

# REALISEGRID

## **Draft Deliverable D3.3.2**

### **Review of costs of transmission infrastructures, including cross-border connections**

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General Meeting

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# Deliverable overview

- Main Authors
  - A. L'Abbate, G. Migliavacca (ERSE)
- Contributions expected from TSOs
  - TenneT
  - Terna
  - RTE-I
  - Verbund-APG
- Interactions ongoing with
  - WP3.1
  - WP3.2
  - WP3.5
  - WP3.7
  - WP1.1
  - WP1.2
  - WP1.4
  - WP2

# Deliverable overview

- Transmission expansion planning
  - Planning process
  - Cost-benefit analysis
  - Choice of the most feasible option(s)
- Assessment of costs of transmission infrastructures
  - Cost elements
  - Equipment costs: HVAC
  - Equipment costs: HVDC
  - Country review: preliminary (partial) figures
  - Cross-border projects review: examples
- Next steps

# Transmission planning

- Transmission expansion planning has become a more and more complex task over the years
- European TSOs deal with several techno-economic, market, regulatory, environmental and socio-political issues
- Choice of the most feasible expansion option(s) is subject to different constraints
- Thorough assessment of benefits and costs is crucial towards decision-making

# Transmission assets costs

- Transmission assets costs depend on various factors:
  - equipment rating and type
  - operating voltage
  - local environmental constraints
  - geographical characteristics
  - material costs
  - manpower (labour) costs
  - technology maturity
- Capital cost elements for transmission assets: equipment, installation, engineering, auxiliaries, civil works, right-of-way, tax, insurance, financing
- Operating cost elements for transmission assets: operation, maintenance, relocation, losses
- Other cost elements: land acquisition, local compensations

# Transmission assets costs

## ■ Main HVAC transmission assets:

- Overhead lines
- Cables
- Transformers
- Switchgears/substations
- Reactive compensators
- PST
- FACTS
- Smart lines
- Smart cables
- HTLS (HTC) lines
- GILs
- HTS cables

Overhead lines equipment costs include costs for: conductors, pylons/towers, foundations, insulators, clamps and related devices

# Transmission assets costs

## ■ Main HVDC transmission assets:

- Overhead lines
- Cables
- Converter stations

Overhead lines equipment costs include costs for: conductors, pylons/towers, foundations, clamps and related devices

Converter stations equipment costs include costs for: valves, converter transformers, filters, control, switchyard

Further specific equipment will be required for offshore grids (including platforms)

## ■ Future HVDC breakthroughs: DC breakers/substations, HTS DC cables

# Transmission assets costs

## ■ Quantitative data on HVAC/HVDC costs

System component	Voltage level	Power rating	Cost range		Unit
			min	max	
HVAC OHL, single circuit <sup>(1)</sup>	400 kV	1500 MVA	400	700	kEUR/km
HVAC OHL, double circuit <sup>(1)</sup>	400 kV	2×1500 MVA	500	1000	kEUR/km
HVAC underground XLPE cable, single circuit	400 kV	1000 MVA	1000	3000	kEUR/km
HVAC underground XLPE cable, double circuit	400 kV	2×1000 MVA	2000	5000	kEUR/km
Reactive power compensation for HVAC cable line, single circuit	400 kV	-	15	15	kEUR/MVAR
HVDC OHL, bipolar <sup>(1)</sup>	±150÷±500 kV	350÷3000 MW	300	700	kEUR/km
HVDC underground cable pair	±350 kV	1100 MW	1000	2500	kEUR/km
HVDC undersea cable pair	±350 kV	1100 MW	1000	2000	kEUR/km
HVDC VSC terminal, bipolar	±150÷±350 kV	350÷1000 MW	60	125	kEUR/MW
HVDC CSC terminal, bipolar	±350÷±500 kV	1000÷3000 MW	75	110	kEUR/MW

<sup>(1)</sup> cost ranges correspond to the base case, i.e. installation over flat land. For installations over hilly landscape +20% and +50% for installations over mountains or urban areas have to be factored in.

