First South East European
Regional CIGRÉ Conference
Portoroz, Slovenia, 7—8 June 2016

SEERC

SUBMARINE CABLE PROJECTS

2-03

Gülnazi Yüce

SUBMARINE CABLE PROJECT GENERAL

PLANNING OF THE SUBMARINE CABLE CROSSING

This presentation describes the planning, design, installation and commissioning of the double circuit 400 kV, 2x1000MW XLPE insulated and copper armoured submarine cable crossing of the Dardanelles Strait in Turkey.

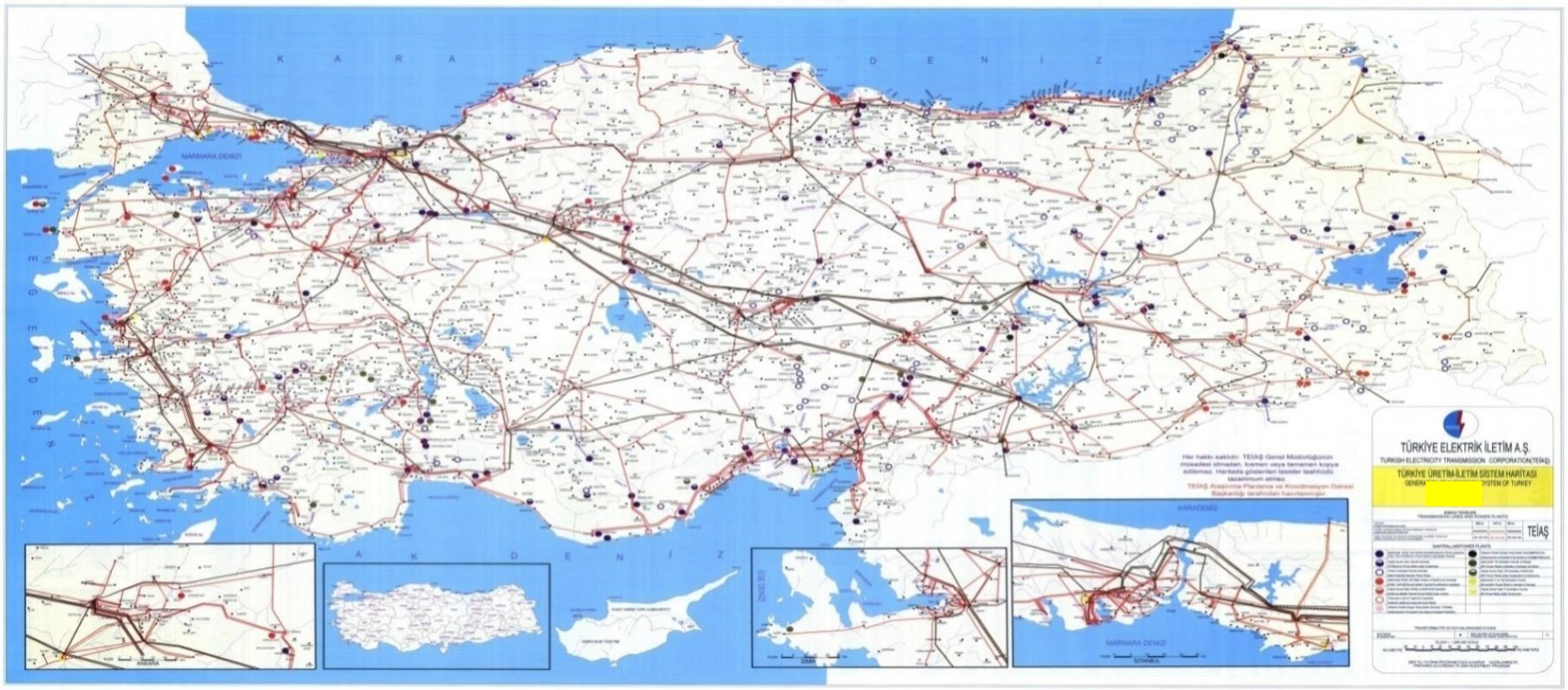
Turkish Electricity Corparation (TEİAŞ) has planned submarine cable projects considering;

- to increase the demand and security of our electricity supply system
- to complete The Marmara ring network via the Western corridor (Trakya)
- to include the power plants located in the southern Marmara Sea
- to provide alternative connections to İstanbul and around

The construction of the cable system and the associated 400 kV OHL TLs have been economically justified for the transmission to Istanbul. For these purposes; TEIAS has planned two Submarine Cable Projects which are 400 kV, Lapseki 1 - Sütlüce 1 and 400 kV, Lapseki 2 - Sütlüce 2

SUBMARINE CABLE PROJECT GENERAL

- The Turkish Power System has speedly developed in the last 50 years, to keep pace with the economic and industrial high rate of growth of the country



SUBMARINE CABLE PROJECT GENERAL

In Turkish Transmision Power Network; according to TEIAS's Annual Report – 2014 There are;

The summer peak of the TPS is ~ 40,000 MW, serving a population of ~ 75 million in a national territory of ~ 780,000 sqkm.

