
European Network of
Transmission System Operators
for Electricity

# NORDIC AND BALTIC HVDC UTILISATION AND UNAVAILABILITY STATISTICS 2015

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REGIONAL GROUP NORDIC

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# 1 SUMMARY

This report presents the availability and utilisation of HVDC links connected to the Nordic power system in 2015, with an emphasis on disturbance outages.

This report presents methods and definitions and statistics for 2015: An overview of availability and utilisation for all links, a closer look on the disturbances and separate presentations of the performance of each HVDC link.

In 2015, 46.7 TWh of electric energy was transmitted through the Nordic HVDC links. 60 disturbance outages were registered, preventing 1.4 TWh of potential energy transmission. Approximately 70 % of the energy transmission lost due to disturbance outages was caused by one disturbance on Konti-Skan 1. This disturbance was caused by a transformer failure in Sweden which started in November 2014 and ended 24 April 2015.

Maintenance outages caused 2.0 TWh and limitations caused 1.6 TWh of reduced transmission capacity.

# 2 INTRODUCTION AND BACKGROUND

The total HVDC power transmission capacity connected to the Nordic power systems is 9190 MW. The majority of this capacity connects the Nordic synchronous system to other systems but Fenno-Skan 1 and Fenno-Skan 2 HVDC links connect Finland and Sweden as Figure 2.1 shows and provide the transmission capacity of 1200 MW.

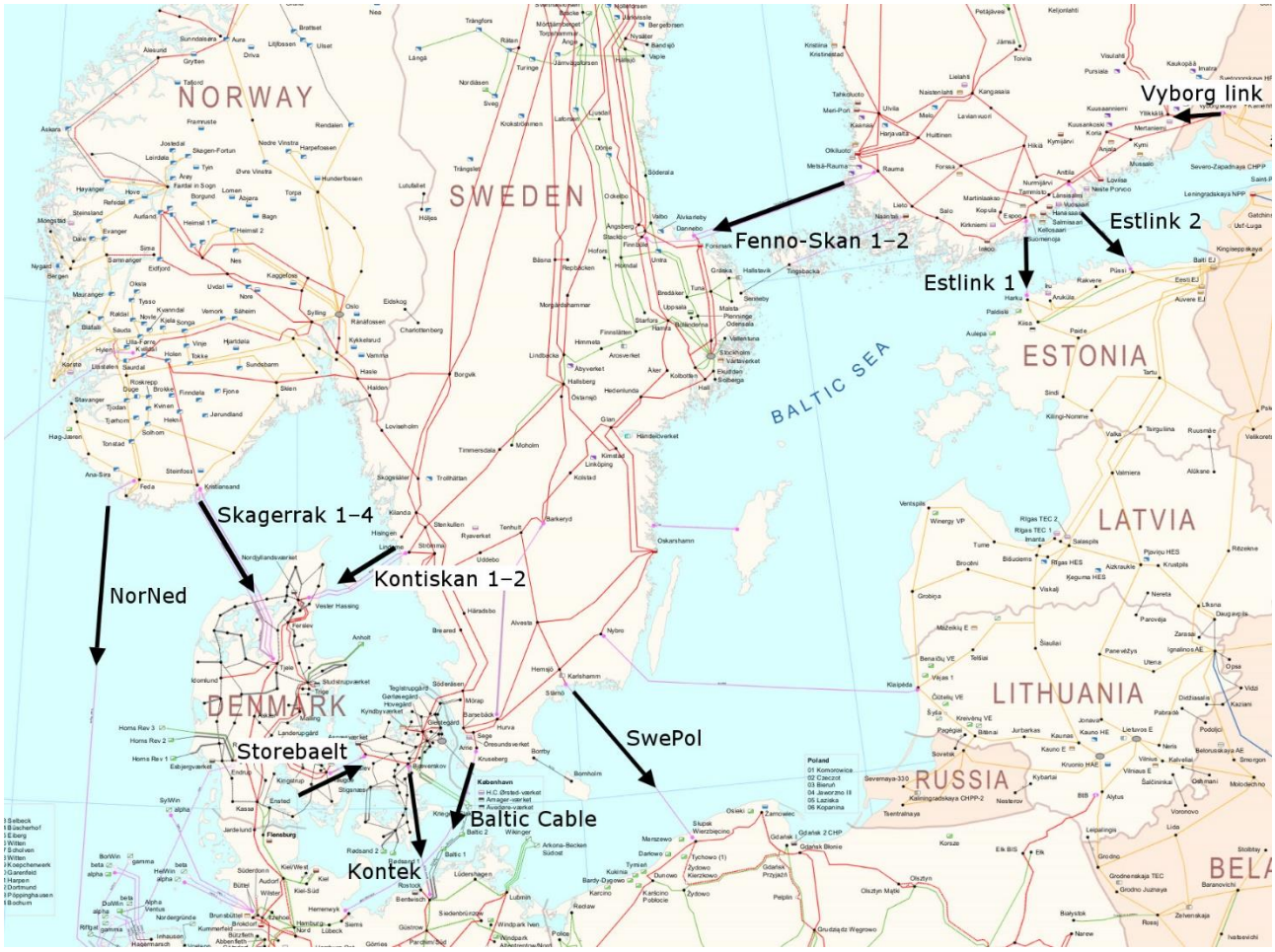


**FIGURE 2.1 PART OF THE NORDIC GRID MAP SHOWING THE HVDC LINKS [1]. THE ARROWS INDICATES THE DIRECTION OF EXPORT USED IN THIS REPORT.**

The total annual HVDC transmission capacity is 81 TWh, which makes HVDC links important components for the stable operation of the Nordic power system, and the essential infrastructure for commercial power trade in the European energy markets. Hence, the advantages of keeping HVDC links in operation as much of the time as possible are obvious.

Schematic presentations of the HVDC links and their converter stations, both for line commutated converters (LCC) and voltage source converters (VSC) are presented in Appendix A.

Disturbances do happen, but high quality hardware components, thorough installation routines, and fault analysis combined with preventive maintenance are means to limit the number of such unfortunate events. Planned outages and limitations due to maintenance work are necessary, but should be planned and conducted as efficient as possible. The result is more available capacity for energy transmission through HVDC links.

Therefore, mapping the available capacity, including the reasons for unavailability, is of vital interest for the utilisation of this infrastructure. Furthermore, the utilisation of the links is of interest in itself since this is the action that actually realizes the value through energy trade.

# 3 SCOPE

The scope of these statistics differs from the scope of the CIGRÉ HVDC statistics, which concentrate on the outages, faults and disturbances of the HVDC links, including the converter stations.

The main interest of this HVDC statistics is a macro view on the *availability* and *utilisation* of the HVDC links, including total outages and limitations. Disturbance outages are more thoroughly examined than other events.

The macro view of these statistics includes only links that were commissioned before the statistical year in question or were available for the electricity market the whole year.

## 3.1 CONTACT PERSONS

Each country is represented by at least one contact person, responsible for the statistical information of the corresponding country. The contact person can provide additional information concerning the HVDC availability and utilisation statistics. The relevant contact information is given in Appendix B.

# 4 METHODS, DEFINITIONS AND CALCULATIONS

This chapter explains the availability and utilisation categories of the HVDC statistics. Interesting details in the collected data will be emphasized.

The utilisation of HVDC link capacities can be calculated by using the data received from SCADA, grid operation, market departments, Urgent Market Messages (UMMs) of the Nord Pool Spot and measurements on each side of a link.

The process of collecting and sorting data for these statistics will be described in the guidelines of this report. This chapter describes how the collected data is defined and used in the calculations.

**The technical capacity ($E_{max}$)** of the HVDC link is the maximum energy that can be transmitted from the AC grid to the converter station on the exporting side, excluding all HVDC link losses, if there are no outages or limitations, the technical capacity is calculated:

$$E_{\max} = P_{\mathrm{R}} \cdot 24 \cdot d, \tag{4.1}$$

where $P_R$ is the rated power capacity and $d$ is the number of days in the reported time period (month or year). The column in Figure 4.1 describes the nine main categories of these statistics, as well as aggregated categories used for simplified presentations.

In Figure 4.1, technical capacity ($E_{max}$) is represented as the total height of the column. This section explains the mutual exclusivity and mathematical consistence of all categories used in the HVDC statistics.

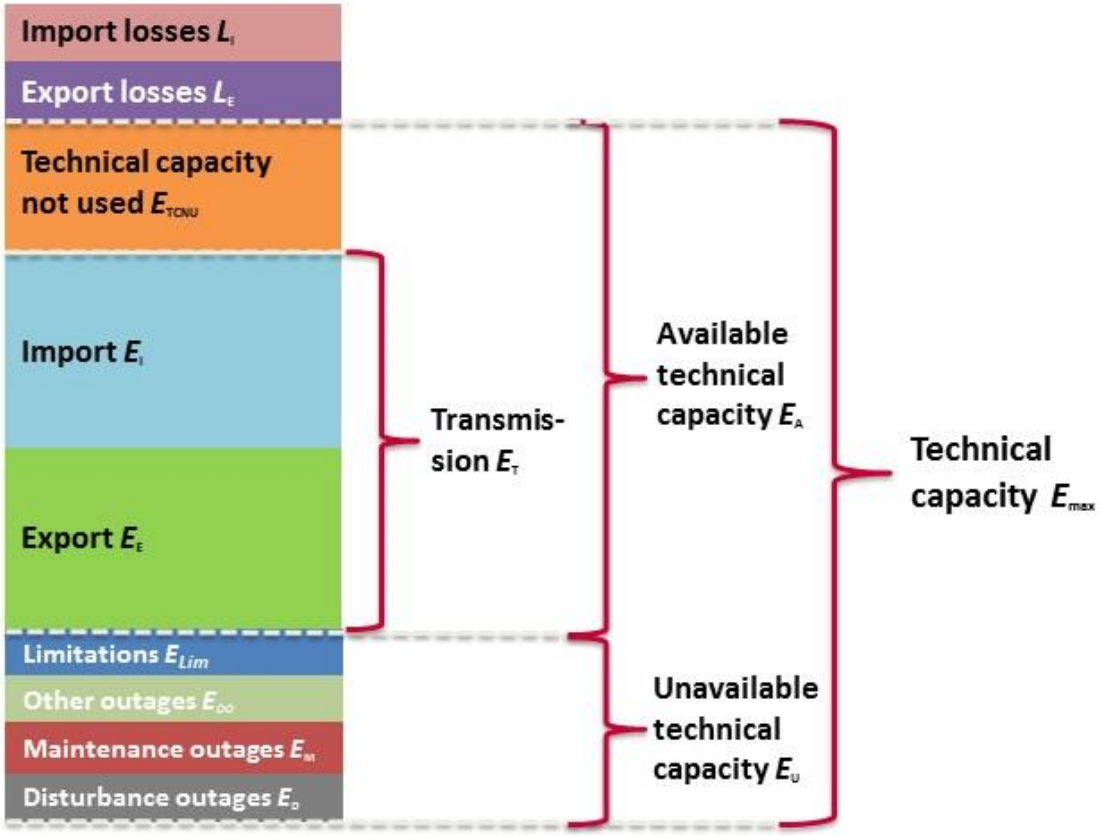


**FIGURE 4.1 THE AVAILABILITY AND UTILISATION CATEGORIES USED IN THE HVDC STATISTICS. THE DEFINITIONS AND CALCULATIONS ARE EXPLAINED IN CHAPTER 4. EVERY VALUE IS AN ENERGY VALUE AND REPRESENTS A PART OF THE AVAILABLE OR UNAVAILABLE TECHNICAL CAPACITY. THE NINE CATEGORIES OF THE COLUMN TO THE LEFT ARE INTERNALLY EXCLUSIVE AND THEIR SUM AMOUNTS TO THE TOTAL TECHNICAL CAPACITY.**

The technical capacity of the link is a theoretical value and can be divided into **available technical capacity ($E_A$) and unavailable technical capacity ($E_U$)**. The unavailable technical capacity $E_U$ is due to outages or limitations.

The capacity used for transmission ($E_T$) is the sum of exported and imported energy:

$$E_T = E_E + E_I, \tag{4.2}$$

where **Imported energy** (**$E_I$**) is the energy transferred from the HVDC link to the importing AC side. It does not include **import losses ($L_I$)**, i.e. the energy losses in any of the HVDC link components during import, which are calculated by subtracting the received energy from the transferred energy. **The exported energy ($E_E$)** and **export losses ($L_E$)** are explained likewise, with an opposite point of view. Exported energy $E_E$ from one side of the link equals imported energy $E_I$ considered from the opposite side of the link. It should be noted that these values are measurements and therefore considered factual.

An **outage** is when a component is partially or fully disconnected from the system and the transfer capacity is reduced to zero. There are different types of outages:

- **Disturbance outages ($E_D$)** are *total outages* due to a fault on the HVDC link or in the AC grid causing a *total outage* of the link. This could be a forced outage or an automatic trip.
- **Maintenance outages ($E_M$)** are *total outages* due to all technically motivated actions on the HVDC link or in the AC grid intended to retain an entity in, or restore it to, a state where it can perform its required function.
- **Other outages ($E_{OO}$)** are *total outages* due to any other reason except those mentioned above. This could be for example when the markets do not need the transmission capacity of the link and the link is disconnected.

