POWER TRANSMISSION TECHNOLOGIES
MEDGRID ACTIVITIES

Philippe ADAM, Strategy Director Infrastructures & Technologies

Medgrid Workshop – Amman (Jordan) – November 28, 2013

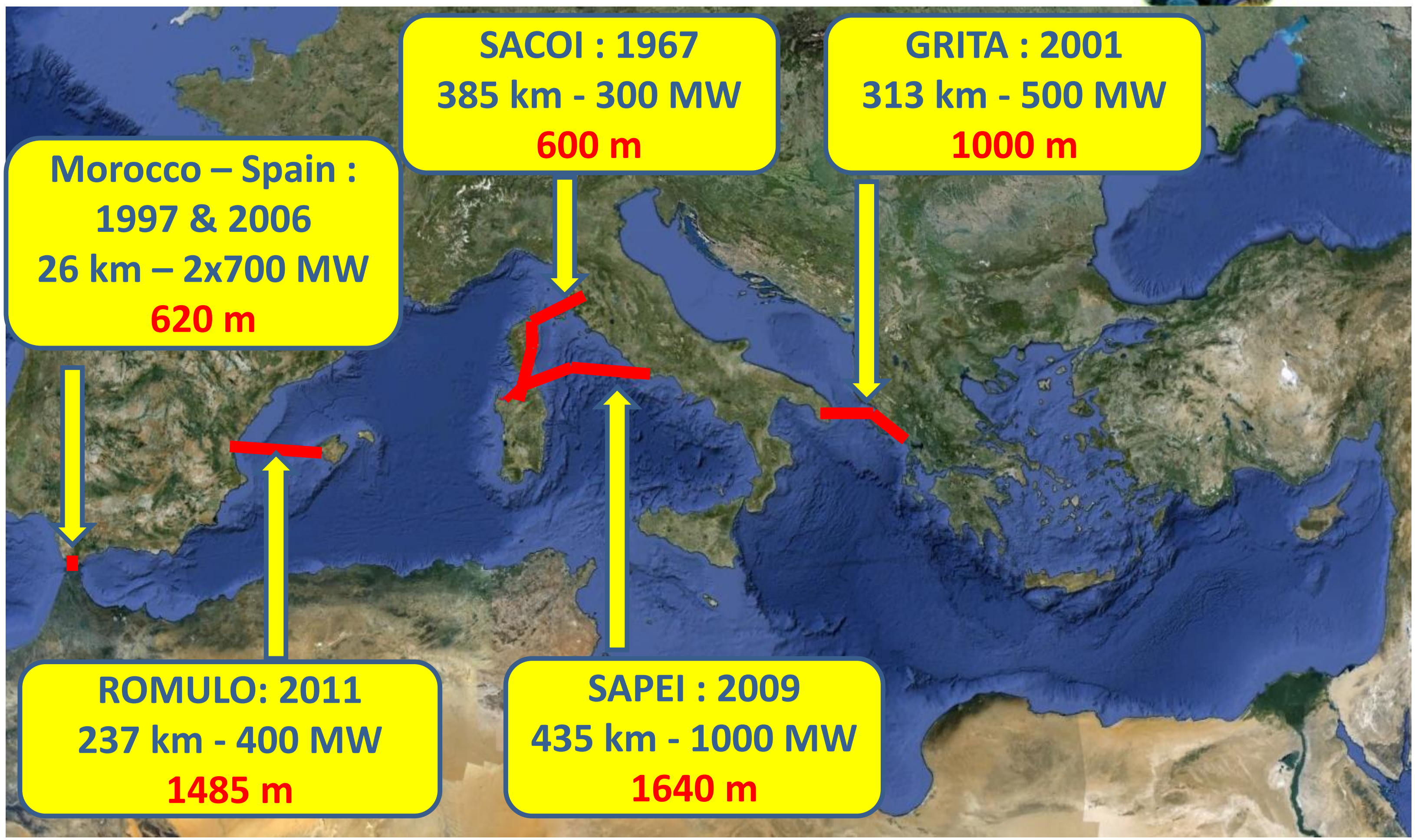
Medgrid objectives in the field of transmission technologies

- **Maintain** the knowledge on present and future power transmission technologies