Sources: public data, TSO questionnaire, REALISEGRID WP1 exercise, REALISEGRID D1.2.1



# Transmission assets costs

## Country review of HVAC assets costs:

### ■ Italy (reference values):

• OHL single circuit, 380 kV	500 k€/km
• OHL double circuit, 380 kV	760 k€/km
• OHL single circuit, 220 kV	350 k€/km
• OHL double circuit, 220 kV	450 k€/km
• OHL single circuit, 120÷150 kV	270 k€/km
• OHL double circuit, 120÷150 kV	410 k€/km
• XLPE cable, 1200 MVA, 380 kV	3250 k€/km
• XLPE cable, 550 MVA, 220 kV	2850 k€/km
• XLPE cable, 400 MVA, 220 kV	2000 k€/km
• XLPE cable, 250 MVA, 150 kV	1700 k€/km

provisional data

# Transmission assets costs

## Country review of HVAC assets costs:

- Germany (average values):
  - OHL single circuit, 380 kV 750 k€/km
  - OHL double circuit, 380 kV 1000 k€/km
- France (average values):
  - OHL single circuit, 380 kV 700 k€/km
  - OHL double circuit, 380 kV 1000 k€/km
  - XLPE cable, 1000 MVA, 380 kV 2000 k€/km
- Netherlands (average values):
  - OHL double circuit, 380 kV 2500 k€/km
  - XLPE cable, 1000 MVA, 380 kV 4500 k€/km
- Austria (average values):
  - OHL double circuit, 380 kV 1000 k€/km
  - XLPE cable, 1000 MVA, 380 kV 9500 k€/km

provisional data

# Transmission assets costs

## Country review of HVAC assets costs:

### ■ Ireland (average values):

- OHL single circuit, 400 kV 550 k€/km
- XLPE (underground) cable, 1500 MVA, 400 kV 4000 k€/km

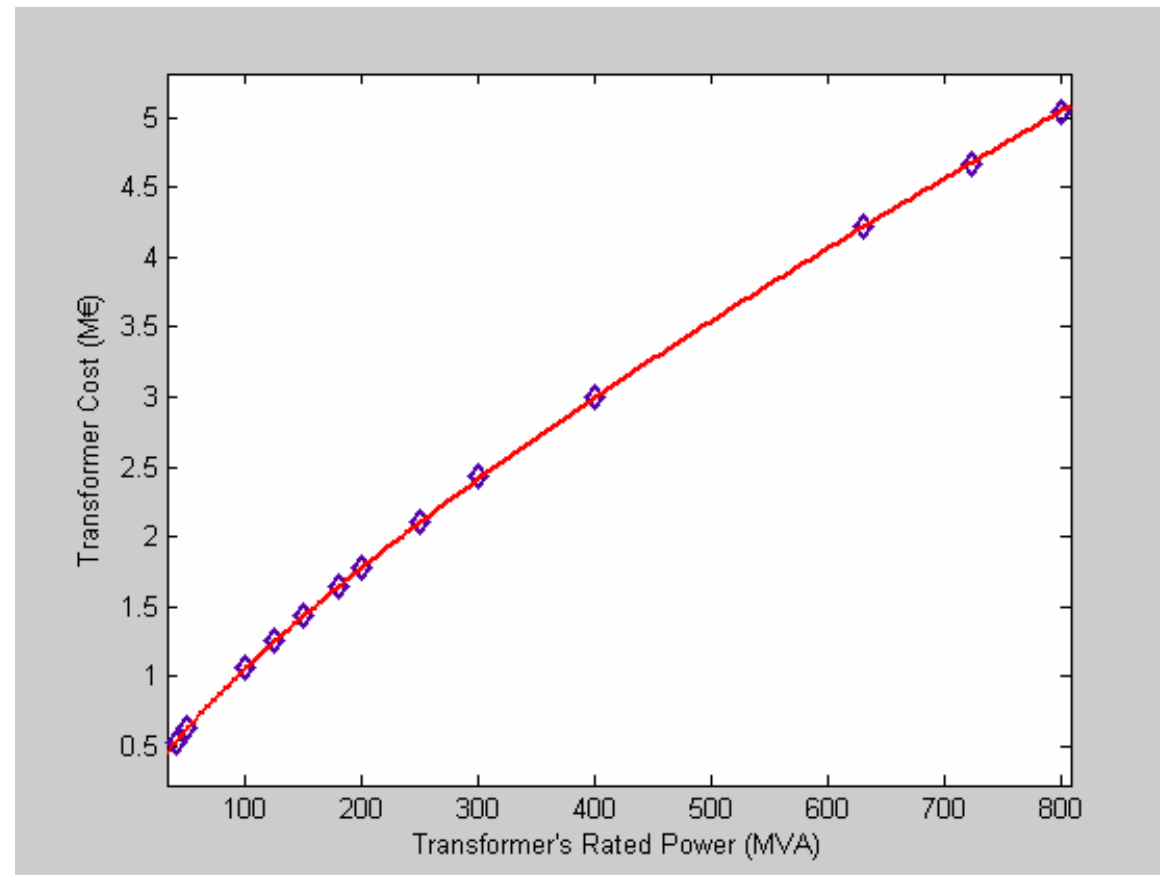
### ■ UK (average values):