The energy transfer made unavailable due to disturbance, maintenance and other outages are calculated by multiplying the **rated power ($P_R$)** by the **disturbance outage duration ($h_D$)**, **maintenance outage duration ($h_M$)**, and **other outage duration ($h_{OO}$)** in the following way:

$$E_{\mathrm{D}} = P_{\mathrm{R}} \cdot h_{\mathrm{D}}, \tag{4.3}$$

$$E_{\mathrm{M}} = P_{\mathrm{R}} \cdot h_{\mathrm{M}}, \tag{4.4}$$

$$E_{\mathrm{OO}} = P_{\mathrm{R}} \cdot h_{\mathrm{OO}}. \tag{4.5}$$

**A limitation ($E_{Lim}$)** is a condition when the transmission capacity of an HVDC link is limited, i.e. the power transmission capacity of the link is less than the rated power. The limitation is always motivated from a technical perspective, but not always concerning the link itself. The most common causes of limitations are:

- faults on any HVDC link component as long as they do not cause a total outage;
- faults, congestions or outages in the AC grid causing a limitation in the transmission capacity of the link;
- seasonal variations on the transmission capacity of the HVDC link;[1]
- link capacity reserved as power reserves.

Limitations lasting less than ten minutes should not be reported. In the scope of this statistics report, these limitations are too small to have an actual significance on the presented data. Hence, short ramping limitations and commutation failures are not cases included in this category.

Limitations are calculated by multiplying the **limited power capacity ($P_{Lim}$)** by the **duration of the limitation in hours ($h_{Lim}$)**:

$$E_{\mathrm{Lim}} = P_{\mathrm{Lim}} \cdot h_{\mathrm{Lim}}. \tag{4.6}$$

The limited power capacity ($P_{Lim}$) describes the amount of power reduced from the rated power.

[1] The transmission capacity of some links is limited during the summer season due to a decreased convection of heat from transmission losses. The full capacity is as rated by the manufacturer, and is given for all links in Table 5.1.

Now it is possible to define the mathematical description of the unavailable technical capacity ($E_U$) as the part of technical capacity that is *not* available for transmission due to outages (disturbance, maintenance, other) and limitations:

$$E_{\mathrm{U}} = E_{\mathrm{D}} + E_{\mathrm{M}} + E_{\mathrm{OO}} + E_{\mathrm{Lim}} = P_{\mathrm{R}}(h_{\mathrm{D}} + h_{\mathrm{M}} + h_{\mathrm{OO}}) + P_{\mathrm{Lim}} \cdot h_{\mathrm{Lim}}. \quad (4.7)$$

The counterpart to unavailable technical capacity ($E_U$) is the available technical capacity ($E_A$), which consists of the remaining of the technical capacity ($E_{max}$). The available technical capacity equals **the capacity used for transmission ($E_T$)** and **technical capacity not used $E_{TCNU}$**.

$$E_{\mathrm{A}} = E_{\mathrm{max}} - E_{\mathrm{U}} = E_{\mathrm{T}} + E_{\mathrm{TCNU}}. \quad (4.8)$$

**Technical capacity not used ($E_{TCNU}$)** can now be calculated:

$$\begin{aligned} E_{\mathrm{TCNU}} &= E_{\mathrm{max}} - E_{\mathrm{U}} - E_{\mathrm{T}} \\ &= E_{\mathrm{max}} - [P_{\mathrm{R}}(h_{\mathrm{D}} + h_{\mathrm{M}} + h_{\mathrm{OO}}) + P_{\mathrm{Lim}} \cdot h_{\mathrm{Lim}}] - [E_{\mathrm{E}} + E_{\mathrm{I}}]. \end{aligned} \quad (4.9)$$

However, there is an exception when calculating the technical capacity not used. If the **transmission ($E_T$)** and **unavailable technical capacity ($E_U$)** equals more than 90 % of the total **technical capacity ($E_{max}$)**, then all of the remaining capacity is categorised as **limitations ($E_{Lim}$)**. If this is not the case, no limitations are recorded and the remaining capacity is categorised as **technical capacity not used ($E_{TCNU}$)**. That is:

$$\begin{aligned} E_{\mathrm{Lim}} &= E_{\mathrm{max}} - E_{\mathrm{D}} - E_{M} - E_{OO} - E_{\mathrm{T}}, \qquad if\ E_{max} \cdot 0.9 \leq E_T + E_U \\ E_{TCNU} &= E_{\mathrm{max}} - E_{\mathrm{D}} - E_{M} - E_{OO} - E_{\mathrm{T}}, \qquad otherwise. \end{aligned} \quad (4.10)$$

Technical capacity not used ($E_{TCNU}$) and limitations ($E_{Lim}$) are what remains when all other categories are mapped and calculated. The content of this category is complex and consists of both technical and market related details. The most important of these are:

- When bidding differences between the markets on each side of the HVDC link are too small to promote transmission, in spite of technical availability. The link is still available and can be used for balancing or transmitting emergency power, and hence not disconnected.
- Any limitations lasting less than ten minutes (does not include total outages):
  - Ramping time: When the power flow is changed the capacity is fully released to the market. Note that, depending on the type of converter technology, the nominal voltage, and hence the full transmission capacity, may not be obtained immediately.
  - Commutation failures may interrupt the power transmission. In the CIGRÉ statistics, commutation failures are categorized as 'transient disturbances'.
  - Emergency power is not usually used for more than ten minutes for a given event. Longer lasting disturbances will be registered as outages or limitations.

# 5 TECHNICAL DETAILS OF THE HVDC LINKS

Table 5.1 presents the main properties of the HVDC links while Table 5.2 presents the technical properties of the HVDC lines. The defined export directions are also presented in Figure 2.1.

**TABLE 5.1 MAIN PROPERTIES OF THE HVDC LINKS**

| Name of the link | Commissioning year | Market connection (Y/N) | Type of HVDC converter | Rated power, mono-polar (MW) | Parallel monopolar capacity (MW) | Bipolar capacity (MW) | Defined export direction (N–S, E–W) |
|---|---|---|---|---|---|---|---|
| Baltic Cable | 1994 | Y | LCC | 600 | | | N–S |
| Estlink 1 | 2006 | Y | VSC | 350 | 1000 | | N–S |
| Estlink 2 | 2014 | Y | LCC | 650 | | | N–S |
| Fenno-Skan 1 | 1989 | Y | LCC | 400 | 1200 | 1200 | E–W |
| Fenno-Skan 2 | 2011 | Y | LCC | 800 | | | E–W |
| Kontek | 1986 | Y | LCC | 600 | | | N–S |
| Konti-Skan 1 | 2008 | Y | LCC | 370 | 740 | | E–W |
| Konti-Skan 2 | 1988 | Y | LCC | 370 | | | E–W |
| NorNed | 2008 | Y | LCC | 700 | | | N–S |
| Skagerrak 1 | 1976–1977 | Y | LCC | 250 | 1000 | 1000 | N–S |
| Skagerrak 2 | | Y | LCC | 250 | | | N–S |
| Skagerrak 3 | 1993 | Y | LCC | 500 | | | N–S |
| Skagerrak 4 | 2014 | Y | VSC | 700 | | | N–S |
| Storebaelt | 2010 | Y | LCC | 600 | | | E–W |
| SwePol | 2000 | Y | LCC | 600 | | | N–S |
| Vyborg Link | 1981, 1982, 1984, 2000 | | LCC | 1300 | | | E–W |

**TABLE 5.2 TECHNICAL DETAILS OF THE HVDC LINES**

| Name of the link | Total length of the link (km) | Length of mass cable (km) | Length of PEX cable (km) | Length of DC overhead line (km) | Length of DC back-to-back connection (km) |
|---|---|---|---|---|---|
| Baltic Cable | 262 | 250 | | 12 | |
| Estlink 1 | 105 | | 210 (2 × 105 km) | | |
| Estlink 2 | 171 | 157 | | 14 | |
| Fenno-Skan 1 | 233 | 200 | | 33 | |
| Fenno-Skan 2 | 299 | 196 | | 103 | |
| Kontek | 160 | | 160 | | |
| Konti-Skan 1 | 150 | 89 | | 61 | |
| Konti-Skan 2 | 150 | 89 | | 61 | |
| NorNed | 580 | 580 | | | |
| Skagerrak 1 | 212.5 | 133.6 | | 78.5 | |
| Skagerrak 2 | 211.4 | 132.9 | | 78.5 | |
| Skagerrak 3 | 212.9 | 134.4 | | 78.5 | |
| Skagerrak 4 | 226 | 226 | | | |
| Storebaelt | 57 | | 57 | | |
| SwePol | 254 | 254 | | | |
| Vyborg Link | < 1 | | | | < 1 |

# 6 PRESENTATION OF THE RESULTS FOR 2015

## 6.1 INTRODUCTION

During 2015 there were 60 disturbance outages affecting the HVDC links connected to the Nordic power system. The disturbances caused a capacity reduction that corresponds to 1.4 TWh (1.7 %) of the total technical HVDC transmission capacity.

Maintenance outages amounted to 2.0 TWh (2.5 %), and limitations reduced the transmission capacity by 1.6 TWh (2.0 %) of the total technical HVDC transmission capacity.

Section 6.2 provides an overview of the HVDC links and Section 6.3 presents the availability and utilisation of each HVDC link. The unavailable technical capacity ($E_U$) due to disturbance outages, the origins that triggered the events, and the performance of all the HVDC links connected to the Nordic power system in 2015 are presented and explained.

## 6.2 OVERVIEW

Figure 6.2.1 presents the overview of the availability and utilisation of HVDC statistics at an aggregated level. This enables a comparison between the connections. It should be noted that the usages of the links show big variations. Most links are market dependent, some are mostly used only in one direction, and some are used for technical reasons to control power flow for system stability according to agreements.

Appendix C shows the overviews of the HVDC links using the same values as Figure 6.2.1 but ranked according to the highest unavailable technical capacity, according to the highest transmission, and according to the highest technical capacity not used.

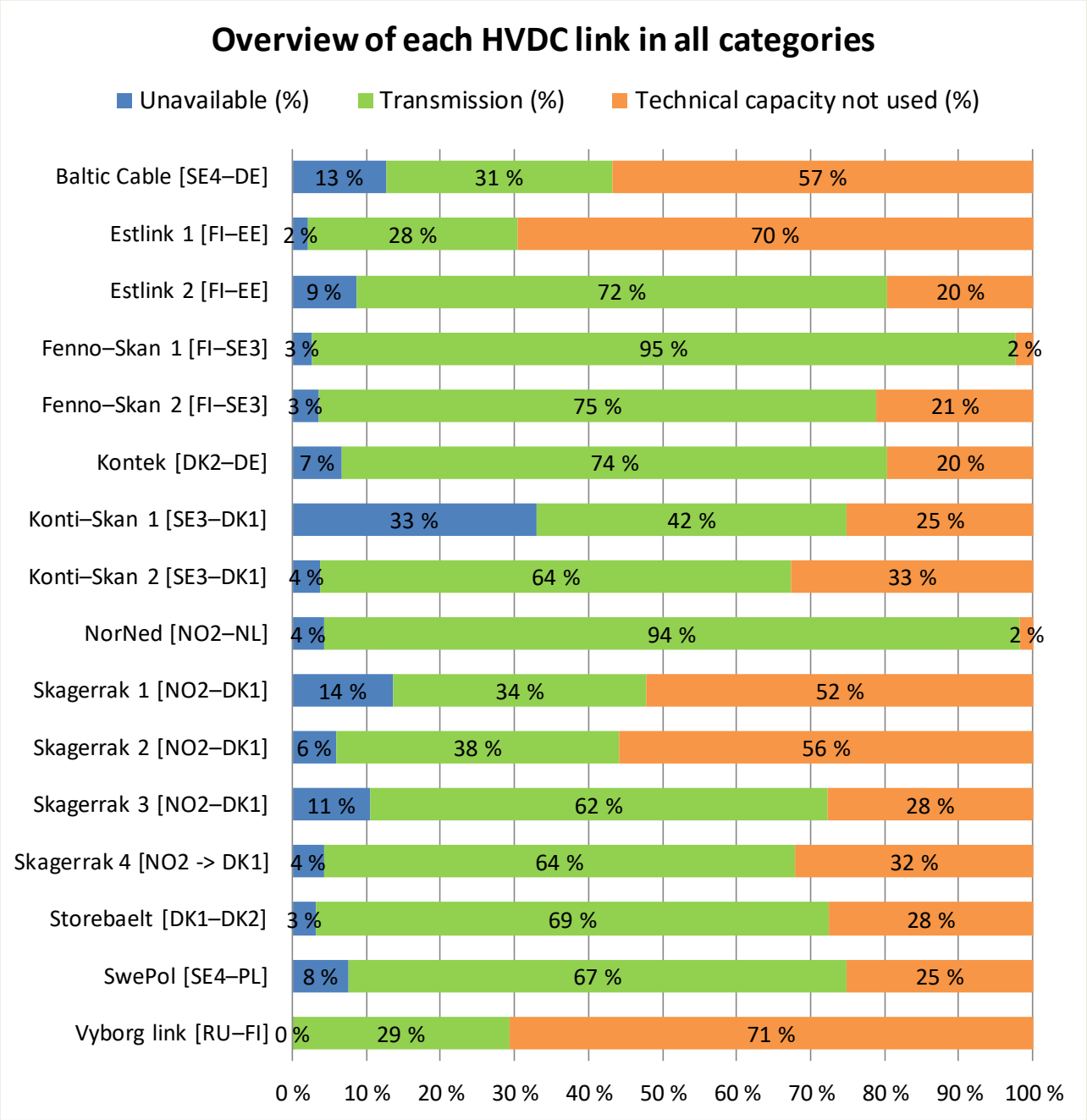


**FIGURE 6.2.1 ANNUAL OVERVIEW OF THE AVAILABILITY AND UTILISATION OF EACH HVDC LINK IN 2015. THE CATEGORIES USED REFER TO THE METHODS, DEFINITIONS AND CALCULATIONS DEFINED IN CHAPTER 4.**

Figure 6.2.2 presents the percentage unavailable technical capacity ($E_U$) of the annual technical capacity ($E_{max}$) due to the disturbance outages. The comments are added below the figure.