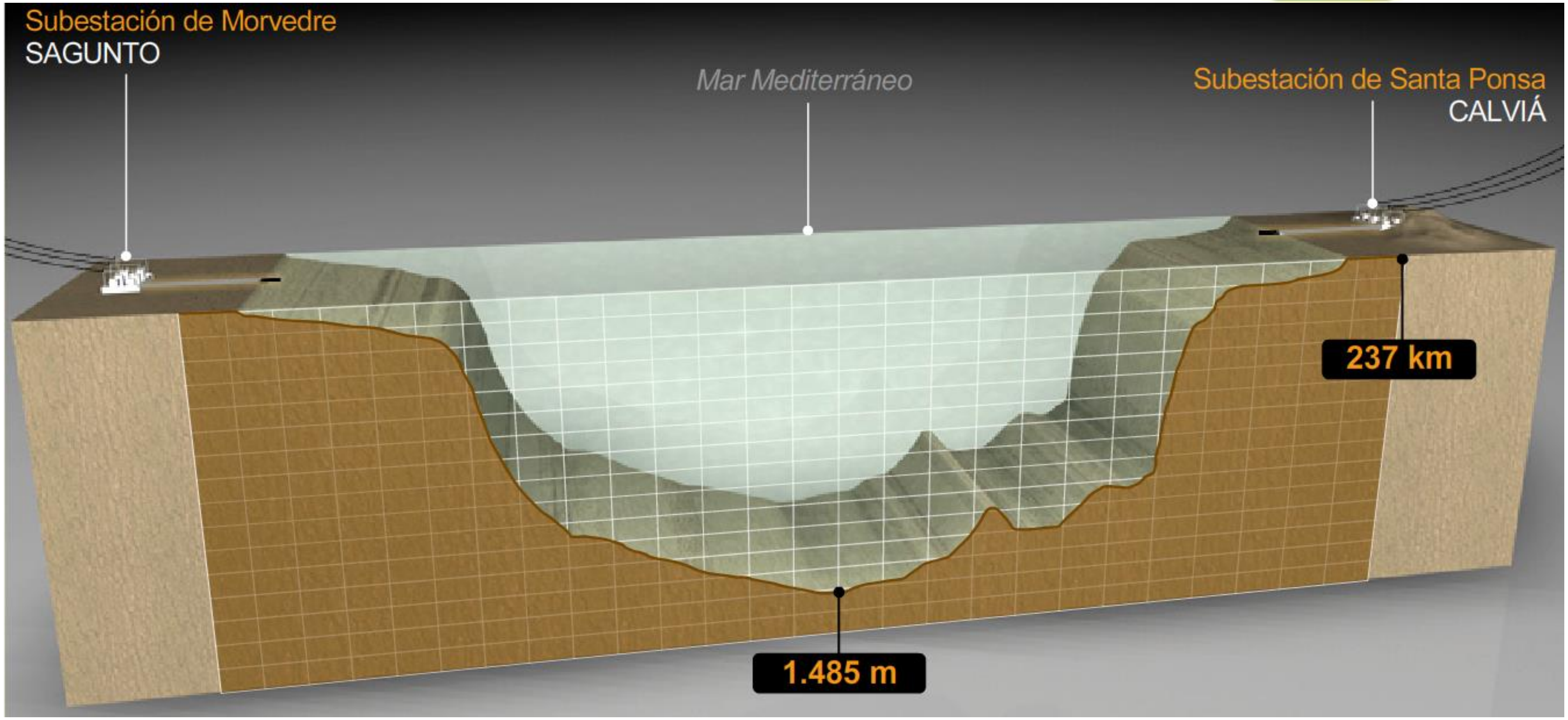
- **Study** the feasibility of a submarine power cable system for depths up to 2500 meters