- 18.400 km 400 kV Overhead Lines
- 37.800 km 170 kV Overhead Lines
- 84,5 km 220 kV Overhead Lines (Georgia, Armenıa)
- 510 km 66 kV Overhead Lines
- 250 km 170 kV XLPE Insulated Underground Power Cable Connection
- 65 km 380 kV XLPE Insulated Underground Power Cable Connection

SUBMARINE CABLE PROJECT GENERAL

- A challenging problem is the power supply of the Istanbul Metropolitan area with a population of ~ 14 million and peak power demand of ~ 10,000 MW. A large part is transmitted from remote power plants located in Central – Eastern Anatolia, with saturation of the transmission capacity across the highly industrialized and narrow region between the Black Sea in the North and Marmara Sea in the South, where construction of new overhead lines (OHLs) is not practicable. Across this transmission corridor on the East of İstanbul, it is therefore not possible to transmit to Istanbul the power generated (over 5,000 MW) from the coal fired and gas fired power plants in existence and in advanced state of construction, located along the Southern Coast of the Marmara Sea.

- The summer peak power demand has been 43,300MW and yearly energy demand 264 TWh. The TPS supplies a population of ~ 75 million in a national territory of ~ 780,000 km^2.

- The objective of this project is the provide power to megacity Istanbul with min. 14 m population demanding more than 10.000 MW.

SUBMARINE CABLE PROJECT GENERAL

400 kV Lapseki-Sütlüce Project's Stages

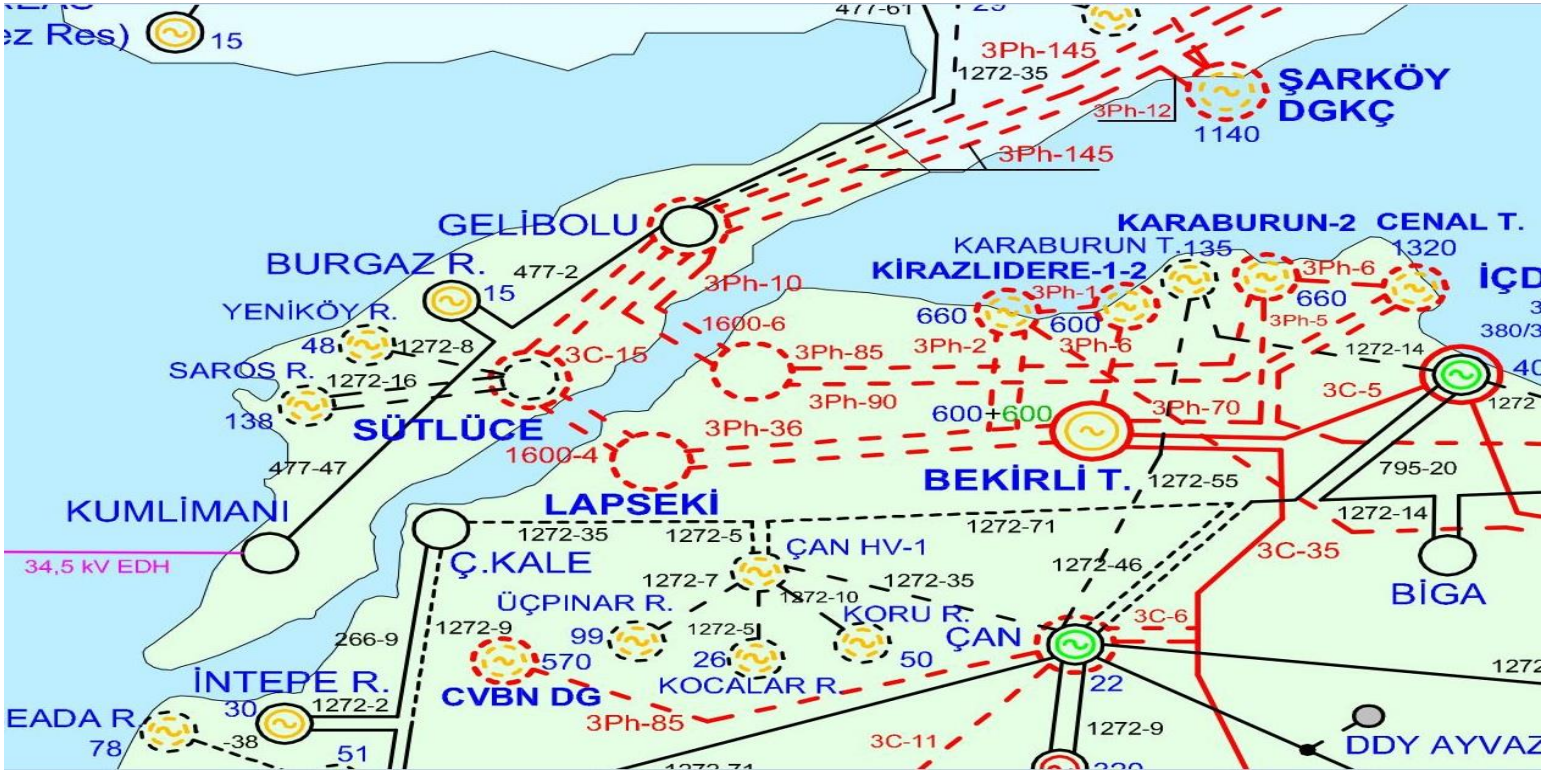
I. Feasibility Study of Project
II. Submarine Cable Route Survey
III. Tendering Procedures of The World Bank (IBRD)
IV. Evaluation of The Bids and Signing of the Contract
V. Contract Management