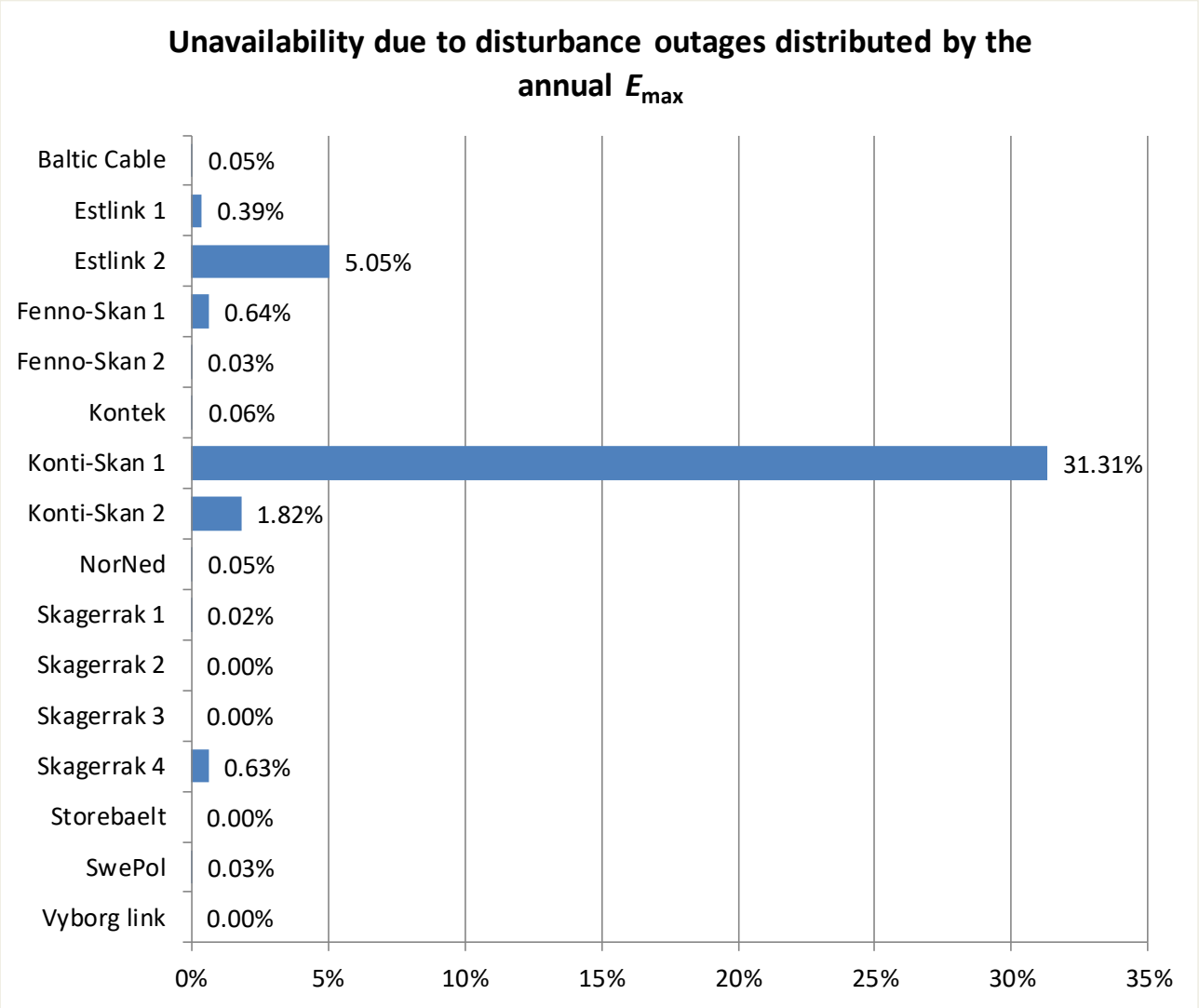


**FIGURE 6.2.2 PERCENTAGE DISTRIBUTION OF UNAVAILABLE TECHNICAL CAPACITY $E_U$ DUE TO DISTURBANCE OUTAGES FOR EACH LINK IN 2015**

1) On 11 November 2014, Konti-Skan 1 had a transformer fault. The outage caused by the fault lasted to 24 April 2015. This transformer fault was the main cause for unavailability.
2) Estlink 2 had a cooling system leakage on 30 April, which caused an outage that lasted 18 days.

Figure 6.2.3 presents the number of all outages and limitations for each link.

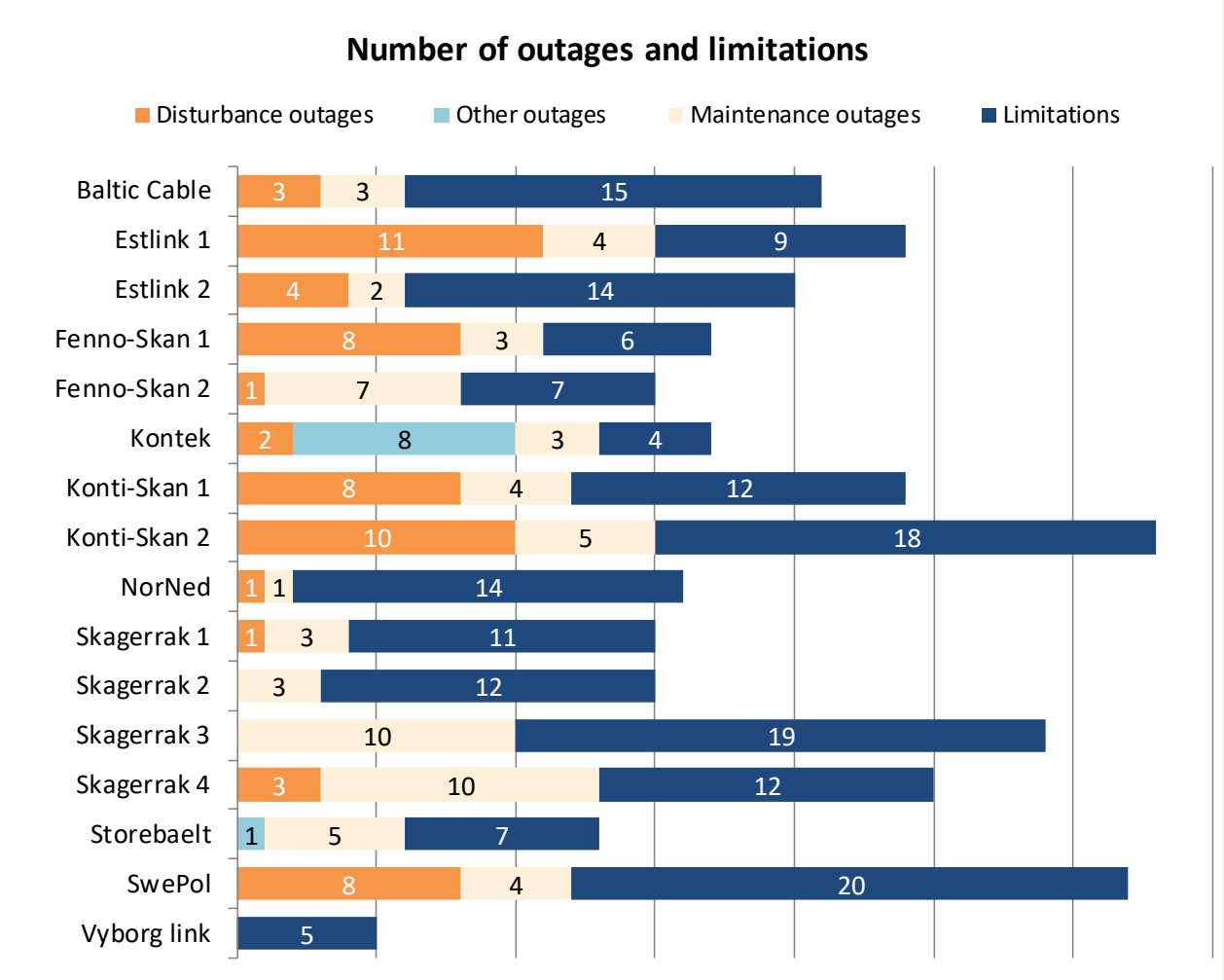


**FIGURE 6.2.3 THE NUMBER OF OUTAGES AND LIMITATIONS FOR EACH LINK IN 2015**

## 6.3 INDIVIDUAL PRESENTATIONS OF ALL LINKS

This section presents the performance of each HVDC link. The categories used in the following presentations of each separate HVDC link are presented and defined in Chapter 4.

Note that the sums in the tables for each link may show a technical capacity $E_{max}$ higher than the $E_{max}$ stated in the diagram. This is due to power flow over the rated technical power capacity of the links. Other times, when power flow is under the rated technical capacity (and there is no limitation reported), the difference is registered in the category 'technical capacity not used'.

## 6.3.1 BALTIC CABLE

Figure 6.3.1 presents the availability and utilisation of Baltic Cable for 2015. Baltic Cable is connected between southern Sweden (bidding zone SE4) and Germany (bidding zone DE-TenneT). The operations started in 1994 and the transmission capacity is 600 MW.

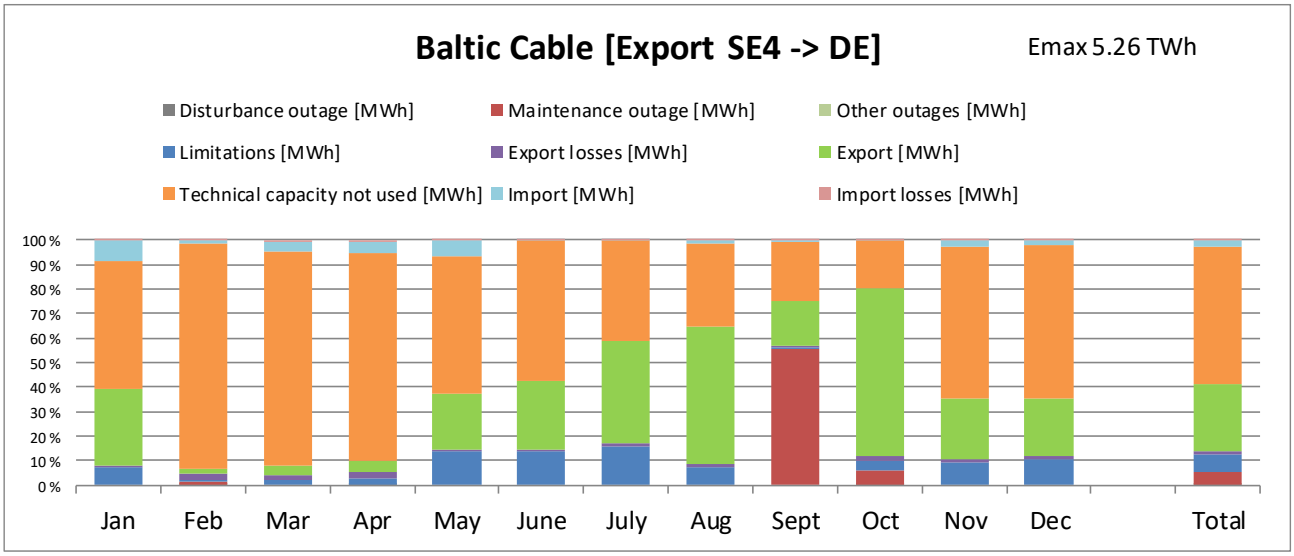


**FIGURE 6.3.1 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR THE BALTIC CABLE IN 2015**

Baltic Cable had an available technical capacity of 87 %. The technical capacity not used was 56 %. Totally, 1.5 TWh (28 % of the technical capacity) was exported from Sweden to Denmark and 144 GWh (2.7 % of the technical capacity) was imported to Sweden. Table 6.1 presents the numerical values behind Figure 6.3.1.