- **Assess** the investment and operation costs of transmission infrastructures

Length and depth profiles of existing interconnectors in the Mediterranean

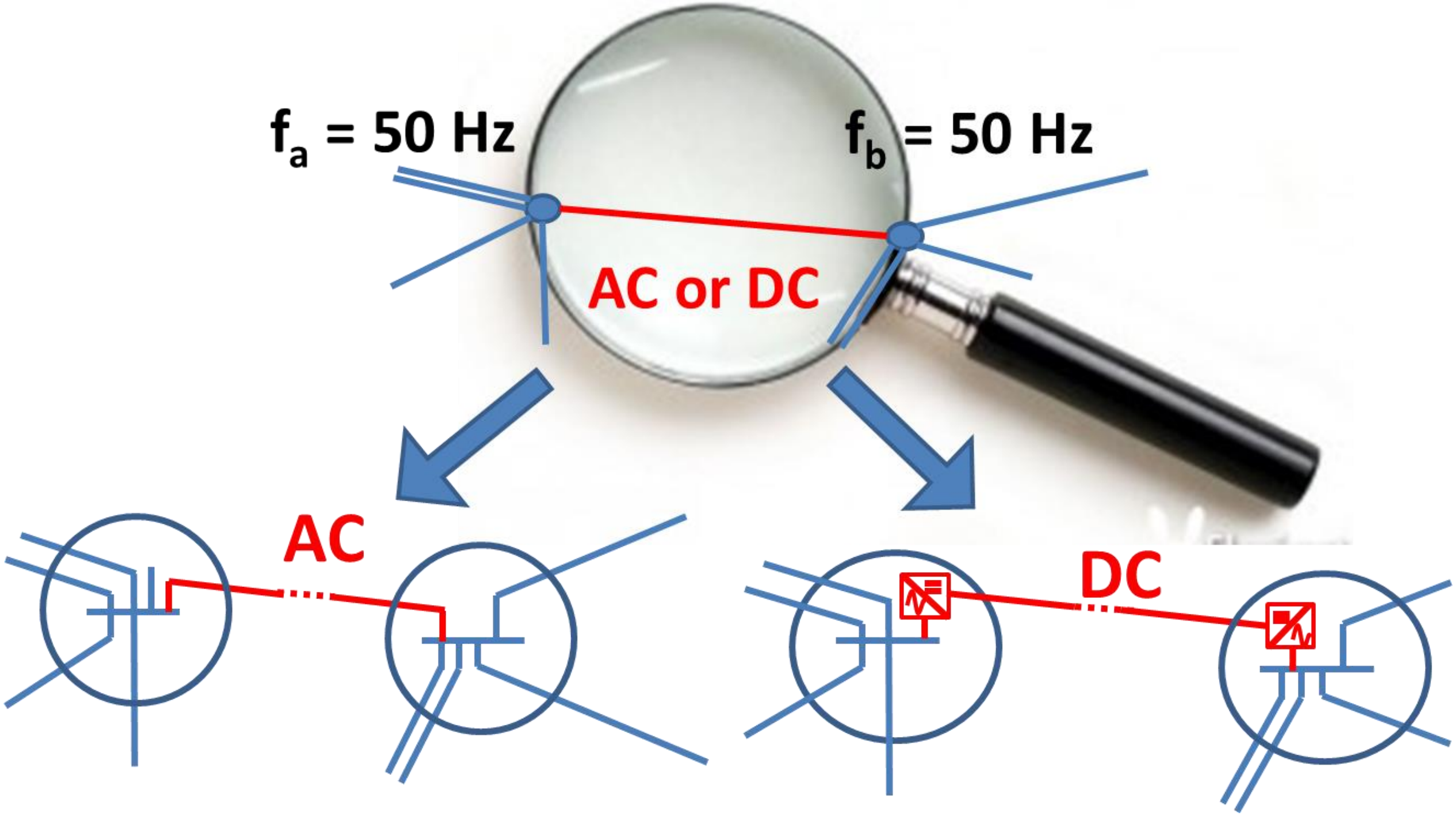


Example of depth profile : the ROMULO project.