SUBMARINE CABLE PROJECT GENERAL

Key Activities :

- Obtainment of the permits from the related Authorities, considering the high international maritime traffic on the Dardanelles Strait, and the need to cross 4 existing fibre optic cables laid along the Strait. The consequentially applied protection against cable damages from boat anchors and fishing trawlers are reported in the paper.
- Avoidance of interference with other planned infrastructures, in particular the planned bridge across the
  Strait in close proximity of the cable route.
- The technical specification for the turn-key design, manufacturing, testing, installation and commissioning of the submarine cables and OHL interface stations.
- Technical Study for integration of submarine link to the National Network.

SUBMARINE CABLE PROJECT GENERAL



Dardanel Bosporus Transmission and Generating Map

SUBMARINE CABLE PROJECT GENERAL

400 kV Lapseki 1– Sütlüce 1 Submarine Cable Project's main features :

- Power & Voltage : 2000MW, 400KV AC
- Routh Lenght: 4,65 km
- Sea: 3,9km,
- Underground: 0,75km
- Cable amount: (2 circuit, 6 phase + 1 spare phase)
- Submarine: 27,3km,
- Underground: 5,25km
- Submarine Cable: 1600mm2
- Underground Cable: 2000mm2
- Cable Type: XLPE, Cu
- Contract Amount : 66,7 MEUR
- Contractor : Turk Prysmian – Prysmian Powerlink Joint Venture
- Status : Energised since April 2015

SUBMARINE CABLE PROJECT GENERAL

400 kV Lapseki 2 – Sütlüce 2 Submarine Cable Project's main features :

- Power & Voltage: 2000MW, 400KV AC
- Routh Lenght: 4,35 km
- Sea: 4,1 km,
- Underground: 0.25 km
- Cable amount: (2 circuit, 6 phase)
- Submarine: 24.6 km,
- Underground: 1.5 km
- Submarine Cable: 1600mm2
- Underground Cable: 2000mm2
- Cable Type: XLPE, Cu
- Contract Amount : 63,6 MEUR
- Contractor : Turk Prysmian – Prysmian Powerlink Joint Venture
- Status : Ongoing

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

- The submarine crossing survey has been performed by an ad hoc equipped Turkish vessel on a swath of ~1500 m. Scope of work was: water depth; seabed morphology and geology; cable burial assessment; sea bottom soil sampling; landing and inshore water survey. The survey has been checked and extended by the project turnkey contractor during implementation, and showed favourable conditions for EHV cable lying: stable sea bottom with regular profile and moderate water stream; feasibility of cable burial at 1.5 m by water jetting almost on the whole crossing routes; absence of obstacles.

- There are along the Dardanelles Strait 4 fibre optic telecommunication cables laid on sea bottom, which had to be over-crossed by all the 400 kV cables. Agreements have been reached with the owners of the fibre optic cables on the crossing procedures and cable protections. Information thereof are provided in section 3.2.