The annual maintenance outages lasted 18 days in September. Baltic Cable had three minor disturbances during year 2015.

**TABLE 6.1 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR THE BALTIC CABLE IN 2015**

| Baltic Cable [SE4 -> DE] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 766 | 1194 | 3125 | 3322 | 582 | 8 | 23 | 136 | 55 | 39 | 266 | 178 | 0.2 |
| Export losses [MWh] | 4157 | 9538 | 6766 | 10936 | 3940 | 4523 | 5302 | 6218 | 2598 | 7585 | 5180 | 4818 | 1.4 |
| Technical capacity not used [MWh] | 237019 | 380340 | 398864 | 378831 | 252073 | 252364 | 184631 | 155155 | 106589 | 87589 | 272137 | 284573 | 56.8 |
| Import [MWh] | 36897 | 6131 | 18108 | 21299 | 29673 | 377 | 846 | 6325 | 2684 | 1994 | 11175 | 8154 | 2.7 |
| Export [MWh] | 140257 | 7478 | 19486 | 22589 | 102955 | 120734 | 188983 | 252174 | 78751 | 313226 | 108966 | 106941 | 27.8 |
| Limitations [MWh] | 32694 | 3014 | 9940 | 10353 | 61903 | 58685 | 72368 | 33630 | 4209 | 19971 | 40034 | 47020 | 7.5 |
| Disturbance outage [MWh] | 0 | 360 | 0 | 910 | 0 | 0 | 0 | 0 | 0 | 1555 | 0 | 0 | 0.1 |
| Maintenance outage [MWh] | 0 | 5877 | 0 | 0 | 0 | 0 | 0 | 0 | 240000 | 23972 | 0 | 0 | 5.1 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (600 MW)** | 446867 | 403200 | 446399 | 433981 | 446604 | 432160 | 446828 | 447284 | 432233 | 448305 | 432312 | 446688 | 101.5 |

## 6.3.2 ESTLINK 1

Figure 6.3.2 presents the availability and utilisation of Estlink 1 for 2015. Estlink 1 has been in operation since 2006 and is the first HVDC connection between Finland and Estonia. In Finland (bidding zone FI) it is connected to Espoo substation and in Estonia (bidding zone EE) it is connected to Harku substation. The transmission capacity is 350 MW.

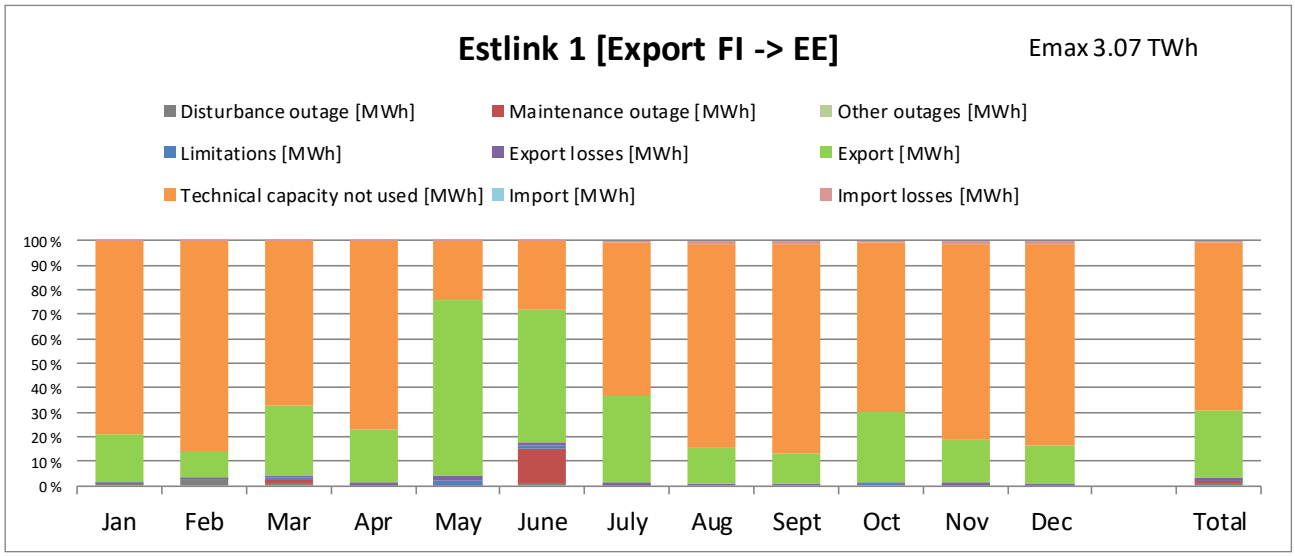


**FIGURE 6.3.2 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR ESTLINK 1 IN 2015**

In 2015, Estlink 1 had an available technical capacity of 98 %. The technical capacity not used was 70 %. Totally, 864 GWh (28 % of the technical capacity) was exported from Finland to Estonia and none was imported to Finland. Table 6.2 presents the numerical values behind Figure 6.3.2.

The annual maintenance outage lasted three days in June. There were 11 minor disturbance outages on Estlink 1.

**TABLE 6.2 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR ESTLINK 1 IN 2015**

| Estlink 1 [FI -> EE] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 249 | 659 | 334 | 189 | 1080 | 44 | 1853 | 3182 | 3385 | 2732 | 3164 | 3421 | 0.7 |
| Export losses [MWh] | 2084 | 1355 | 2811 | 2345 | 4148 | 3629 | 3362 | 2186 | 1765 | 2911 | 2156 | 2077 | 1.0 |
| Technical capacity not used [MWh] | 207629 | 204097 | 176999 | 195538 | 63212 | 72706 | 167477 | 220260 | 219868 | 182740 | 205441 | 219046 | 69.6 |
| Import [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Export [MWh] | 50661 | 24958 | 74897 | 55859 | 191606 | 138113 | 92486 | 40140 | 32132 | 76844 | 45826 | 40861 | 28.2 |
| Limitations [MWh] | 343 | 271 | 1522 | 603 | 4660 | 3241 | 437 | 0 | 0 | 1166 | 733 | 493 | 0.4 |
| Disturbance outage [MWh] | 1767 | 5874 | 1289 | 0 | 922 | 1983 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 |
| Maintenance outage [MWh] | 0 | 0 | 5343 | 0 | 0 | 35957 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| $P_r$ (350 MW) | 260400 | 235200 | 260050 | 252000 | 260400 | 252000 | 260400 | 260400 | 252000 | 260750 | 252000 | 260400 | 101.7 |

## 6.3.3 ESTLINK 2

Figure 6.3.2 presents the availability and utilisation of Estlink 2 for 2015. Estlink 2 was commissioned in Feb 2014 but was available for the market during the test period 6 dec 2013 – 6 Feb 2014. During this period the link was already available for the electricity markets. Estlink 2 is the second HVDC connection between Finland and Estonia. In Finland (bidding zone FI) it is connected to Anttila substation and in Estonia (bidding zone EE) it is connected to Püssi substation. The transmission capacity is 650 MW.

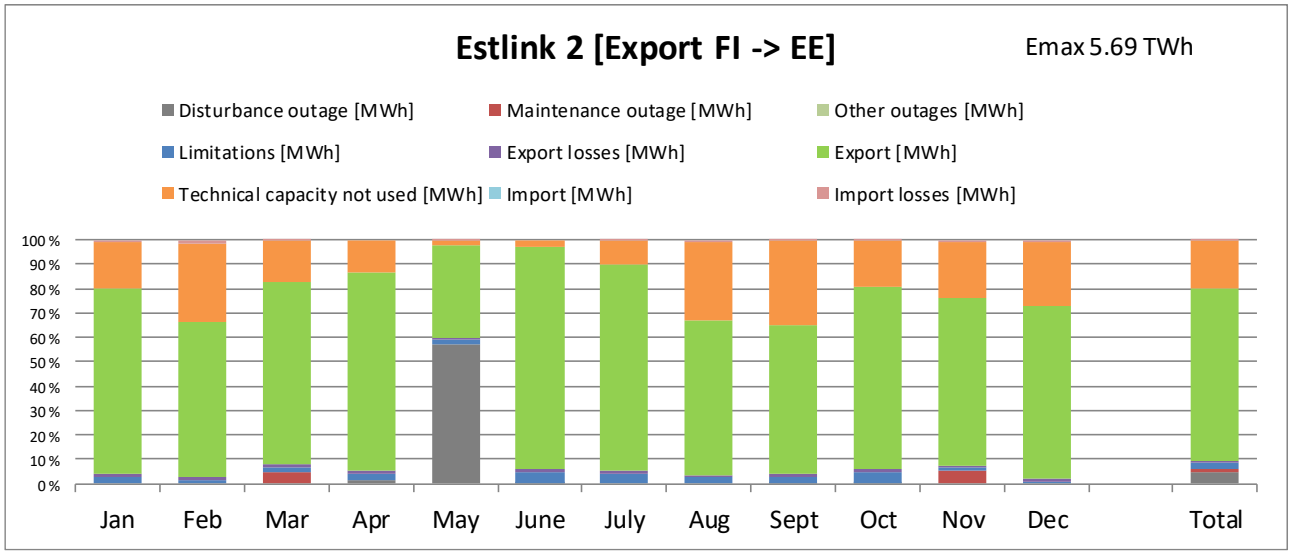


**FIGURE 6.3.3 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR ESTLINK 2 IN 2015**

In 2015, Estlink 2 had an available technical capacity of 91 %. The technical capacity not used was 20 %. Totally, 4.1 TWh (72 % of the technical capacity) was exported from Finland to Estonia and none was imported to Finland. Table 6.3 presents the numerical values behind Figure 6.3.3.

There were 4 disturbance outages on Estlink 2. All of them were minor except one in May which lasted 18 days. It was caused by a leakage in the valve cooling system which subsequently caused a flashover on the cable conduits.

Estlink 2 had two maintenance outages: one in March and one in November.

**TABLE 6.3 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR ESTLINK 2 IN 2015**

| Estlink 2 [FI -> EE] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 2751 | 5458 | 489 | 0 | 0 | 0 | 238 | 4739 | 475 | 1296 | 4103 | 5950 | 0.4 |
| Export losses [MWh] | 6020 | 6055 | 7085 | 5554 | 2303 | 5557 | 5133 | 4631 | 5292 | 5153 | 5222 | 6040 | 1.1 |
| Technical capacity not used [MWh] | 94709 | 146320 | 85090 | 61978 | 9481 | 14887 | 48264 | 158210 | 165849 | 94224 | 108626 | 129072 | 19.6 |
| Import [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Export [MWh] | 376065 | 282764 | 364800 | 386382 | 185514 | 429603 | 414801 | 312181 | 289135 | 366801 | 328215 | 351647 | 71.8 |
| Limitations [MWh] | 12828 | 7716 | 9200 | 13328 | 11133 | 22921 | 20535 | 13209 | 11944 | 21431 | 7028 | 2881 | 2.7 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 6381 | 277474 | 590 | 0 | 0 | 1072 | 1794 | 0 | 0 | 5.0 |
| Maintenance outage [MWh] | 0 | 0 | 23877 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24131 | 0 | 0.8 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (650 MW)** | 483602 | 436801 | 482967 | 468069 | 483603 | 468001 | 483600 | 483600 | 468000 | 484250 | 468002 | 483600 | 101.6 |

## 6.3.4 FENNO-SKAN 1

Figure 6.3.4 presents the availability and utilisation of Fenno-Skan 1 for 2015. Fenno-Skan 1 has been in operation since 1989 and is the first HVDC connection between Finland and Sweden. In Finland (bidding zone FI) Fenno-Skan 1 is connected to Rauma and in Sweden to Dannebo (bidding zone SE3). The transmission capacity used to be 500 MW during summer and 550 MW during winter but was decreased to 400 MW due to a cable issue for the year 2015.