- OHL single circuit, 400 kV 1200 k€/km
- OHL double circuit, 400 kV 1400 k€/km
- XLPE (underground) cable, 230 MVA, 132 kV 2100 k€/km
- XLPE (submarine) cable, 220 MVA, 132 kV 1500 k€/km
- XLPE (underground) cable, 360 MVA, 220 kV 2300 k€/km
- XLPE (submarine) cable, 360 MVA, 220 kV 1800 k€/km
- XLPE cable, 750 MVA, 400 kV 3800 k€/km

provisional data

# Transmission assets costs

Review of HVAC assets costs (average values):



(Source: KTH)

# Transmission assets costs

Review of HVAC assets costs (average values):

- Transformers 250 MVA, 400/220 kV 2.1 M€
- Transformers 400 MVA, 400/220 kV 3.0 M€
- Transformers 500 MVA, 400/220 kV 3.5 M€
- Reactive compensation (onshore) 20 k€/MVAR
- Reactive compensation (offshore) 28 k€/MVAR
- Switchgear, 132 kV 0.12 M€
- Switchgear, 220 kV 0.18 M€
- Switchgear, 400 kV 0.30 M€
- GIS Switchgear, 132 kV 0.40 M€
- GIS Switchgear, 220 kV 0.80 M€

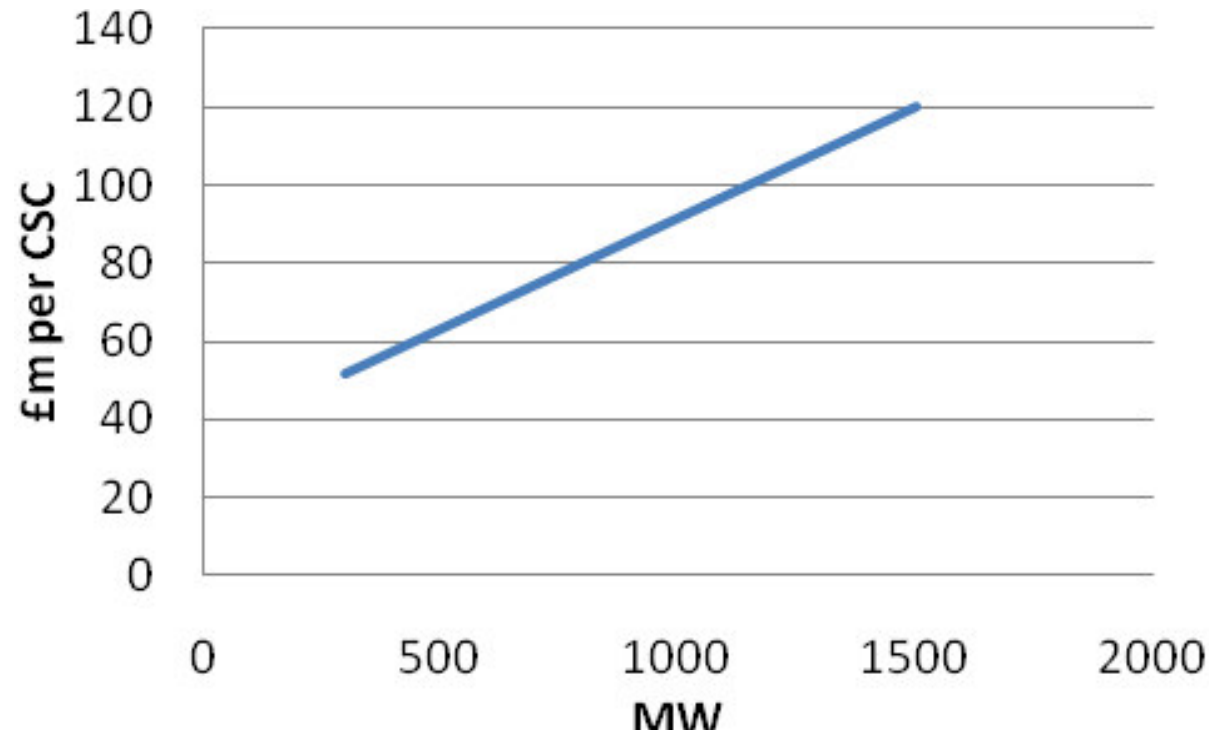
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# Transmission assets costs

Review of HVDC assets costs (average values):

- Current Source Converter (CSC)

$$\text{Cost [M€]} = 0.067 * P \text{ [MW]} + 33$$



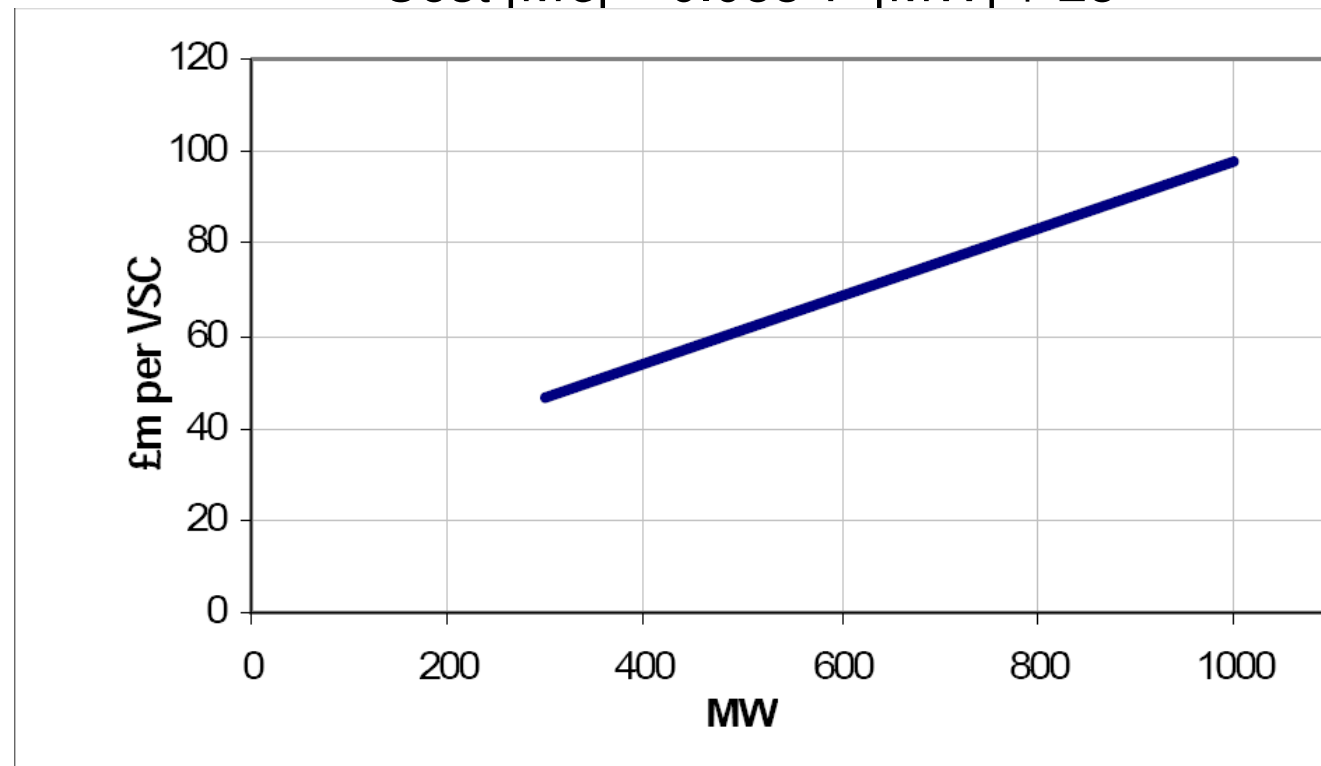
(Source: NGET)