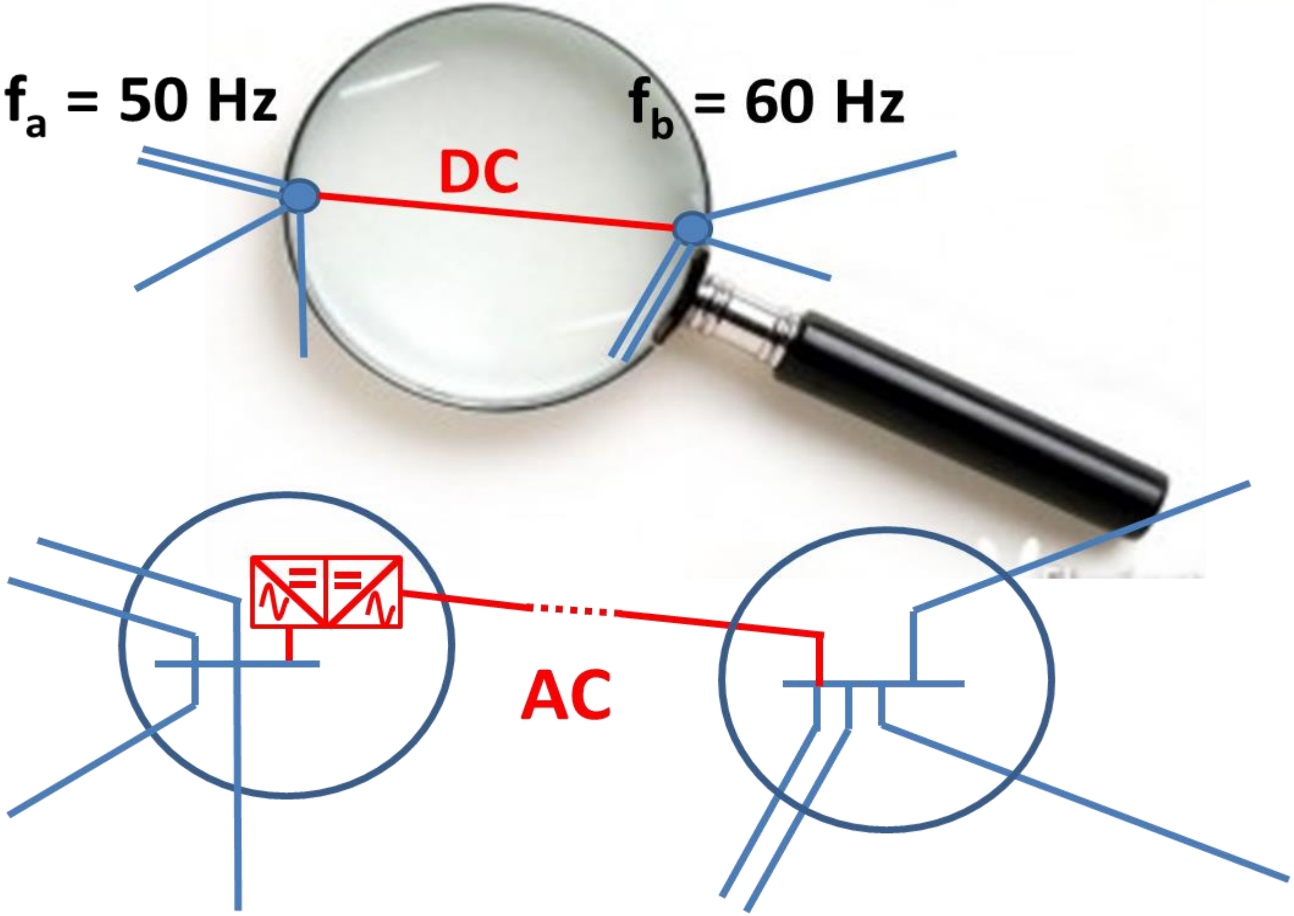


Courtesy : Red Electrica de España

The 2 different transmission technologies

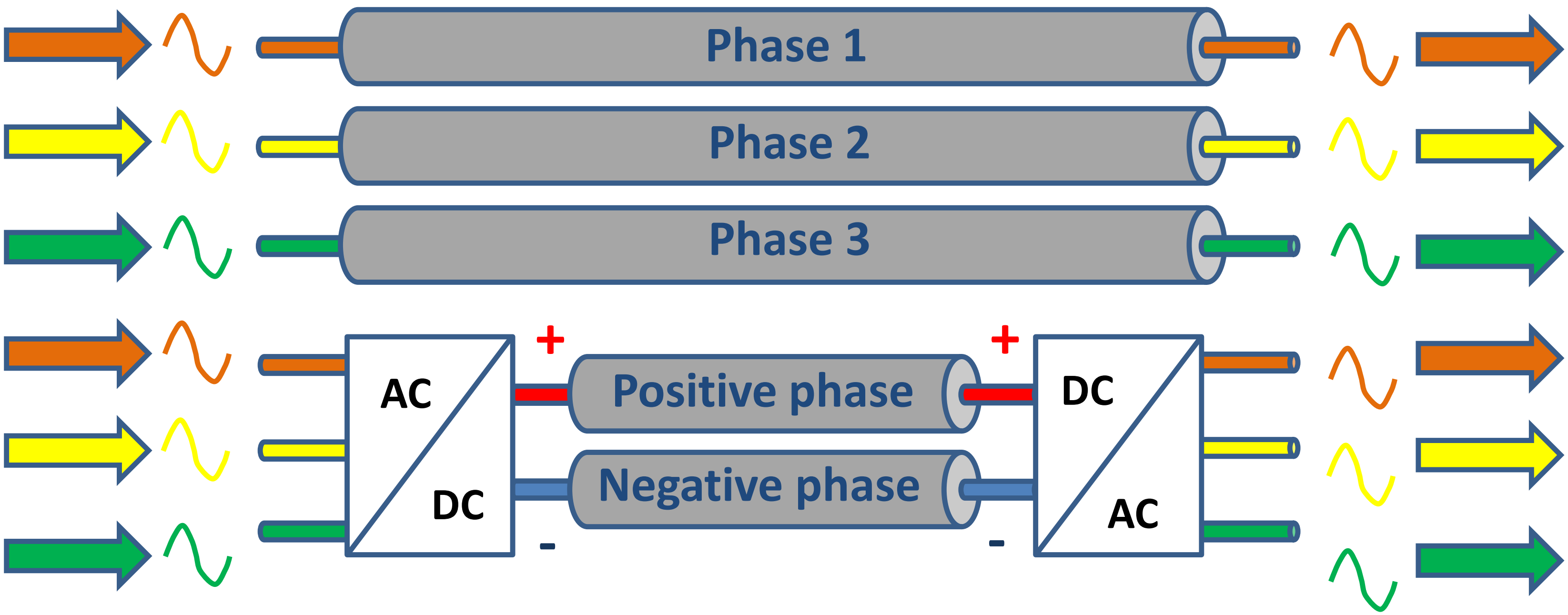


The 2 different transmission technologies



Why high voltage direct current (HVDC) ?