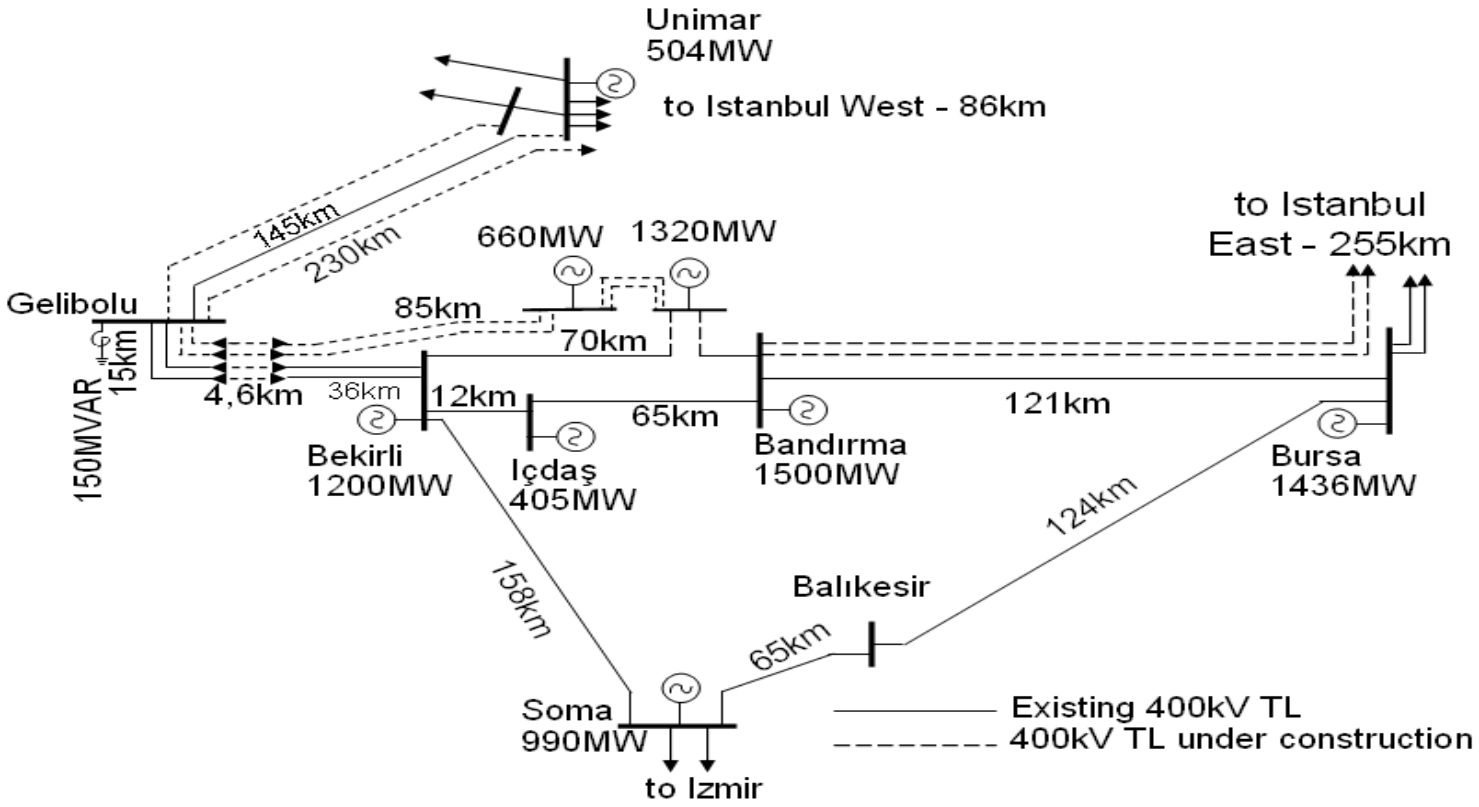
- Permissions have been requested and obtained from 15 State, Provincial and Municipal Entities, including the Energy Market Regulation Authority, 5 Ministries, 4 General Directorates, 3 Provincial Directorates and 2 Municipalities.

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

- The specified main technical characteristics of the submarine and land 400 kV cables and of the fibre optic cables are reported in section 3.1.

- The single line diagram of the OHL–cable transition switchyards in the European and Asiatic sides is shown in Figure 2 and Figure 3. Each transition bay includes: a motor operated disconnecting switch: earthing switches on the OHL and cable sides; current transformers for the supply of the dedicated differential protection of the cables; surge arresters; cable terminals.

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION



Single-line diagram of the Southern Marmara Sea 400 kV network

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

- The submarine XLPE insulated cables have 1600 mm^2 copper conductor cross section designed to reduce power losses. The conductor design includes an inner aluminium rod and an outer layer made of compacted copper wires, waterblocked by water swelling material.

- The metallic screen is made of lead sheath protected by a polyethylene anticorrosion sheath. The armour is made of one layer of round copper wires providing a sufficiently low resistance path for the AC current and the necessary mechanical performances.

- The underground XLPE insulated cables have 2000 mm^2 copper conductor cross section with Milliken design. The metallic screen is made of longitudinally welded aluminium sheath protected by a polyethylene anticorrosion sheath.

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

LAND CABLE	SUBMARINE CABLE
	

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

LAND CABLE

Rated voltage	(kV)	400
Conductor cross section	(mm^2)	2000
Conductor material and formation	Copper Milliken	
Insulation material	XLPE	
Nominal diameter	(mm)	138
Weight in air	(kg/m)	31

SUBMARINE CABLE

Rated voltage	(kV)	400
Conductor cross section	(mm^2)	1600
Conductor material	Copper + Internal aluminium rod	
Insulation material	XLPE	
Nominal diameter	(mm)	155
Weight in air	(kg/m)	60

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION

1600 mm² CONDUCTOR:

- Stranded copper with annealed plain copper wires
- With aluminum central rod (in order to reduce conductor loses)
- Conductor filled with water blocking medium (to limit water propagation)

SEMI CONDUCTING TAPE

- In order to avoid entering the extruded inner semi-conducting screen layer to conductor wires (avoid inter-layer contamination)
- Provides mountability