# Transmission assets costs

Review of HVDC assets costs (average values):

- Voltage Source Converter (VSC)

$$\text{Cost [M€]} = 0.083 * P \text{ [MW]} + 28$$



(Source: NGET)

# Transmission assets costs

## Review of HVDC assets costs (average values):

- |   |            |
|---|------------|
| • XLPE (submarine) cable, 500 MW, $\pm 150$ kV    | 2600 k€/km |
| • XLPE (submarine) cable, 650 MW, $\pm 150$ kV    | 3400 k€/km |
| • XLPE (submarine) cable, 700 MW, $\pm 300$ kV    | 1900 k€/km |
| • XLPE (submarine) cable, 1000 MW, $\pm 300$ kV   | 2600 k€/km |
| • XLPE (submarine) cable, 1200 MW, $\pm 300$ kV   | 3200 k€/km |
| • XLPE (underground) cable, 600 MW, $\pm 300$ kV  | 1500 k€/km |
| • XLPE (underground) cable, 800 MW, $\pm 300$ kV  | 1800 k€/km |
| • XLPE (underground) cable, 1000 MW, $\pm 300$ kV | 2200 k€/km |
| • XLPE (underground) cable, 1200 MW, $\pm 300$ kV | 2500 k€/km |
| • OHL, $\pm 150$ kV                               | 830 k€/km  |
| • OHL, $\pm 300$ kV                               | 940 k€/km  |
| • OHL, $\pm 600$ kV                               | 1200 k€/km |

provisional data



# Transmission assets costs

- Recent/ongoing cross-border HVDC infrastructure projects:
  - East-West 1 IE-GB, 550 M€, 500 MW,  $\pm 200$  kV, 2x75 km DC underground cable, 2x186 km DC submarine cable
  - Fenno-Skan 2 FI-SE, 130 M€, 800 MW, 500 kV, 103 km DC OHL, 200 km DC submarine cable
  - NorNed NO-NL, 600 M€, 700 MW,  $\pm 450$  kV, 2x580 km DC submarine cable
  - Estlink 1 EE-FI, 110 M€, 350 MW,  $\pm 150$  kV, 2x31 km DC underground cable, 2x74 km DC submarine cable

## Next steps

- Completion of cost values collection (at Europe-wide level)
- Validation/contributions/feedback from TSOs
- Interaction with other WPs

# Thank you for the attention

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## REALISEGRID project

<http://realisegrid.erse-web.it/>