> For economic reasons : 2 DC cables carry nearly the same power as 3 AC cables of the same design >>> lower cost…



> … but AC/DC & DC/AC conversion is required at both ends >>> additional cost.

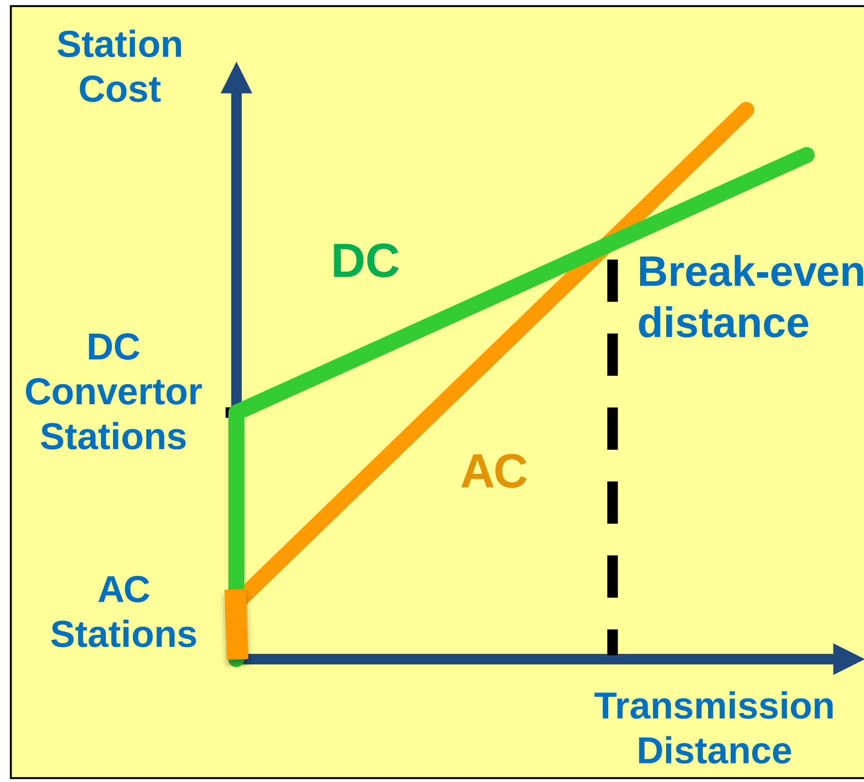
> HVDC is more appropriate than HVAC for long distance transmission,

High voltage direct current (HVDC) technologies

Applications:

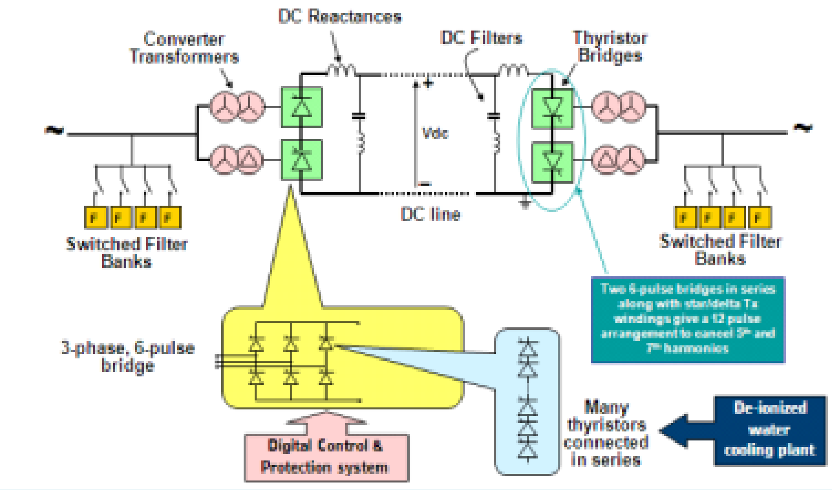
- Transmission over long distances by over head lines or cables : from 600 km (over head lines) ou 50 km (cables)

- Frequency changers (back-to-back)



HVDC converter stations

CCHT LCC



- Use of Thyristors
- Current source
- High power capability (up to 7,2GW @ +/- 800 kV)
- Mature technology

