SF6 phase out and the grid

TSO perspective: TSO 50Hertz as part of the Elia group

July 2023 | Frank Richter | Offshore
Introduction

- Electrical engineer
- Employed as an Asset Manger Offshore
- Member of CIGRE,
- Member of different standardization bodies national and international

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## 50Hertz at a glance

<table>
<thead>
<tr>
<th>Year</th>
<th>RE share of power consumption</th>
<th>Installed capacity</th>
<th>Power consumption</th>
<th>Revenue</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>~ 65%</td>
<td>65,306 MW</td>
<td>~ 97 TWh</td>
<td>€6.9 billion</td>
<td>1,594</td>
</tr>
<tr>
<td>2010</td>
<td>~ 25%</td>
<td>38,354 MW</td>
<td>~ 98 TWh</td>
<td>€5.6 billion</td>
<td>643</td>
</tr>
</tbody>
</table>

- Installed capacity:

- Power consumption: ~ 97 TWh (2022), ~ 98 TWh (2010)

- Revenue:
  - of which grid turnover: €2.5 billion (2022), €0.6 billion (2010)
Our transmission system

**50Hertz offshore circuit lengths in 2022***

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>Type</th>
<th>Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>220-AC</td>
<td>Kabel undersea cables</td>
<td>290</td>
</tr>
<tr>
<td>150-AC</td>
<td>Kabel undersea cables</td>
<td>290</td>
</tr>
</tbody>
</table>

**50Hertz onshore circuit lengths in 2022***

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>Type</th>
<th>Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>380-AC</td>
<td>Overhead lines</td>
<td>7,480</td>
</tr>
<tr>
<td>220-AC</td>
<td>Overhead lines</td>
<td>2,370</td>
</tr>
<tr>
<td>380-AC</td>
<td>Cables</td>
<td>55</td>
</tr>
<tr>
<td>400-DC</td>
<td>Cables</td>
<td>15</td>
</tr>
<tr>
<td>220-AC</td>
<td>Cables</td>
<td>3</td>
</tr>
</tbody>
</table>

In 2022, the transmission grid length of 50Hertz was over 10,500 km with ca. 90 substations

*Total values

111.8 TWh
50Hertz is the TSO in the north-east of Germany. Extra high voltage TSO (from 150 to 525 kV)

Facilitating the green energy transition, sustainability is at the core of our strategy.

We want to achieve 100% renewables in our grid by 2032.

We want to reduce SF$_6$ in new assets by 50% by 2030.
EU's electricity grid: Backbone of the clean energy transition

Facilitation of the energy transition

- Decarbonisation of industry & society
- Electrification of mobility, heating sector,…
- Integration of renewables

Role of system operators

Reliable operation, reinforcement and development of Europe's electricity Grid
Facts about $\text{SF}_6$ and electrical assets

Why are F-Gases used in the electricity grid?

- Electricity transmission and distribution system operators (TSOs and DSOs) use SF6 (sulphur hexafluoride) as an insulation and arc-quenching medium in electrical control- and switchgear.

SF6 special properties and handling

- Chemically reacts with very few substances
- Global warming potential (GWP) is 24,300
- Used and monitored in closed cycles (leakage < 1%)

Use in switchgear of The Grid

- APPROX. 500,000 SUBSTATIONS (10-380 KV) in Germany alone
- USED IN PLACES WITH LIMITED SPACE AND/OR DIFFICULT ENVIRONMENTS

The grid development and reinforcement projects of the next years require a substantial amount of new assets – therefore, alternatives are needed as swiftly as possible.
Switchgear in a nutshell (High Voltage >52kV)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Number* of CB needed by 2030</th>
<th>Total additional SF₆ volume in kg</th>
<th>Number* of IT needed by 2030</th>
<th>Total additional SF₆ volume in kg</th>
<th>Number* of GIS-Bays needed by 2030</th>
<th>Total additional SF₆ volume in kg</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>380kV</td>
<td>570</td>
<td>33,800</td>
<td>1200</td>
<td>72,000</td>
<td>75</td>
<td>120,000</td>
<td>91%</td>
</tr>
<tr>
<td>220kV</td>
<td>165</td>
<td>3,800</td>
<td>105</td>
<td>5,250</td>
<td>30</td>
<td>7,750</td>
<td>7%</td>
</tr>
<tr>
<td>110kV</td>
<td>250</td>
<td>2,000</td>
<td>400</td>
<td>1,360</td>
<td>25</td>
<td>2,060</td>
<td>2%</td>
</tr>
</tbody>
</table>

*estimated numbers for 50Hertz needs until 2030
Our conflict: Necessary grid expansion with simultaneous SF6 minimization by 2030

If all new equipment is installed with conventional SF6 technology, the amount of SF6 would double by 2030.

ACT NOW
FOR A SUSTAINABLE WORLD

Share of SF6-free solutions in new assets

- 50% until 2030

- Shifting away from SF6
- Continue to improve SF6 leakage management to remain well below 0.25%
Action plan for SF6 savings

**Savings by new assets**
- New assets with alternative gasses *as many as possible, as soon as possible*
- Define GIS & GIB, Instrument transformer and circuit breaker pilot projects
- Require lower leakage rate of new assets

**Savings through project design**
- Replace planned GIS 380kV substations by AIS solutions (if possible)
- Optimize GIB length
- For existing AIS keep AIS as much as possible until GIS alternatives gasses are available
- Systematic check of the CO$_2$ impact of different project options

**Savings through portfolio management**
- Postpone 380kV circuit breaker replacements until alternatives are available
- Postpone full scope EoL replacement projects until GIS with alternative gasses are available

**Savings through Maintenance**
- Better leakage follow-up on compartment level (via new software tool)
- Gas leakage monitoring for earlier leak detection
First Steps: pilot installations
SF6 free Circuit breaker

Vacuum with clean Air in different applications:

30 kV – Reactor switching
POC in construction phase (commissioning planned 08/2023)
Equipped with a system for measuring transient voltages

70 kV – Line switching
In service since 11/2021
Equipped with a fault recorder

110 kV-Transformer switching
POC in construction phase (commissioning planned 2024)
Equipped with a system for measuring transient voltages
First steps: pilot installations
SF6 free instrument transformers

Pilots installed in grids with different rated voltages

123 kV – Combined Instrument transformer / Clean Air
   POC in operation since 2022

380 kV – Combined Instrument transformer / Clean Air
   POC in construction phase
   Commissioning planned in 2024

123 kV – Voltage transformer / Clean air
   POC in operation since 12/2022

380 kV - NCIT / Nitrogen
   POC in operation since 04/2018
First steps: Pilot installations
SF6 free gasinsulated switchgear

Pilots with different solutions installed

123 kV – GIS with C4FN mixture
POC in Operation since 03/2021
Transformer connected via long cable

70 kV – GIS with clean air and vacuum
POC in construction phase
commissioning planned in 2024
Criteria for New assets

• Type tested acc. to IEC and fulfills our technical specifications

• Need for all new technologies in the mid term, especially in order to be able to realize our 2030 SF6 ambition and that a maximum of niche applications could be covered

• No implementation of an alternative solution with a risk of obsolete technology in the mid term. Long-term OEM support is needed in order to guarantee the LT security off supply of the network

• sufficient market availability: acceptable/plannable delivery times and delivery in sufficient quantities

• Comparison of the different solutions by TCO (total cost of ownership) analysis

• In the long-term aim is to use equipment with gases of natural origin
Thank you!