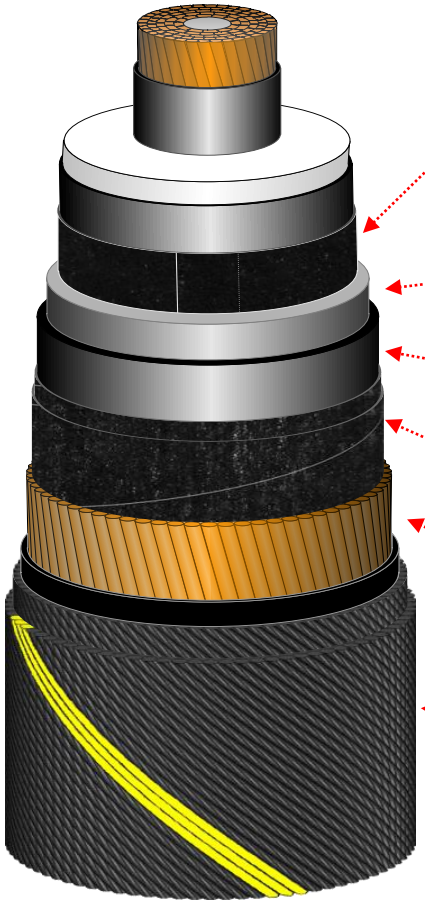
SEMI CONDUCTING LAYER(INNER)

- To make smooth interface between conductor and insulation
- To avoid space between conductor and insulation layer, prevents partial discharges
- To limit radial electrical field on the insulation layer and provide homogeneous distribution
- Creates a thermal barrier

XLPE INSULATON

- It is electrically inslulated to condcutor from the outer layers

SUBMARINE CABLE PROJECT DESIGN AND QUALIFICATION



SEMI CONDUCTING LAYER(OUTER)

- To make smooth interface between insulation and outer metallic layers
- To avoid space between conductor and insulation layer, prevents partial discharges
- To limit radial electrical field on the insulation layer and provide homogeneous distribution
- Creates a thermal barrier

WATER SWELLING TAPE

- To provide longitudial water barrier between outer semi-conducting screen and metallic sheath

METALLIC SHEATH

- To provide over the cable core as metallic screen and radial water barrier

CORE JACKET

- To protect the metallic sheath against to corrosion

COPPER ARMOUR

- Provides mechanical protection against to external effects

POLYPROPYLENE STRINGS

- Provides mechanical protection
- To provide a degree of abrassion protection and to reduce cable/skid friction during laying, Yellow/Black pattern is applied in order to give high visibility to the cable

SUBMARINE CABLE PROJECT INSTALLATION

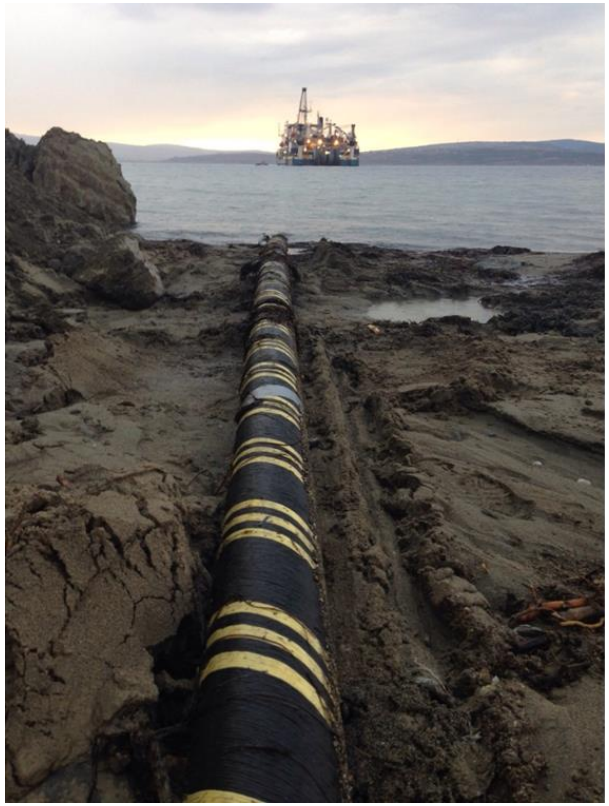
- For Lapseki 1 - Sütlüce 1 submarine cable project; submarine cables have been manufactured and installed without any intermediate joint in one laying campaign.
- Installation was carried out through Dardanelles Strait by the Giulio Verne cable laying ship.
- Maximum spacing between two of the intermediate couples of adjacent submarine cables reaches 250 m in correspondence to the maximum water depth which is ~ 100 m.
- Cables have been protected against external damages by burial in the seabed at the target depth of 1.5 m in ~ 80 % of total laid length.
- The main cable protection methodology used was burial by jetting, using specialized subsea machines. In short hard soil areas and at crossings with existing telecommunication cables concrete mattresses have been used to protect ~ 20 % of the cable routes.
- In the shallow water sections (up to 10 m water depth) at both ends, characterized by the presence of Cymodocea prairies, a dredging system run by divers has been used.
- Four in service optical submarine cables have been crossed on the Dardanelles Strait. At the crossing locations, “uraduct” plastic shells have been fitted to 400kV submarine cables on board during the cable laying to provide the physical separation between energy and optical cables. Post-lay matresses have been installed to cover the crossing area to protect the 400kV submarine cables. Power cables routes have an angle with the crossed in service cables higher than 70°. All the seven complete length of submarine cables have been tested in the factory for 30 minutes at 470 kVrms before armouring and at 440 kVrms after armouring.