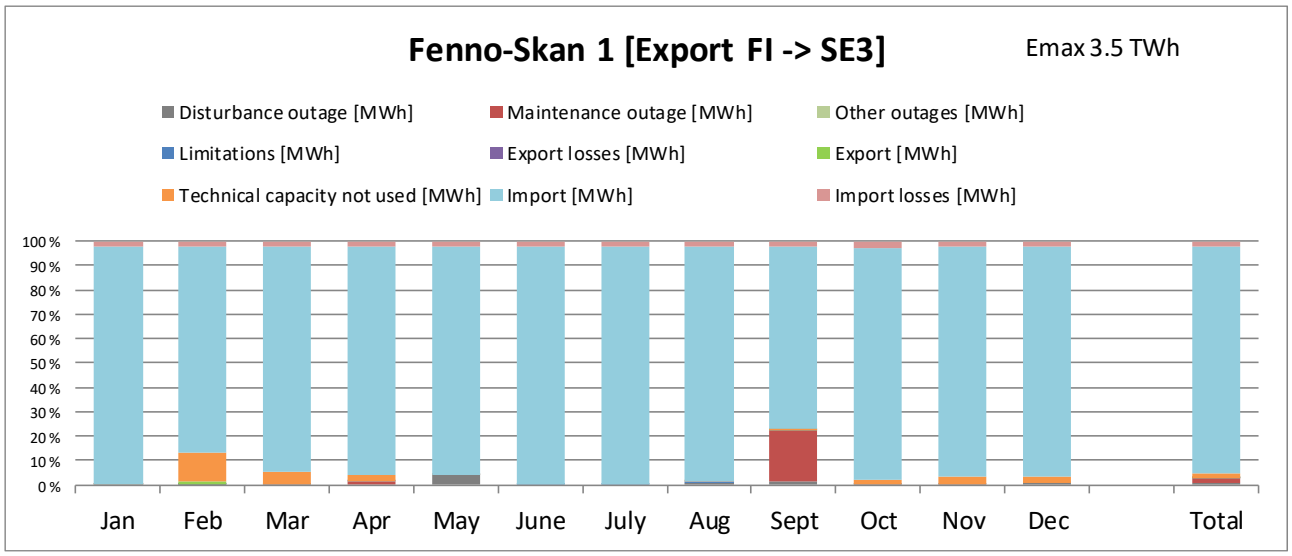


**FIGURE 6.3.4 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR FENNO-SKAN 1 IN 2015**

In 2015, Fenno-Skan 1 had an available technical capacity of 97 %. The technical capacity not used was 2.3 %. Totally, 3.8 GWh (0.1 % of the technical capacity) was exported from Finland to Sweden and 3.3 TWh (95 % of the technical capacity) was imported to Finland. Table 6.4 presents the numerical values behind Figure 6.3.4.

Fenno-Skan 1 had 8 disturbances in 2015 which caused only minor outages. The annual maintenance outage was between 21–27 September.

**TABLE 6.4 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR FENNO-SKAN 1 IN 2015**

| Fenno-Skan 1 [FI -> SE3] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 7709 | 6001 | 7663 | 7291 | 7552 | 7232 | 7397 | 7203 | 5669 | 7758 | 7449 | 7458 | 2.5 |
| Export losses [MWh] | 0 | 111 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0.0 |
| Technical capacity not used [MWh] | 766 | 31815 | 15477 | 8596 | 974 | 0 | 0 | 1029 | 909 | 6016 | 9795 | 6783 | 2.3 |
| Import [MWh] | 297712 | 232981 | 281758 | 276656 | 285552 | 288661 | 298316 | 293833 | 221160 | 292653 | 278453 | 288362 | 95.0 |
| Export [MWh] | 0 | 3830 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0.1 |
| Limitations [MWh] | 26 | 174 | 766 | 36 | 173 | 1 | 3 | 12 | 5 | 263 | 468 | 132 | 0.1 |
| Disturbance outage [MWh] | 0 | 612 | 0 | 0 | 11834 | 0 | 0 | 3412 | 3685 | 0 | 0 | 3029 | 0.6 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 3597 | 0 | 0 | 0 | 0 | 62767 | 0 | 0 | 0 | 1.9 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (400 MW)** | 298504 | 269411 | 298001 | 288885 | 298533 | 288661 | 298319 | 298286 | 288528 | 298931 | 288717 | 298306 | 100.0 |

## 6.3.5 FENNO-SKAN 2

Figure 6.3.5 presents the availability and utilisation of Fenno-Skan 2 for 2015. Fenno-Skan 2 has been in operation since 2011 and is the second HVDC connection between Finland and Sweden. In Finland (bidding zone FI) Fenno-Skan 2 is connected to Rauma and in Sweden to Finnböle (bidding zone SE3). The transmission capacity is 800 MW.

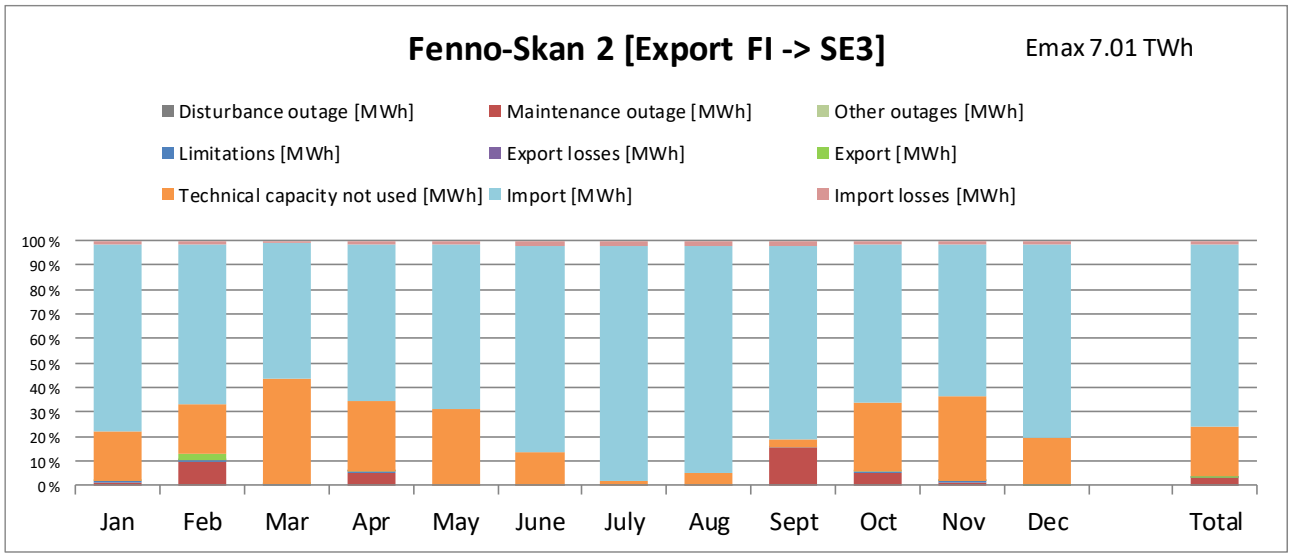


**FIGURE 6.3.5 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR FENNO-SKAN 2 IN 2015**

In 2015, Fenno-Skan 2 had an available technical capacity of 97 %. The technical capacity not used was 21 %. Totally, 19 GWh (0.3 % of the technical capacity) was exported from Finland to Sweden and 5.3 TWh (75 % of the technical capacity) was imported to Finland. Table 6.5 presents the numerical values behind Figure 6.3.5.

Fenno-Skan 1 had only 1 disturbance outage. The annual maintenance outage was between 26 September and 2 October.

**TABLE 6.5 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR FENNO-SKAN 2 IN 2015**

| Fenno-Skan 2 [FI -> SE3] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 9931 | 7646 | 5978 | 7835 | 8823 | 11114 | 13990 | 13355 | 11339 | 8448 | 7906 | 10377 | 1.7 |
| Export losses [MWh] | 0 | 300 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 46 | 43 | 0.0 |
| Technical capacity not used [MWh] | 124778 | 110757 | 259974 | 168560 | 186792 | 77630 | 11809 | 31092 | 20782 | 168026 | 200203 | 116187 | 21.1 |
| Import [MWh] | 460133 | 357717 | 330539 | 374669 | 407504 | 497014 | 583072 | 563941 | 464277 | 392878 | 363290 | 475276 | 75.2 |
| Export [MWh] | 3 | 14204 | 67 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 2568 | 2262 | 0.3 |
| Limitations [MWh] | 2048 | 1343 | 1632 | 1469 | 1027 | 1522 | 524 | 553 | 869 | 2307 | 906 | 1558 | 0.2 |
| Disturbance outage [MWh] | 0 | 0 | 2240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 8398 | 53712 | 0 | 31401 | 0 | 0 | 0 | 0 | 90400 | 33004 | 9121 | 0 | 3.2 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (800MW)** | 595360 | 537734 | 594452 | 576112 | 595323 | 576166 | 595405 | 595586 | 576329 | 596216 | 576088 | 595283 | 101.7 |

## 6.3.6 KONTEK

Figure 6.3.6 presents the availability and utilisation of Kontek for 2015. Kontek has been in operation since 1986. In Denmark it is connected to Bjaeverskov (bidding zone DK2) and in Germany to Bentwisch (bidding zone DE-TenneT). The transmission capacity is 600 MW.

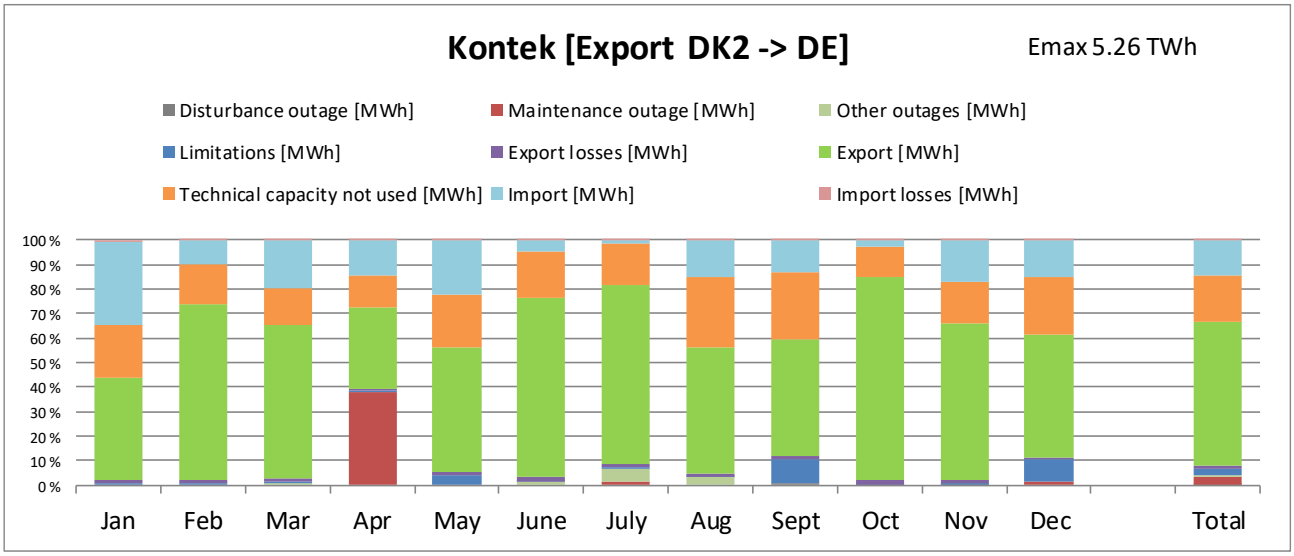


**FIGURE 6.3.6 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR KONTEK IN 2015**

In 2015, Kontek had an available technical capacity of 93 %. The technical capacity not used was 20 %. Totally, 3.1 TWh (59 % of the technical capacity) was exported from Denmark to Germany and 0.7 TWh (14 % of the technical capacity) was imported to Denmark. Table 6.6 presents the numerical values behind Figure 6.3.6.

There were 2 minor disturbance outages in on Kontek. The annual maintenance outage was from 13 April to 24 April.

**TABLE 6.6 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR KONTEK IN 2015**

| Kontek [DK2 -> DE] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 3373 | 960 | 2091 | 1448 | 1997 | 426 | 156 | 1357 | 1215 | 250 | 1600 | 1433 | 0.3 |
| Export losses [MWh] | 4285 | 6559 | 6553 | 3144 | 4811 | 6754 | 7042 | 4828 | 4202 | 7669 | 5649 | 4245 | 1.3 |
| Technical capacity not used [MWh] | 97015 | 67543 | 67988 | 56063 | 98283 | 83454 | 75718 | 128690 | 119762 | 56432 | 74359 | 106563 | 19.6 |
| Import [MWh] | 154864 | 40387 | 86973 | 62148 | 98566 | 21395 | 7824 | 67187 | 55784 | 11843 | 73423 | 68125 | 14.2 |
| Export [MWh] | 189930 | 292708 | 285151 | 146583 | 231249 | 320612 | 331147 | 234733 | 210365 | 377201 | 279922 | 224928 | 59.4 |
| Limitations [MWh] | 4591 | 2562 | 3891 | 2100 | 18596 | 1647 | 1813 | 1923 | 43628 | 1525 | 3706 | 40216 | 2.4 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2507 | 0 | 590 | 0 | 0.1 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 165304 | 0 | 0 | 4817 | 0 | 0 | 0 | 0 | 6569 | 3.4 |
| Other outages [MWh] | 0 | 0 | 1797 | 0 | 0 | 5400 | 25723 | 14162 | 0 | 0 | 0 | 0 | 0.9 |
| $P_r$ (600MW) | 446400 | 403200 | 445800 | 432198 | 446693 | 432507 | 447042 | 446694 | 432047 | 447001 | 432000 | 446400 | 101.6 |

## 6.3.7 KONTI-SKAN 1

Figure 6.3.7 presents the availability and utilisation of Konti-Skan 1 for 2015. In south-western Sweden it is connected to Lindome (bidding zone SE3) and in Denmark to Vester Hassing (bidding zone DK1). It has been in operation since 1965. Today the transmission capacity is 370 MW and the upgraded converter stations were commissioned in 2008.

