Grid Development and offshore meshed Infrastructure: Outlook on the TYNDP

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Drivers in European Grid Development

Objectives of EU networks:
- ensuring the development of a European grid to permit the 20-20-20 and 2030 goals
- guaranteeing security of supply completing the internal energy market
- Integrate RES

The 2030 targets:
- 40% cut in greenhouse gas emissions (1990)
- at least a 27% share of renewable energy consumption
- at least 27% energy savings

Interconnection targets:
- 10% by 2020;
- 15% by 2030 (import cap/production-cap)
Europe is divided into 6 Planning Regions
Transmission Planning in Europe

2 yrs
Scenario building
• Scenarios describe key factors of potential development in technology, economic growth, generation, demand, ….
• across several time horizons
• Combination of bottom-up and top-down scenarios

1 yr
Screening
• Identification of system needs (IoSN): (focus on capacity increases in transmission system)
• Based on: Socioeconomic welfare (SEW), Integration of renewables (RES) & Security of supply (SoS)
• Based on long term scenarios for 2040

1 yr
CBA
• Cost Benefit Analyses (CBA) of individual projects on mid term time horizon 2025 and 2030
• Also additional studies on e.g. Interconnection Targets and Impact of “No-Grid development” study

2040
Projects
2030

TSO
3PP
0,75 yr
TSO
3PP
TSO
3PP
TSO
3PP

TYNDP 2018
Identification of the System Needs - Scenarios

Scenario used in TYNDP18 process

Key factors:
- Transport
- Heating
- Power
- Renewable Gases
### Identification of the System Needs - Scenarios

#### 2040 scenarios – Key Indicators

<table>
<thead>
<tr>
<th>Key Indicators</th>
<th>GCA 2040</th>
<th>ST 2040</th>
<th>DG 2040</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transport</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric and hybrid vehicles</td>
<td>High growth</td>
<td>Moderate growth</td>
<td>Very high growth</td>
</tr>
<tr>
<td>Gas vehicles</td>
<td>High growth</td>
<td>Very high growth</td>
<td>Low growth</td>
</tr>
<tr>
<td><strong>Heating</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric heat pump</td>
<td>High growth</td>
<td>Low growth</td>
<td>Moderate growth</td>
</tr>
<tr>
<td>Hybrid heat pump</td>
<td>High growth</td>
<td>Moderate growth</td>
<td>Very high growth</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>Moderate growth</td>
<td>Low growth</td>
<td>Very high growth</td>
</tr>
<tr>
<td>Wind</td>
<td>High growth</td>
<td>Moderate growth</td>
<td>High growth</td>
</tr>
<tr>
<td>Solar</td>
<td>High growth</td>
<td>Moderate growth</td>
<td>Very high growth</td>
</tr>
<tr>
<td><strong>Renewable Gases</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power-to-gas</td>
<td>High growth</td>
<td>Not significant</td>
<td>High growth</td>
</tr>
<tr>
<td>Bio-methane</td>
<td>High growth</td>
<td>High growth</td>
<td>High growth</td>
</tr>
</tbody>
</table>
Identification of the System Needs - Scenarios

2040 scenarios – Electricity: Energy Mix

Scenarios create contrasted Country level results

RES share:
2030: 48-58%
2040: 65-81%

from: Scenario Report for Consultation, Oct 2017
Identification of the System Needs - Methodology

Main steps of the approach

- Identification of potential needs based on: marginal costs diff. and CAPEX of capacity incr.
- Check of economic efficiency

Market studies

- Identification of cross border and internal bottlenecks
- Update of costs of capacity increase

Network studies

- Integration of renewable generation (RES)
- Reduction of risk of SoS issue (SoS)
- Check of interconnection targets

Regional expert check

Main update compared to TYNDP 2016
Better balance between overall EU view and RGs specificity

Additional capacity increases don’t necessarily result in new infrastructure projects in TYNDP 2018
Many investments needed.