SUBMARINE CABLE PROJECT INSTALLATION

- Crossings of four existing fibre optic cables have made use of plastic sleeves and concrete mattresses to minimize cables abrasion and ensure adequate separation and protection.
- Land cables have been laid in a dedicated tunnel.
- After installation the cables have been tested at 330 kV for 60 minutes by means of resonant systems. Testing frequency was 34 Hz with 54 A conductor to screen current. Partial Discharges have also been measured during the voltage test.
- Integrity of PE anticorrosion sheath and Sheath Voltage Limiters (SVLs) has been verified by DC after installation test.
- Some pictures of submarine and land cables installation are followings.

SUBMARINE CABLE PROJECT INSTALLATION

CABLE LAYING VESSEL – GIULIO VERNE



SUBMARINE CABLE PROJECT INSTALLATION

CABLE PULLING VINCH AT LANDING POINTS

SUBMARINE CABLE PROJECT INSTALLATION

ONSHORE MOBILISATION

SUBMARINE CABLE PROJECT INSTALLATION

SUPPORT BOATS AND DIVERS

SUBMARINE CABLE PROJECT INSTALLATION

PREPARATIONS ON BOARD

SUBMARINE CABLE PROJECT INSTALLATION

CABLE PULLING

SUBMARINE CABLE PROJECT INSTALLATION

MONITORING

SUBMARINE CABLE PROJECT INSTALLATION

FIBER OPTICAL CABLE BUNDLING

SUBMARINE CABLE PROJECT INSTALLATION

URADUCT INSTALLATION FOR SPECIAL CROSSINGS

SUBMARINE CABLE PROJECT INSTALLATION

URADUCT INSTALLATION FOR SPECIAL CROSSINGS

SUBMARINE CABLE PROJECT PROTECTION

Protection Methodologies applied in 400kV Lapseki 1 – Sütlüce 1 Submarine Cable Project
Protection Of Cables On Seabed
Cables have been protected all along the whole crossing route, with the different methods which determines according to seabed conditions.

The acceptable burial depths specified on the specifications are as follows:

Protection **Burial Depth**	**Specified** **Type**	**Minimum** **Acceptable Burial Depth**
Jetting	150 cm	100 cm
Trenching	75 cm	40 cm

It is foreseen to apply same protection methodologies for the 400kV Lapseki 2 – Sütlüce 2 Submarine Cable Project

SUBMARINE CABLE PROJECT PROTECTION

1- PROTECTION METHODOLOGIES IN OFFSHORE SECTIONS

1.1- JETTING

Jetting activities can be performed on the soft soils. Jetting is the preferred cable protection methodology. The jetting work by burial is performed in post-lay mode by means of a subsea jetting machine, assisted by a dedicated support vessel.

This machine, characterized by low weight in the water and high maneuverability, is equipped with high pressure water jets as well as jetting swords (stingers) to be deepen into the seabed soil.

The cable burial is achieved by soil fluidizing (by high pressure water) around the cable, causing the opening of a trench below the cable and its lowering due to its own weight. The fluidized material will shortly afterwards fall down again mostly into the trench, covering the cable and partially re-filling the trench itself.

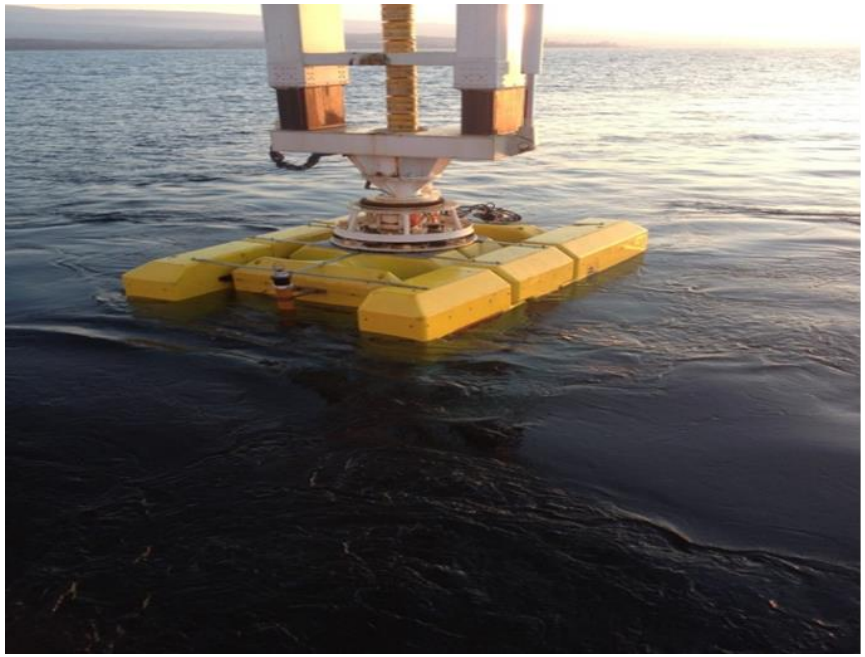
The trench backfilling will be completed with time due to current. The burial target is specified at 1.5 m, with minimum acceptable level at 1 m.