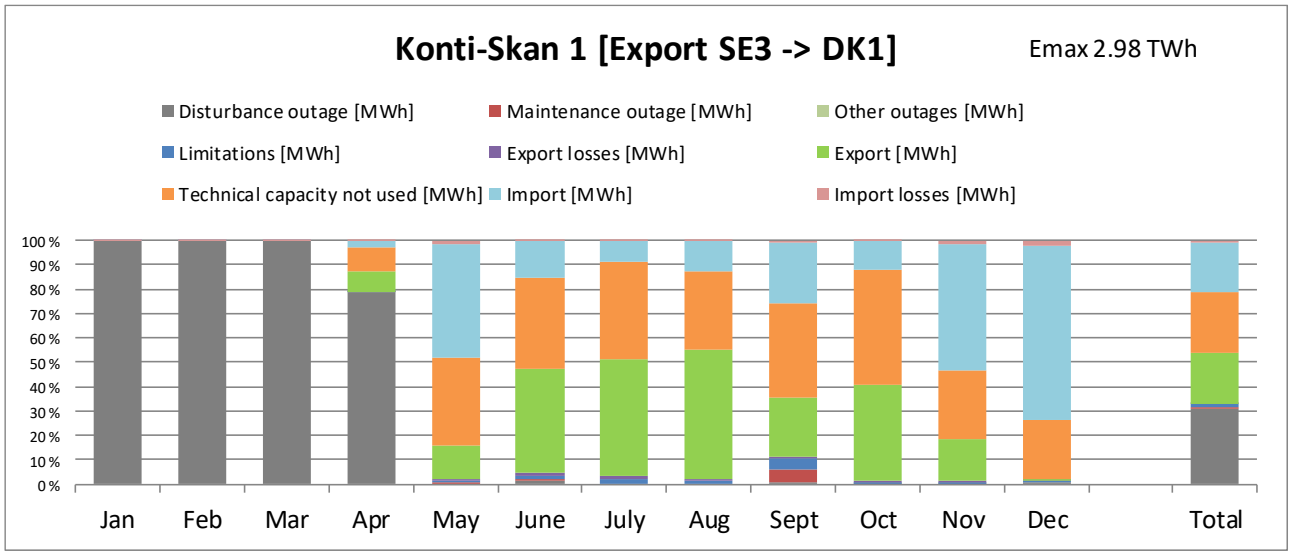


**FIGURE 6.3.7 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR KONTI-SKAN 1 IN 2015**

In 2015, Konti-Skan 1 had an available technical capacity of 67 % and the technical capacity not used was 25 %. Totally, 0.6 TWh (21 % of the technical capacity) was exported from Sweden to Denmark and 0.6 TWh (21 % of the technical capacity) was imported to Sweden. The available technical capacity of the link was 5 percentage points lower in comparison with 2014. Table 6.7 presents the numerical values behind Figure 6.3.7.

There were 8 disturbance outages on Konti-Skan 1, of which the most severe was due to a transformer failure in Sweden which started in November 2014 and ended 24 April 2015. The annual maintenance was performed in September.

**TABLE 6.7 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR KONTI-SKAN 1 IN 2015**

| Konti-Skan 1 [SE3 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of Emax) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 16 | 12 | 9 | 169 | 3431 | 1053 | 551 | 883 | 1889 | 815 | 3622 | 5201 | 0.6 |
| Export losses [MWh] | 1 | 0 | 0 | 377 | 876 | 2180 | 2344 | 2832 | 1381 | 1982 | 859 | 38 | 0.4 |
| Technical capacity not used [MWh] | 0 | 0 | 0 | 24294 | 94761 | 92721 | 102353 | 82598 | 95339 | 121888 | 71966 | 62927 | 25.1 |
| Import [MWh] | 16 | 12 | 9 | 6285 | 120717 | 37519 | 22461 | 32345 | 62967 | 29647 | 129678 | 188118 | 21.1 |
| Export [MWh] | 0 | 0 | 0 | 20818 | 35915 | 106208 | 122248 | 134992 | 60468 | 99598 | 42940 | 2328 | 20.9 |
| Limitations [MWh] | 0 | 0 | 0 | 344 | 914 | 3004 | 5935 | 3275 | 12484 | 2314 | 1097 | 1251 | 1.0 |
| Disturbance outage [MWh] | 252944 | 228468 | 252611 | 193097 | 0 | 3859 | 0 | 0 | 1642 | 24 | 1081 | 1697 | 31.3 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 0 | 2839 | 2034 | 0 | 0 | 12707 | 0 | 0 | 0 | 0.6 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (370 MW)** | 252960 | 228480 | 252620 | 244837 | 255146 | 245346 | 252997 | 253211 | 245607 | 253471 | 246762 | 256321 | 101.0 |

## 6.3.8 KONTI-SKAN 2

Figure 6.3.8 presents the availability and utilisation of Konti-Skan 2 for 2015. Konti-Skan 2 is connected between Sweden and Denmark in parallel to Konti-Skan 1. It has a transmission capacity of 370 MW and has been in operation since 1988.

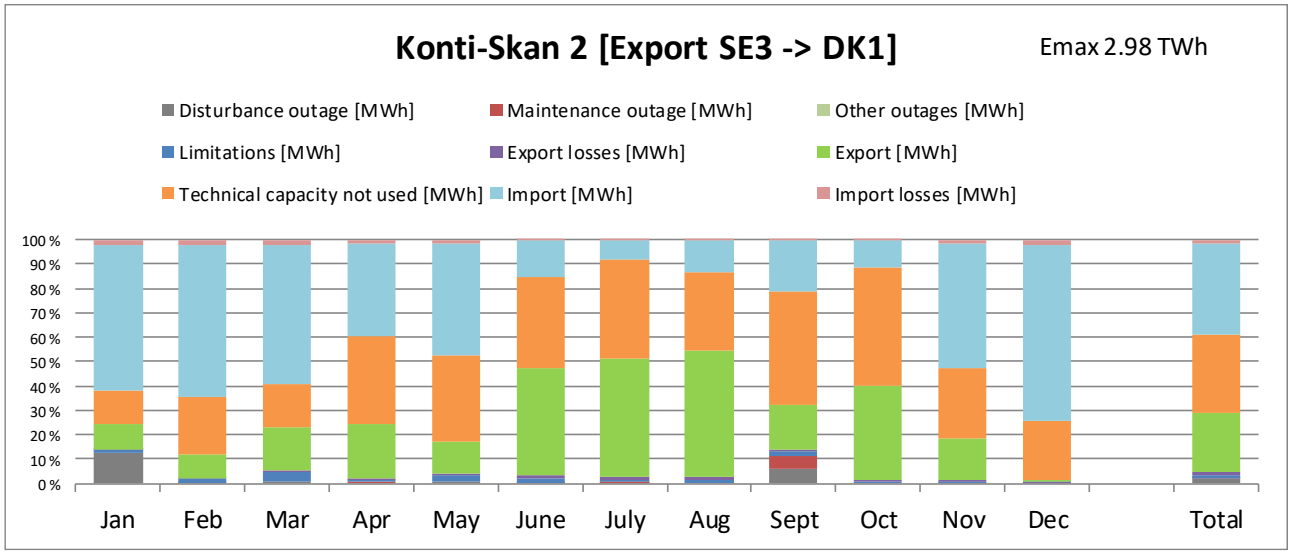


**FIGURE 6.3.8 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR KONTI-SKAN 2 IN 2015**

In 2015, Konti-Skan 2 had an available technical capacity of 96 % and the technical capacity not used was 33 %. Totally, 0.7 TWh (25 % of the technical capacity) was exported from Sweden to Denmark and 1.2 TWh (39 % of the technical capacity) was imported to Sweden. The available technical capacity of the link was 17 percentage points higher in comparison with 2014. Table 6.8 presents the numerical values behind Figure 6.3.8.

There were 10 disturbance outages on Konti-Skan 2 of which the longest lasted three days in January. The annual maintenance was performed in September.

**TABLE 6.8 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR KONTI-SKAN 2 IN 2015**

| Konti-Skan 2 [SE3 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of Emax) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 6294 | 5833 | 5863 | 3613 | 3207 | 965 | 460 | 860 | 1365 | 647 | 3322 | 4859 | 1.2 |
| Export losses [MWh] | 1051 | 847 | 1728 | 1873 | 973 | 2992 | 3338 | 3876 | 1254 | 2649 | 1156 | 49 | 0.7 |
| Technical capacity not used [MWh] | 35679 | 55043 | 45726 | 90264 | 92979 | 93491 | 103791 | 82110 | 116010 | 124915 | 72243 | 62921 | 32.6 |
| Import [MWh] | 155677 | 146516 | 149142 | 96431 | 119909 | 37551 | 21016 | 34113 | 50526 | 28543 | 129802 | 188837 | 38.7 |
| Export [MWh] | 26584 | 22420 | 46204 | 55562 | 34431 | 109841 | 124508 | 134458 | 46685 | 98775 | 42514 | 2229 | 24.9 |
| Limitations [MWh] | 2177 | 4247 | 10109 | 1821 | 6852 | 4545 | 1053 | 2970 | 5431 | 1375 | 1346 | 1160 | 1.4 |
| Disturbance outage [MWh] | 33211 | 481 | 2013 | 0 | 2372 | 0 | 928 | 0 | 14379 | 0 | 975 | 0 | 1.8 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 1360 | 0 | 419 | 1930 | 0 | 12915 | 0 | 0 | 0 | 0.6 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (370 MW)** | 253328 | 228708 | 253193 | 245437 | 256544 | 245848 | 253225 | 253652 | 245946 | 253607 | 246880 | 255147 | 102.0 |

## 6.3.9 NorNed

Figure 6.3.9 presents the availability and utilisation of NorNed for 2015. NorNed has been in operation since 2008, and is, with a length of 580 km, the longest HVDC link connected to the Nordic power system. In Norway on the south-western coast (bidding zone NO2) it is connected to Feda substation and in Netherlands to Eemshaven (bidding zone APX NL). The transmission capacity is 700 MW.

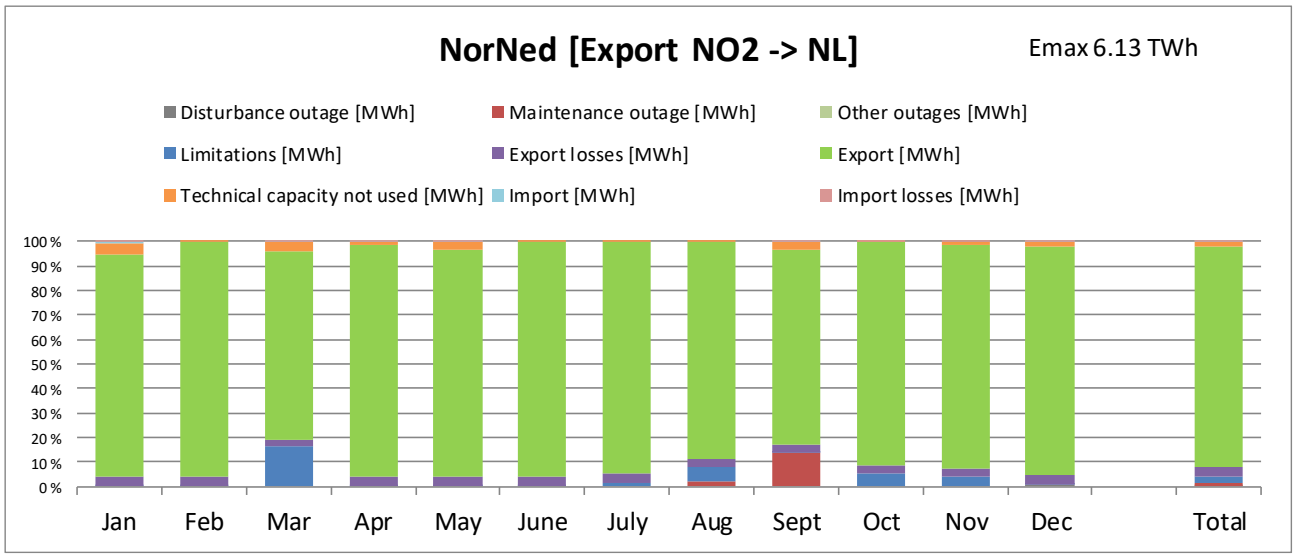


**FIGURE 6.3.9 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR NORNED IN 2015**

In 2015, NorNed had had an available technical capacity of 96 %. The technical capacity not used was 1.8 %. Totally, 5.8 TWh (94 % of the technical capacity) was exported from Norway to the Netherlands and 11 GWh (0.2 % of the technical capacity) was imported to Norway.

Table 6.9 presents the numerical values behind Figure 6.3.9.

There was 1 disturbance outage on NorNed with minor significance. The annual maintenance outage lasted five days in the beginning of September.

