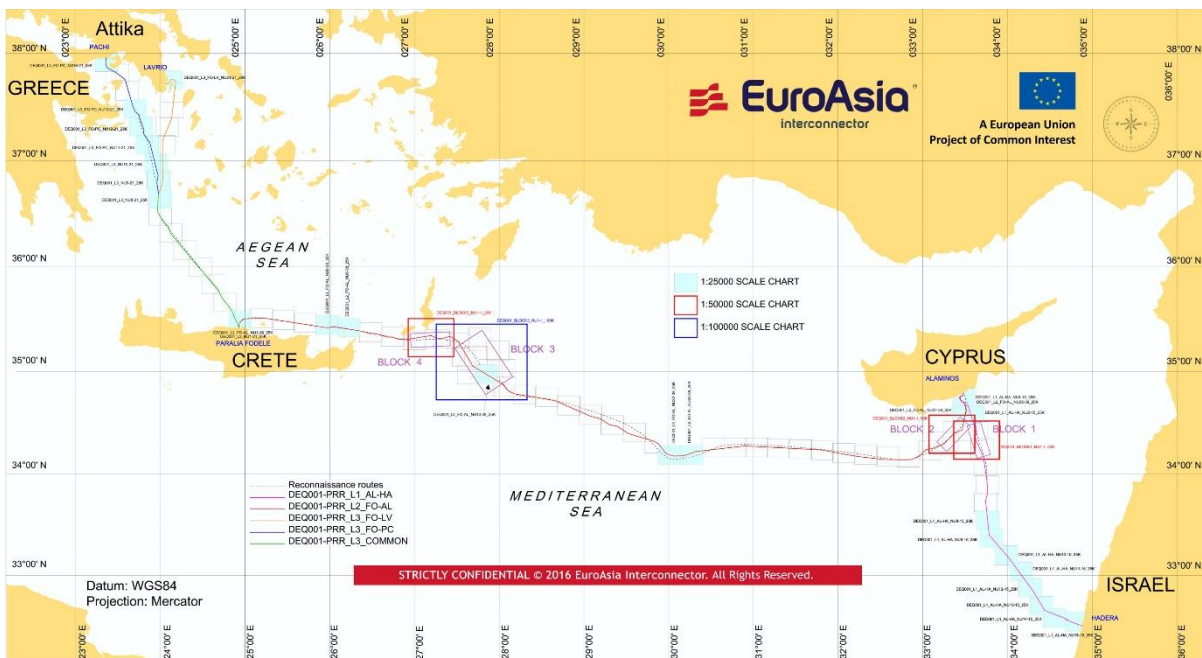


Figure 8: Map of the Cable

## 5 Benefits of the EuroAsia Interconnector

The project is part of the European Union's energy policy and receives positive evaluation due to its contribution to the energy targets set by the E.U. as presented below:

- It ends the Energy Isolation of Cyprus. Being the last E.U. member which remains fully isolated without any electricity or gas interconnections, its connection to the European network is a priority. Likewise, the energy isolation of Crete is ended and therefore this project contributes to the completion of the European internal energy market
- It is a key enabler and unlocks a pathway for channeling the Mediterranean natural gas findings towards new markets in the form of electricity. Israel benefits significantly as well
- The EuroAsia Interconnector is ensuring the security of energy supply of the three countries and of the EU system altogether, through the integration of the isolated small systems of Cyprus and Crete with the Israeli and European Network with an uninterrupted – multidirectional flow of energy
- Promotes the substantial development of the Renewable Energy Sources and contributes to the reduction of the CO<sub>2</sub> emissions
- Offers significant economic and geopolitical benefits to the involved countries
- Contributes to the target of the European Union for 10 % of electricity interconnection between Member States.
- Provides significant socio-economic benefits