SUBMARINE CABLE PROJECT PROTECTION

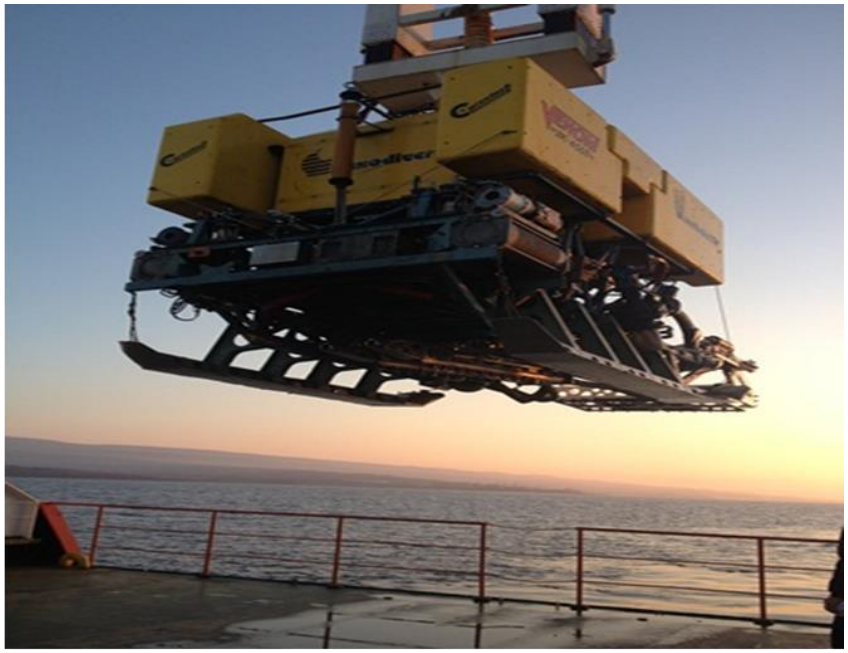
JETTINGS - PROTECTION METHODOLOGIES IN OFFSHORE SECTIONS

SUBMARINE CABLE PROJECT PROTECTION

IN OFFSHORE SECTIONS JETTING



JETTING MACHINE



SUBMARINE CABLE PROJECT PROTECTION

1.2- TRENCHING

The presence, in some areas, of subcropping/outcropping very coarse materials (generally Coarse SAND, over loose GRAVEL and PEBBLES) outcomes with the result of reduced possibility to achieve the 1.50 m target burial depth by jetting.

In these areas, it is foreseen to perform the trenching in order to reach the 0.75 m target burial depth or at least to reach the 0.4 m minimum level for trenching works.

SUBMARINE CABLE PROJECT PROTECTION

Typical Trenching Machine

- During the operation cables are lifted by clamps located under the machine.
- Cable gets out of the route by moving clamps during the operation.
- The breaker located front end applied to excavate to hard soil.
- Vacuum sweeper located back side draws the broken stones and hydraulic ejector pitch the broken stones away.
- Cable place into the opened trench by the moving clamps.

SUBMARINE CABLE PROJECT PROTECTION

1.3- MATTRESSING

Mattresses are formed by relatively small concrete blocks (each block typically 50 x 30 x thickness 30 cm) connected by suitable ropes. This configuration gives the mattresses a good flexibility and capacity to adapt itself to a not flat surface (seabed, cable).

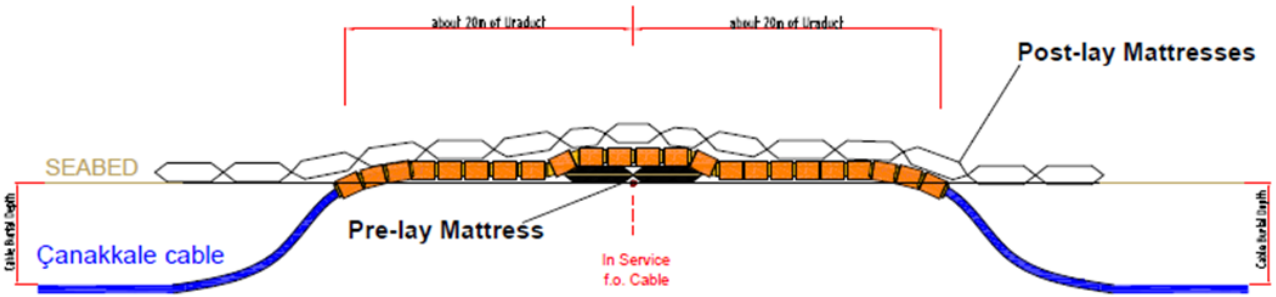
The most used overall typical dimensions are 5.0m x 2.5m or 6.0m x 3.0m or 6.0m x 2.0m. Dynamic Positioning (DP) support vessels will be used, assisted by DGPS as surface positioning and USBL systems for underwater positioning.