**TABLE 6.9 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR NORNED IN 2015**

| NorNed [NO2 -> NL] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 160 | 0 | 70 | 7 | 54 | 0 | 0 | 0 | 2 | 0 | 0 | 77 | 0.0 |
| Export losses [MWh] | 19464 | 18732 | 14308 | 19661 | 20035 | 20248 | 20458 | 18481 | 16455 | 19428 | 18569 | 20343 | 3.7 |
| Technical capacity not used [MWh] | 23675 | 2330 | 20894 | 7826 | 16050 | 392 | 481 | 1280 | 18535 | 1885 | 7223 | 8159 | 1.8 |
| Import [MWh] | 4830 | 0 | 2307 | 244 | 1590 | 0 | 0 | 0 | 4 | 0 | 0 | 2208 | 0.2 |
| Export [MWh] | 492823 | 469410 | 410396 | 497091 | 504579 | 505306 | 515242 | 478266 | 414502 | 494936 | 477477 | 508856 | 93.8 |
| Limitations [MWh] | 921 | 105 | 87112 | 528 | 362 | 213 | 7071 | 32712 | 1552 | 27352 | 20671 | 351 | 2.9 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2816 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10500 | 71355 | 0 | 0 | 0 | 1.3 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (700 MW)** | 522249 | 471844 | 520710 | 505689 | 522580 | 505911 | 522794 | 522758 | 505948 | 524172 | 505372 | 522389 | 103.7 |

## 6.3.10 SKAGERRAK 1

Figure 6.3.10 presents the availability and utilisation of Skagerrak 1 for 2015. Skagerrak 1 and Skagerrak 2 have been in operation since 1976 and are the oldest HVDC links in operation in the Nordic countries. In Norway, the links are connected to Kristiansand on the southern coast (bidding zone NO2) and in Denmark to Tjele (bidding zone DK1), approximately 15 km east of the town of Viborg in the northern part of Jutland. The transmission capacity is 250 MW.

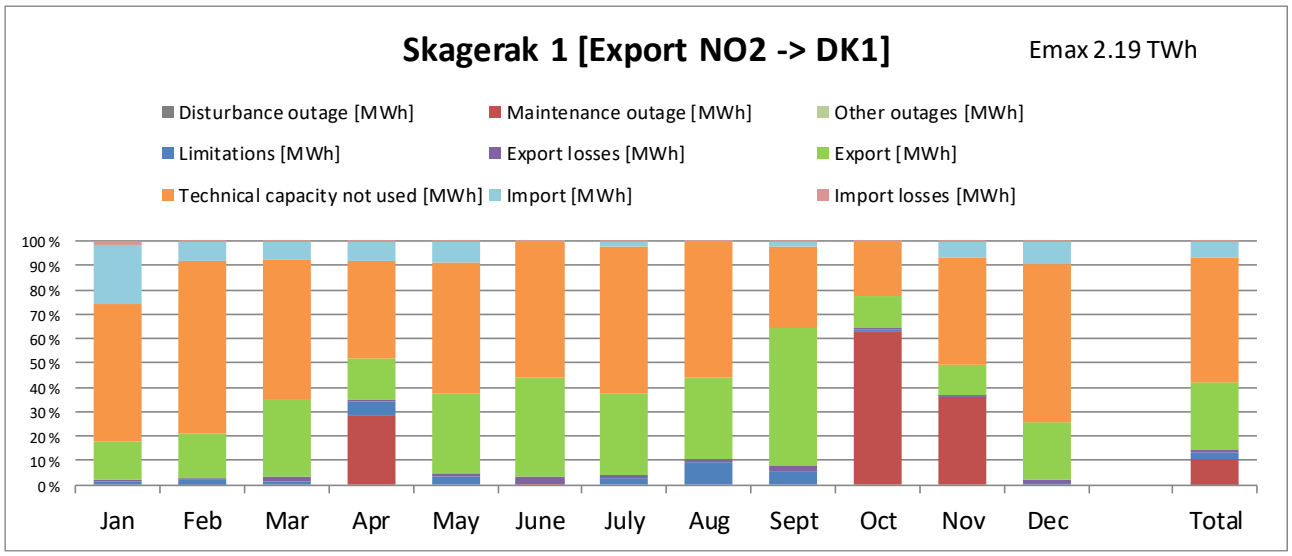


**FIGURE 6.3.10 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR SKAGERRAK 1 IN 2015**

In 2015, Skagerrak 1 had an available technical capacity of 86 %. The technical capacity not used was 52 %. Totally, 0.6 TWh (28 % of the technical capacity) was exported from Norway to the Denmark and 0.1 TWh (6.3 % of the technical capacity) was imported to Norway. Table 6.10 presents the numerical values behind Figure 6.3.10.

There was 1 disturbance outage with minor significance on Skagerrak 1. There were 3 maintenance outages with the longest lasting from 12 October to 11 November. The annual maintenance was performed in April.

**TABLE 6.10 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR SKAGERRAK 1 IN 2015**

| Skagerrak 1 [NO2 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 2551 | 789 | 797 | 846 | 835 | 148 | 318 | 111 | 261 | 49 | 660 | 961 | 0.4 |
| Export losses [MWh] | 1235 | 1172 | 2995 | 1373 | 3022 | 3826 | 3145 | 3084 | 5313 | 1309 | 1007 | 2205 | 1.4 |
| Technical capacity not used [MWh] | 107049 | 120797 | 108976 | 72504 | 102634 | 102382 | 114344 | 106231 | 61454 | 42051 | 80307 | 123319 | 52.1 |
| Import [MWh] | 46817 | 12751 | 13292 | 14419 | 15216 | 741 | 3988 | 42 | 3845 | 49 | 11251 | 16412 | 6.3 |
| Export [MWh] | 29534 | 30653 | 60427 | 30773 | 62092 | 74991 | 62880 | 62281 | 104787 | 25143 | 22338 | 44851 | 27.9 |
| Limitations [MWh] | 2600 | 3343 | 3054 | 10940 | 6058 | 932 | 4788 | 17446 | 9915 | 367 | 764 | 1418 | 2.8 |
| Disturbance outage [MWh] | 0 | 456 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 51364 | 0 | 954 | 0 | 0 | 0 | 118641 | 65340 | 0 | 10.8 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (250 MW)** | 186000 | 168000 | 185750 | 180000 | 186000 | 180000 | 186000 | 186000 | 180001 | 186250 | 180000 | 186000 | 101.7 |

## 6.3.11 SKAGERRAK 2

Figure 6.3.11 presents the availability and utilisation of Skagerrak 1 for 2015. Skagerrak 1 and Skagerrak 2 have been in operation since 1976 and are the oldest HVDC links in operation in the Nordic countries. In Norway, the links are connected to Kristiansand on the southern coast (bidding zone NO2) and in Denmark to Tjele (bidding zone DK1), approximately 15 km east of the town of Viborg in the northern part of Jutland. The transmission capacity is 250 MW.

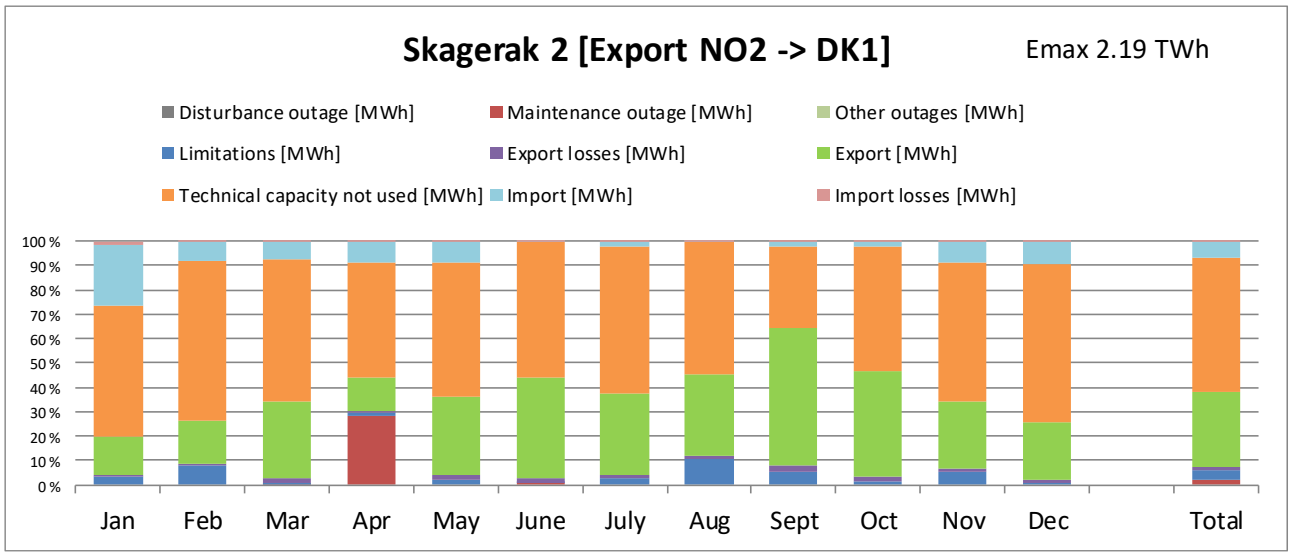


**FIGURE 6.3.11 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR SKAGERRAK 2 IN 2015**

In 2015, Skagerrak 2 had an available technical capacity of 94 %. The technical capacity not used was 56 %. Totally, 0.7 TWh (32 % of the technical capacity) was exported from Norway to the Denmark and 0.1 TWh (6.7 % of the technical capacity) was imported to Norway. Table 6.11 presents the numerical values behind Figure 6.3.11.

There were no disturbance outages with minor significance on Skagerrak 2. There were 3 maintenance outages. The annual maintenance was performed between 22–30 April.

**TABLE 6.11 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR SKAGERRAK 2 IN 2015**

| Skagerrak 2 [NO2 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 2604 | 817 | 795 | 863 | 899 | 143 | 289 | 82 | 256 | 281 | 908 | 994 | 0.4 |
| Export losses [MWh] | 1249 | 1176 | 3044 | 1088 | 2967 | 3809 | 3127 | 3059 | 5096 | 4366 | 2576 | 2267 | 1.5 |
| Technical capacity not used [MWh] | 101804 | 110822 | 110362 | 86807 | 104576 | 102441 | 114397 | 103607 | 61733 | 98335 | 104598 | 123166 | 55.8 |
| Import [MWh] | 47513 | 13286 | 13374 | 14544 | 15229 | 741 | 3976 | 17 | 3870 | 3560 | 15014 | 16509 | 6.7 |
| Export [MWh] | 29892 | 30793 | 60295 | 24451 | 62031 | 75113 | 62978 | 62329 | 104898 | 81910 | 50283 | 45089 | 31.5 |
| Limitations [MWh] | 6791 | 13110 | 1064 | 2202 | 4164 | 751 | 4650 | 20047 | 9499 | 2641 | 10104 | 1236 | 3.5 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 660 | 51997 | 0 | 954 | 0 | 0 | 0 | 0 | 0 | 0 | 2.4 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (250 MW)** | 186000 | 168010 | 185755 | 180000 | 186000 | 180000 | 186001 | 186001 | 180001 | 186446 | 180000 | 186001 | 102.0 |

## 6.3.12 SKAGERRAK 3

Figure 6.3.12 presents the availability and utilisation of Skagerrak 3 for 2015. Skagerrak 3 has been in operation since 1993. In Norway it is connected to Kristiansand (bidding zone NO2) and in Denmark to Tjele (bidding zone DK1). The transmission capacity is 500 MW.

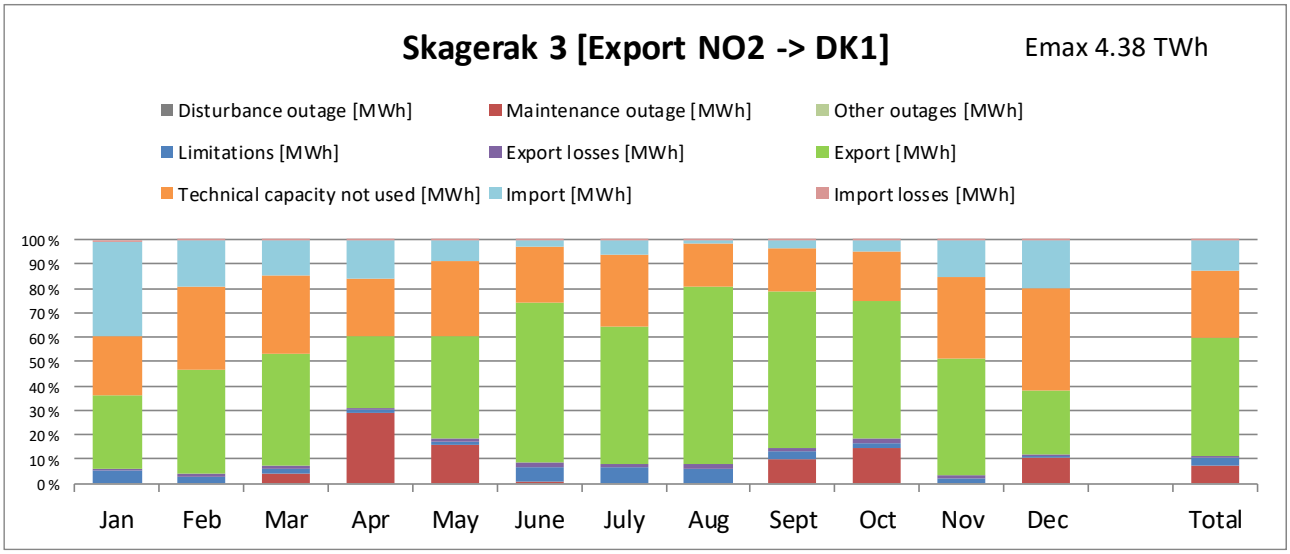


**FIGURE 6.3.12 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR SKAGERRAK 3 IN 2015**

In 2015, Skagerrak 3 had an available technical capacity of 89 %. The technical capacity not used was 28 %. Totally, 2.2 TWh (49 % of the technical capacity) was exported from Norway to Denmark and 0.6 TWh (13 % of the technical capacity) was imported to Norway. Table 6.12 presents the numerical values behind Figure 6.3.12.