CCHT VSC

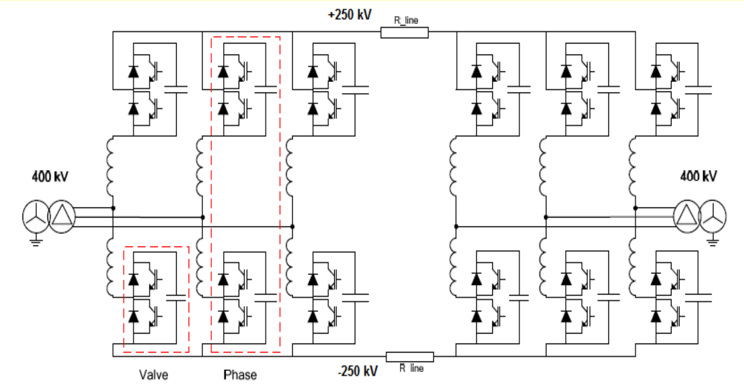


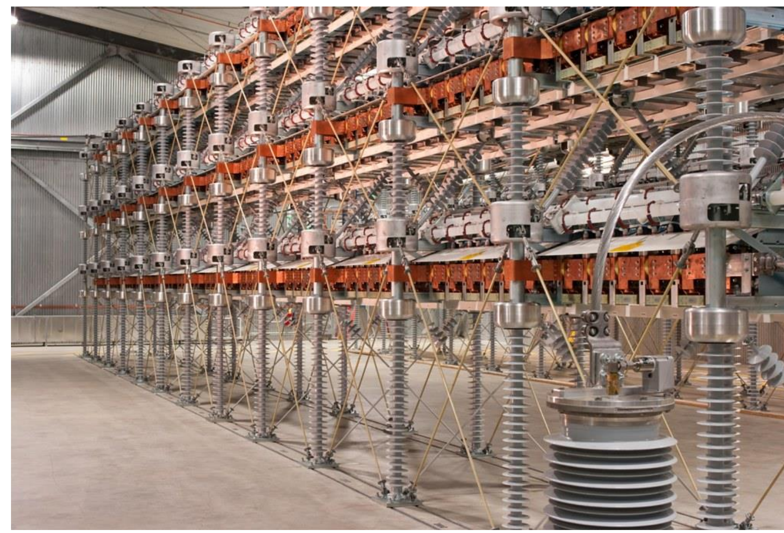
Figure 1 – General scheme layout

- Use of IGBTs (Power transistors)
- Voltage source
- Medium power capability (up to 1000 MW @ +/- 320 kV)
- Fast growing technology

Valve halls in HVDC converter stations

CCHT LCC

CCHT VSC



- Converter station size : for the same power, VSC requires about 50% less space than LCC.

HVDC technologies

CCHT LCC

Xiangjiaba – Shanghai China

- 6 400 MW +/- 800 kV bipole scheme
- 2071 km Overhead line transmission
- Commissioning in 2010 (1st pole) and 2011 (2nd pole)
- Link between Fulong 525 kV s/s and Fengxian 515 kV s/s
- State Grid Corporation of China

GCCIA Phase 1 Saudi Arabia

- 3 x 600 MW 222 kV Back to Back scheme
- Interconnection of Saudi Arabia (380 kV - 60 Hz) into the 400 kV - 50 Hz Gulf AC interconnector scheme
- DRPS function integrated (Dynamic Reserve Power Sharing)
- Commissioning in 2009
- Located at Al Fadhili s/s in Saudi Arabia
- Gulf Cooperative Council Interconnection Authority (GCCIA)

CCHT VSC

INELFE -France – Spain Interconnection

- Double symmetric monopole => 2 x 1000 MW @ ±320 kV
- 65 km underground cable
- Commissioning due for mid 2014
- Converters location: France (Baixas, near Perpignan) and Spain (Santa Llogaia, near Figueres)
- RTE and REE

DOLWIN 1 – Germany

- Symmetrical monopole 800 MW @ ±320 kV
- Offshore Wind Park grid connection
- 165 km submarine cable
- Commissioning due for 2013
- Converters location: Dolwin Alpha platform in North sea and Dorpen in Germany