Mattresses are deployed on the seabed from the support vessel by means of a suitable frame equipped with an automatic release system. Their positioning on the seabed is assisted by a ROV.

Applications are following Lapseki 1 - Sütlüce 1 Project.

SUBMARINE CABLE PROJECT INSTALLATION

Crossing methodology for surface laid In Service f.o. cables (MedNautilus, Itur, Turmeos)
One Pre-lay mattress (thickness 30 cm) installed on top of the surface laid f.o. cables.
Plastic sleeves (Uraduct shells) installed on board the cableship on the Çanakkale cable, during the lay campaign.
Post-lay mattresses will be installed on the Çanakkale exposed cable.

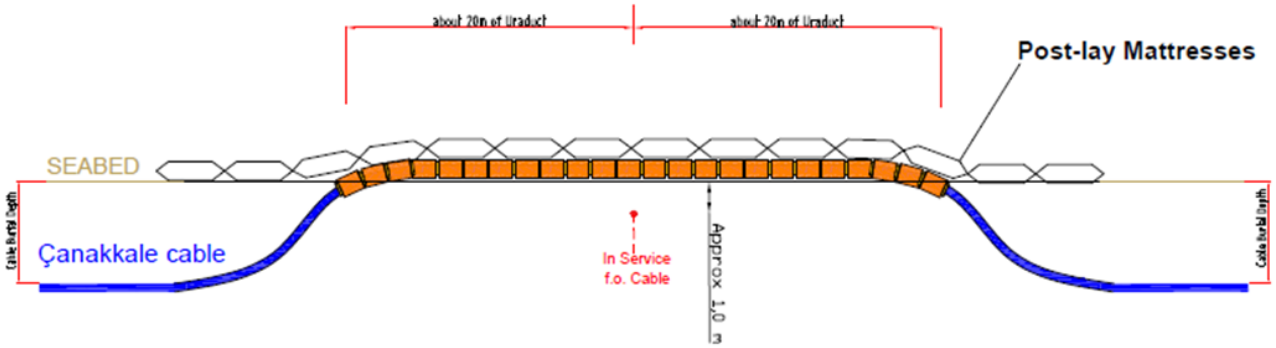


NOTE: Mattress length depends on the burial feasibility of Uraduct section
Within the scope of the project two submarine FO cables will be bundled with 2nd and 6th 380kV submarine cables

PRYSMIAN POWERLINK	Çanakkale Project
Title	Crossing Metodology Sketch - Rev.1
Date: September 2014	Format: A4 not to scale
Index: Submarine Systems Installation	

SUBMARINE CABLE PROJECT INSTALLATION

Crossing methodology for buried In Service f.o. cable (MedTurk)
Plastic sleeves (Uraduct shells) installed on board the cableship on the Çanakkale cable, during the lay campaign.
Post-lay mattresses will be installed on the exposed cable.



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Title	Crossing Metodology Sketch - Rev.1
Date: September 2014	Format: A4 not to scale
Index: Submarine Systems Installation	

SUBMARINE CABLE PROJECT INSTALLATION

2- PROTECTION METHODOLOGIES AT LANDING POINT AND IN SHALLOW WATERS

2.1- CABLE PROTECTION AT LANDING POINTS

- At the landing locations, the cables are protected by lowering them in pre-excavated trenches.
- The submarine cables are pulled from the ship towards land and simultaneously lowered in the mentioned trenches while proceeding towards the sea-land joint pit.
- The trenches are covered afterwards, at the end of landing operations.

SUBMARINE CABLE PROJECT INSTALLATION

SUBMARINE CABLE PROJECT INSTALLATION

Lapseki Interface Primary Equipment Installation Works

SUBMARINE CABLE PROJECT INSTALLATION

Sütlüce Interface Underground Cable Gallery Civil Works

SUBMARINE CABLE PROJECT INSTALLATION

Lapseki Joint Place & Lapseki Cable Gallery Civil Works

SUBMARINE CABLE PROJECT INSTALLATION

Sütlüce Interface Underground Cable Gallery Civil Works

SUBMARINE CABLE PROJECT INSTALLATION

Sütlüce Interface Joint Place

SUBMARINE CABLE PROJECT INSTALLATION

THANK YOU