Submitted TYNDP18 projects

Challenged AC borders

Internal reinforcement needs

ST

DG

GCA

2040

Standard costs per 1 GW

RGNS Regional Investment Plan (RegIP) – details online: http://tyndp.entsoe.eu/
Identification of System Needs (IoSN) - Results 2040
Result of project Collection: TYNDP 2018 projects
– zoom Northern Seas Area -

Until 2030:

166 transmission projects in Europe
~ 60 in RGNS/ BS

15 storage projects in Europe
(12 pump storage, 3 CAES)
7 in RGNS/ BS

See interactive online map:
http://tyndp.entsoe.eu/

A click on the project links to each ‘project sheet’ and get detailed information plus CBA results
Overview of CBA indicators

Each project is investigated with:
- At least 3 market modelling tools and
- At least 2 grid modelling tools
- For 3 scenarios, with
  - 3 klimate-years per scenario
  - 8760 hours per year
2030 Northern Seas Offshore Grid infrastructure in TYNDP 2018

Key Figures:
- 20 individual projects develop into a global scheme
- Infrastructure costs of 14 - 27 bn €
- Socio-economic benefits of 1.3 - 2.4 bn € / yr
- Facilitates extra RES generation between 13.8 – 19.2 TWh/yr
- Reduces annual CO2 emissions between 7,500… 15,000 kt / yr

Northern Seas Offshore Grid Infrastructure

Wind Power to be integrated into the NSOG Region

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>ST 2030</th>
<th>DG 2030</th>
<th>EUCC 2030</th>
<th>ST 2040</th>
<th>DG 2040</th>
<th>GCA 2040</th>
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</thead>
<tbody>
<tr>
<td>Onshore wind (GW)</td>
<td>142</td>
<td>142</td>
<td>137</td>
<td>170</td>
<td>185</td>
<td>197</td>
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<tr>
<td>Offshore wind (GW)</td>
<td>24</td>
<td>59</td>
<td>59</td>
<td>40</td>
<td>86</td>
<td>86</td>
<td>127</td>
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</table>

Offshore Wind 40… 60 86… 127

2030 Northern Seas offshore grid infrastructure addressing RES- and Market integration

Source: TYNDP17 Insight report "North Seas Regional Planning"
# List of Projects ≤ 2030

**TYNDP 2018**

**Northern Seas Offshore Grid Infrastructure**

<table>
<thead>
<tr>
<th>Country/ies</th>
<th>Project ID</th>
<th>Project Name</th>
<th>Commission</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR, GB</td>
<td>25</td>
<td>IFA 2</td>
<td>2020</td>
<td>1000</td>
</tr>
<tr>
<td>FR, GB</td>
<td>153</td>
<td>France- Aldernay – Britain (FAB)</td>
<td>2022</td>
<td>1400</td>
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<tr>
<td>FR, GB</td>
<td>172</td>
<td>Electlink</td>
<td>2019</td>
<td>1000</td>
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<tr>
<td>BE, GB</td>
<td>74</td>
<td>Thames Estuary Cluster (NEMO)</td>
<td>2019</td>
<td>1000</td>
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<tr>
<td>BE, GB</td>
<td>121</td>
<td>Nautilus: 2nd link BE-UK</td>
<td>Earliest 2018</td>
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<td>FR, IE</td>
<td>107</td>
<td>Celtic Interconnector</td>
<td>2026</td>
<td>700</td>
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<tr>
<td>GB, NO</td>
<td>110</td>
<td>North Sea Link</td>
<td>2021</td>
<td>1400</td>
</tr>
<tr>
<td>GB, NO</td>
<td>190</td>
<td>NorthConnect</td>
<td>2022</td>
<td>1400</td>
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<tr>
<td>DE, NO</td>
<td>37</td>
<td>Nordlink</td>
<td>2020</td>
<td>1400</td>
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<tr>
<td>DKW, NL</td>
<td>71</td>
<td>Cobra Cable</td>
<td>2019</td>
<td>700</td>
</tr>
<tr>
<td>DKW, GB</td>
<td>167</td>
<td>Viking Link</td>
<td>2023</td>
<td>1400</td>
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<tr>
<td>FR, GB</td>
<td>247</td>
<td>Aquind Interconnector</td>
<td>2022</td>
<td>2000</td>
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<td>FR, GB</td>
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<td>2022</td>
<td>1400</td>
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<tr>
<td>GB, NL</td>
<td>260</td>
<td>New GB-NL Interconnector</td>
<td>2030</td>
<td>1000-2000</td>
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<tr>
<td>IE, GB</td>
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<td>Greenlink</td>
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<td>GB- NO</td>
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<td>Maali</td>
<td>2025</td>
<td>600</td>
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<td>BE</td>
<td>75</td>
<td>Modular OFG 1</td>
<td>2020</td>
<td>1000</td>
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<tr>
<td>BE</td>
<td>120 + 329</td>
<td>Modular OFG 2 + new onshore corridor</td>
<td>2030 + 2028</td>
<td>2000</td>
</tr>
<tr>
<td>GB DE</td>
<td>309</td>
<td>NeuConnect</td>
<td>2022</td>
<td>1400</td>
</tr>
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</table>