Future HVDC technologies : DC grids

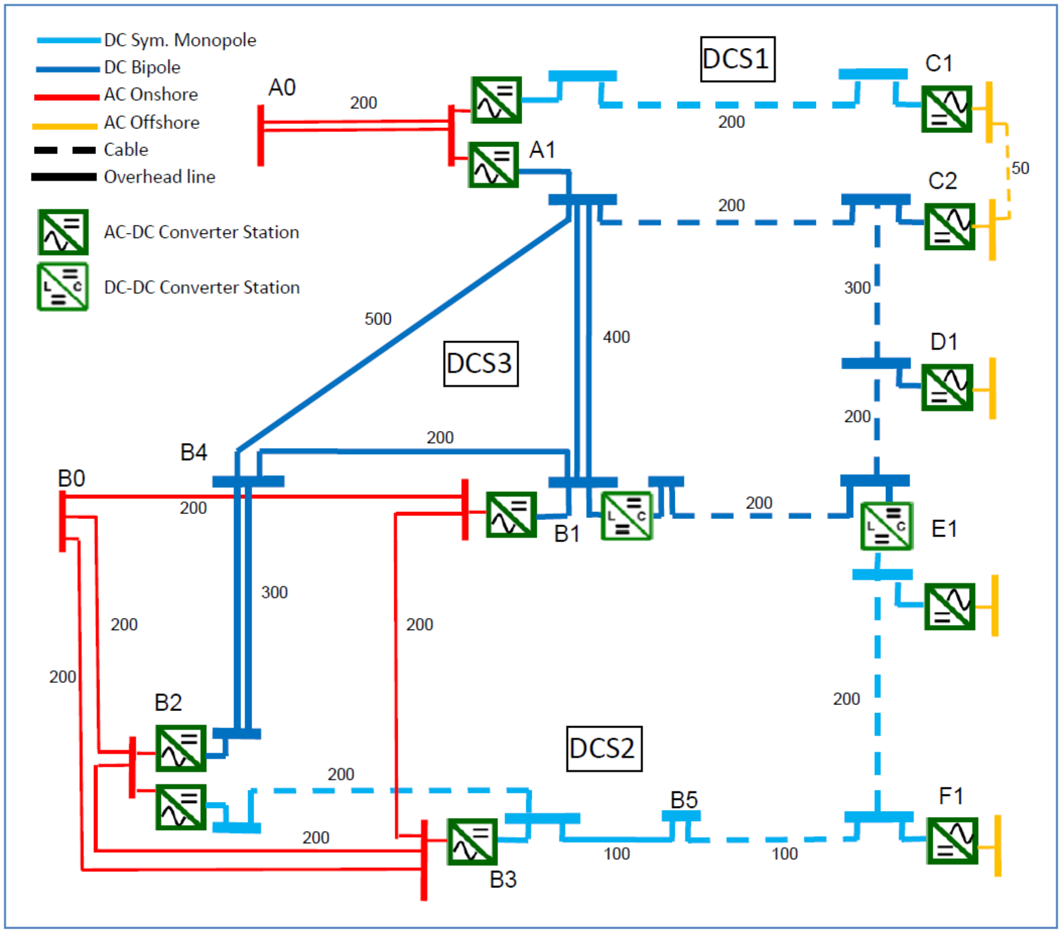
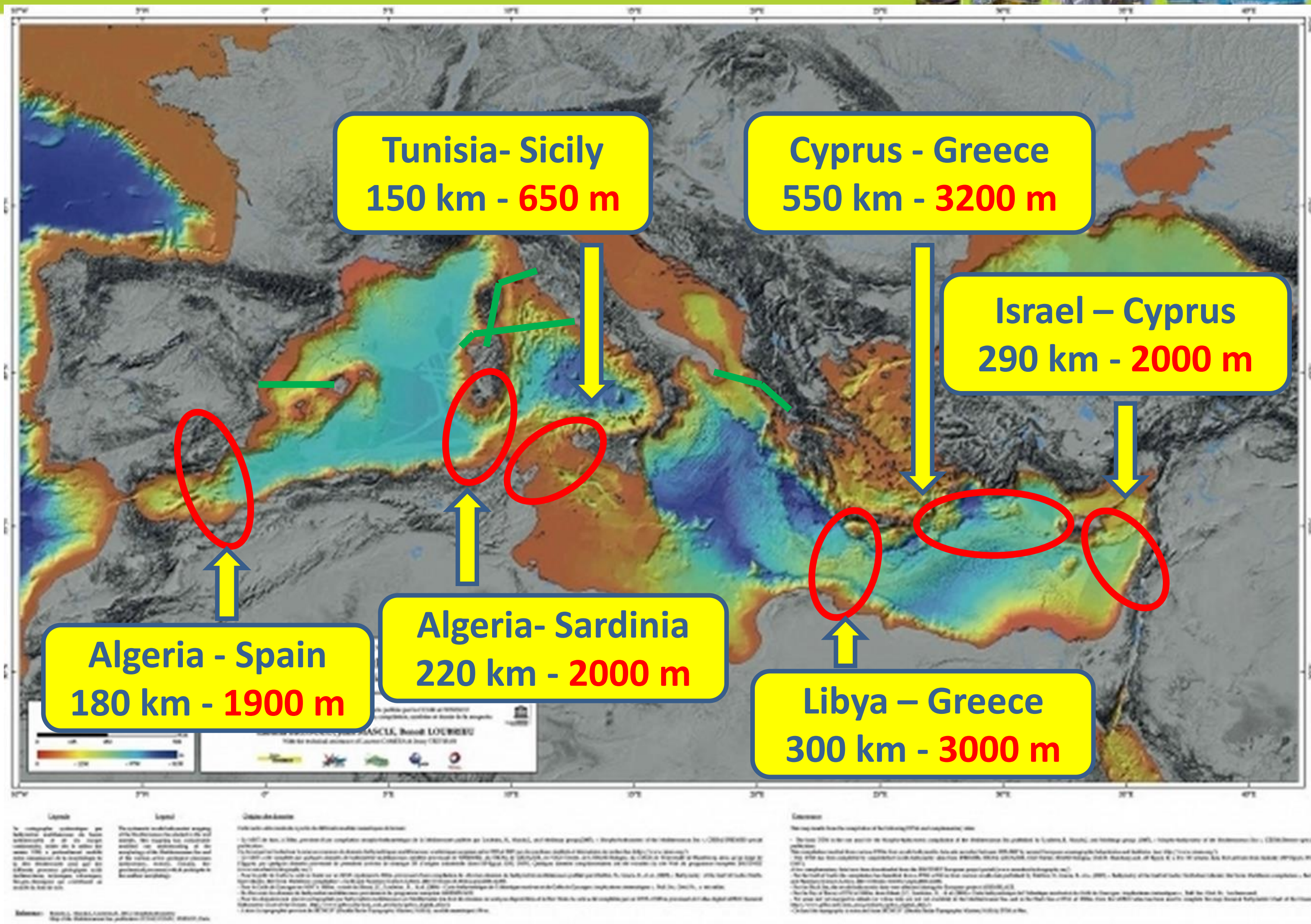


Figure 1 CIGRE B4 DC Grid Test System

- How to plan ?
- How to design ?
- How to control ?
- How to protect ?
- How to operate ?
- How to standardize ?
- How to ensure multivendor procurement ?

Length and depth profiles of potential interconnectors in the Mediterranean



Submarine cable for HVDC transmission

✦ Oil filled cables

Voltage : ±400 kV
short distance: 60 km
depth : jusqu'à 2000 m

✦ Impregnated paper cables

Voltage : ±550 kV
long distance
depth : jusqu'à 1650m
weight : 50 kg/m

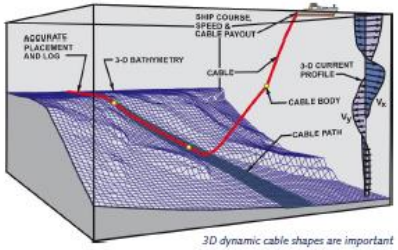
✦ Extruded cables

Voltage : ±320 kV
long distance
depth : jusqu'à 400m
weight : 17 à 34 kg/m

Challenges to implement deep water cables

- Which technologies for cables and joints at 2500 meters?
  - Insulation, conductor, sheath, armour, tests…

- Laying and installation of power cables at 2500 meters
  - Vessels to transport and lay long and heavy cables…
  - How to recover in case of incident during laying over 2500 m of water?



3D dynamic cable shapes are important

- Operation and maintenance
  - How to monitor the state of the cables at 2500 meters?
  - How to detect cable faults and how to analyse them?
  - How to repair cable faults under 2500 meters (procedure and tools)?
  - What are the possible spare parts strategies?

- How to manage the risks at the different steps of such projects?

Medgrid programme of works

- To deal with these challenges, Medgrid has launched the feasibility study of a submarine power cable system for depths up to 2500 meters.
- The study will result in the specification of such systems, expected in October 2013.
- The main players of the industry will be questionned on the present state of the art, and on their vision of possible innovations and progress for the medium term (2015/2020) and long term horizons (2030).
- Medgrid has awarded the study to a consortium of international consultants :

CESI ismes FGH IPH | PARSONS BRINCKERHOFF | Intertek

Exemple of cost assessment

- **Costs du MSP: 40 billions € for generation**
- **Submarine cable laid: between 1000 et 2 000 € / MW / km**
- **End converter stations (for 2): 200 000 € / MW**
- **The cost of a submarine link of a transmission capacity of 1000 MW over 500 km is between 700 millions and 1,2 billion d'Euros**
- **Depending on the utilization and the financing conditions, the average transmision cost can vary from 10 to 30 €/MWh.**

Thank you for your attention

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