Source: TYNDP17 Insight report "North Seas Regional Planning"
Offshore Grid infrastructure in TYNDP 2016

25 individual projects develop into a global scheme

Infrastructure costs of 12 - 25 bn €

Socio-economic benefits of 2 - 3 bn € / yr

Wind power [GW] to be integrated in NSOG region

<table>
<thead>
<tr>
<th>Year</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4</th>
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<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2030</td>
<td>2030</td>
<td>2030</td>
</tr>
<tr>
<td>offshore</td>
<td>24.1</td>
<td>30.6</td>
<td>30.8</td>
<td>72.2</td>
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<tr>
<td>onshore</td>
<td>94.0</td>
<td>110.9</td>
<td>124.7</td>
<td>155.0</td>
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</tbody>
</table>

Source: TYNDP16 Insight report "North Seas Regional Planning"
Offshore Grid infrastructure in TYNDP 2014

Comparison between NSCOGI Grid study, TYNDP14 results & EC study, concluding:

- Northern Seas Offshore Grid Infrastructure will be composed of
  - various technologies (AC and DC)
  - Various designs:
    i. point-to-point interconnections (ICs)
    ii. Radial offshore wind connections (single of via hubs)
    iii. Hybrid projects (combination of offshore wind connection and IC)
    iv. Multiterminal offshore platforms combining interconnections.

- Modular and stepwise offshore grid development with choices based on case-by-case decisions, evaluating technical and economic parameters.
- Compact hybrid offshore design could be envisaged in cases where scheduling and technology required for ICs & wind connections match (DC/AC/voltage level ...).
Impact on Price Differences per Boundary

No Action

Reference Grid Projects (2027)

Avg. hourly marginal cost differences (€/MWh)
- Green: From 0 to 2
- Yellow: From 2 to 5
- Blue: From 5 to 10
- Red: From 10 to 15
- Black: More than 15

All projects until 2035
TYNDP 2018 projects

**Benefit**

- **48 - 58% RES share** of energy demand in 2030 … and 65 - 81 % until 2040

- **65 – 75% CO2 reduction**, compared to 1990 … and 80 – 90% until 2040

- **2 to 5 bn€ annual savings** in cost of el-production due to TYNDP projects in 2030 … and 3 til 14 €/MWh reduction in marginal production costs with optimal grid in 2040

**Until 2030:**

- 166 transmission projects
- 15 storage projects

**357 investments**, out of which

- 201 overhead lines
- 23 cables
- 67 subsea cables

114 bn € investments
Thanks!

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