There were no disturbance outages on Skagerrak 3. There were 10 maintenance outages, which mainly aimed to improve bipolarity capabilities with Skagerrak 4. The annual maintenance was performed between 22 April and 5 April.

**TABLE 6.12 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR SKAGERRAK 3 IN 2015**

| Skagerrak 3 [NO2 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 4099 | 1690 | 1487 | 1573 | 877 | 257 | 609 | 127 | 342 | 532 | 1521 | 1981 | 0.3 |
| Export losses [MWh] | 2741 | 3390 | 4068 | 2592 | 3724 | 5951 | 5178 | 6718 | 5763 | 5576 | 4474 | 2285 | 1.2 |
| Technical capacity not used [MWh] | 92639 | 117312 | 119632 | 87289 | 115639 | 84855 | 112376 | 68404 | 65291 | 75733 | 122428 | 155755 | 27.8 |
| Import [MWh] | 145704 | 63519 | 54141 | 55484 | 32250 | 10024 | 22352 | 5315 | 11783 | 18866 | 53756 | 73822 | 12.5 |
| Export [MWh] | 114539 | 145156 | 173758 | 107685 | 158572 | 240553 | 212834 | 275389 | 234544 | 214692 | 176798 | 99058 | 49.2 |
| Limitations [MWh] | 19158 | 10012 | 9680 | 4761 | 6240 | 22659 | 24440 | 22893 | 11658 | 7703 | 7019 | 3426 | 3.4 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 14289 | 104780 | 59300 | 1909 | 0 | 0 | 36724 | 55885 | 0 | 39938 | 7.1 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (500 MW)** | 372040 | 336000 | 371500 | 360000 | 372000 | 360000 | 372002 | 372000 | 360000 | 372881 | 360000 | 372000 | 101.5 |

## 6.3.13 SKAGERRAK 4

Figure 6.3.13 presents the availability and utilisation of Skagerrak 4 for 2015. Skagerrak 4 has been in commercial operation since 29 December 2014. In Norway it is connected to Kristiansand (bidding zone NO2) and in Denmark to Tjele (bidding zone DK1). The transmission capacity is 700 MW.

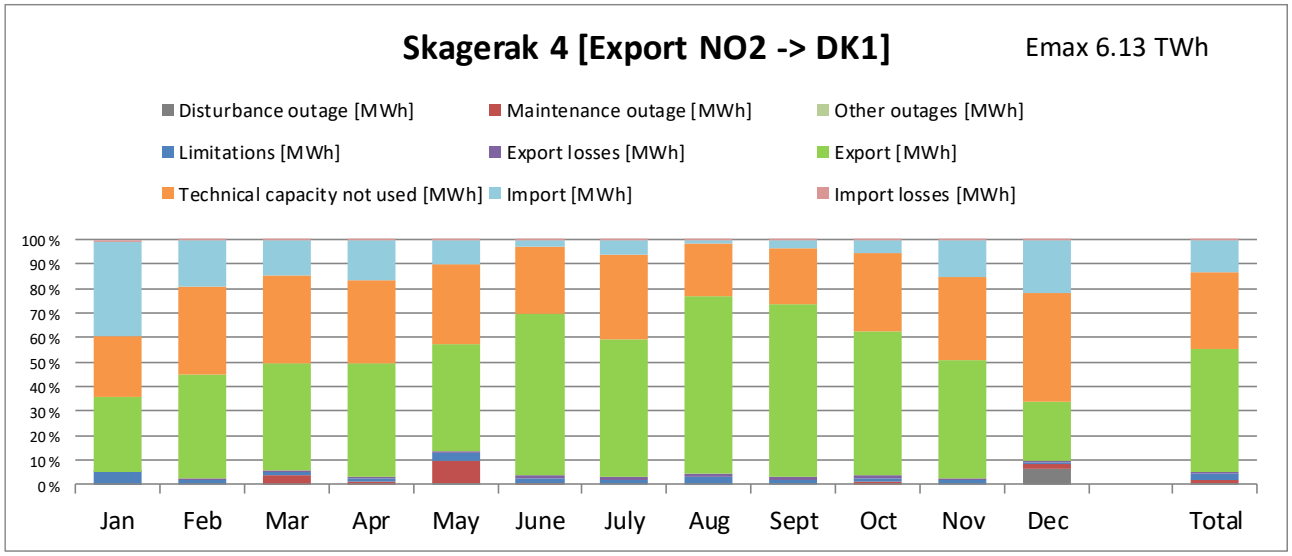


**FIGURE 6.3.13 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR SKAGERRAK 4 IN 2015**

In 2015, Skagerrak 4 had an available technical capacity of 96 %. The technical capacity not used was 32 %. Totally, 3.1 TWh (51 % of the technical capacity) was exported from Norway to the Denmark and 0.8 TWh (13 % of the technical capacity) was imported to Norway. Table 6.13 presents the numerical values behind Figure 6.3.13.

There were 3 minor disturbance outages Skagerrak 4. There were 10 maintenance outages, which mainly aimed to improve bipolarity capabilities with Skagerrak 3. The annual maintenance was performed 24 April and 5–8 May.

**TABLE 6.13 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR SKAGERRAK 4 IN 2015**

| Skagerrak 4 [NO2 -> DK1] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 4972 | 2178 | 1910 | 2080 | 1281 | 372 | 819 | 183 | 416 | 671 | 1883 | 2696 | 0.3 |
| Export losses [MWh] | 3031 | 3704 | 4182 | 4402 | 4160 | 6263 | 5381 | 6959 | 6666 | 5253 | 4317 | 2334 | 0.9 |
| Technical capacity not used [MWh] | 128677 | 169715 | 189995 | 173246 | 174536 | 140946 | 182715 | 112491 | 115940 | 170888 | 174732 | 233944 | 32.1 |
| Import [MWh] | 204632 | 89915 | 75165 | 82853 | 49995 | 14327 | 31913 | 7626 | 16572 | 27035 | 75646 | 110393 | 12.8 |
| Export [MWh] | 161643 | 202701 | 228416 | 234826 | 229289 | 336109 | 295455 | 383311 | 362687 | 309250 | 245144 | 127441 | 50.8 |
| Limitations [MWh] | 25682 | 8069 | 6375 | 6106 | 13953 | 9968 | 10717 | 17372 | 8802 | 8595 | 8478 | 4593 | 2.1 |
| Disturbance outage [MWh] | 456 | 0 | 0 | 0 | 4832 | 0 | 0 | 0 | 0 | 0 | 0 | 33420 | 0.6 |
| Maintenance outage [MWh] | 0 | 0 | 20148 | 6969 | 48195 | 2649 | 0 | 0 | 0 | 6258 | 0 | 11009 | 1.6 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_t$ (700 MW)** | 521091 | 470400 | 520100 | 504000 | 520800 | 504000 | 520800 | 520800 | 504000 | 522026 | 504000 | 520800 | 101.2 |

## 6.3.14 STOREBAELT

Figure 6.3.14 presents the availability and utilisation of Storebaelt for 2015. Storebaelt has been in operation since 2010. It connects together the western part of the Danish system that belongs to the Continental European synchronous system (Jutland and the island of Fynen) and the eastern part belonging to the Nordic synchronous system (Zealand). The link is connected to Fraugde on Fynen (bidding zone DK1) and to Herslev on Zealand (bidding zone DK2). The transmission capacity is 600 MW.

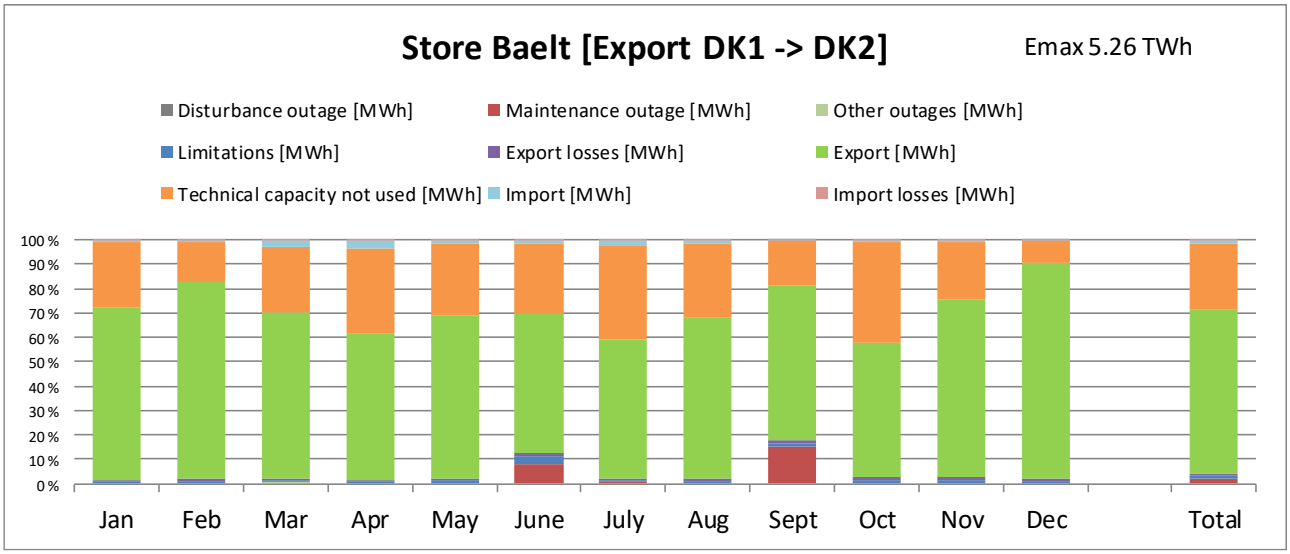


**FIGURE 6.3.14 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR STOREBELT IN 2015**

In 2015, Storebaelt had an available technical capacity of 97 %. The technical capacity not used was 28 %. Totally, 3.6 TWh (68 % of the technical capacity) was exported from Jutland to Zealand and 0.1 TWh (1.4 % of the technical capacity) was imported to Jutland. Table 6.14 presents the numerical values behind Figure 6.3.14.

There were no disturbance outages and 5 maintenance outages on Storebaelt. Faulty cooling was replaced in June and generic maintenance was done in September.

**TABLE 6.14 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR IN 2015**

| Storebaelt [DK1 -> DK2] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 62 | 41 | 178 | 248 | 140 | 117 | 150 | 98 | 27 | 140 | 82 | 13 | 0.0 |
| Export losses [MWh] | 5291 | 5493 | 5087 | 4328 | 5034 | 4218 | 4274 | 5016 | 4768 | 4099 | 5399 | 6922 | 1.1 |
| Technical capacity not used [MWh] | 121271 | 68350 | 123217 | 152496 | 134572 | 126432 | 175659 | 136860 | 79564 | 185704 | 102499 | 41099 | 27.5 |
| Import [MWh] | 3659 | 2645 | 11501 | 15759 | 6783 | 5593 | 9137 | 5611 | 764 | 4979 | 5190 | 459 | 1.4 |
| Export [MWh] | 319184 | 328420 | 305620 | 260893 | 299565 | 250593 | 256335 | 300728 | 279112 | 249091 | 319050 | 401572 | 67.9 |
| Limitations [MWh] | 2649 | 4157 | 3324 | 3160 | 5843 | 13760 | 3141 | 3515 | 6024 | 7402 | 5442 | 3760 | 1.2 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 35967 | 2320 | 0 | 67077 | 0 | 0 | 0 | 2.0 |
| Other outages [MWh] | 0 | 0 | 2420 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (600 MW)** | 446764 | 403572 | 446082 | 432307 | 446763 | 432345 | 446592 | 446715 | 432541 | 447177 | 432181 | 446889 | 101.2 |

## 6.3.15 SwePol

Figure 6.3.15 presents the availability and utilisation of SwePol for 2015. SwePol Link has been in operation since 2000 and it connects the Swedish and Polish transmission grids. In south-eastern Sweden (bidding zone SE4) it is connected to Stärnö and in Poland (bidding zone PL) to Slupsk. The transmission capacity is 600 MW.

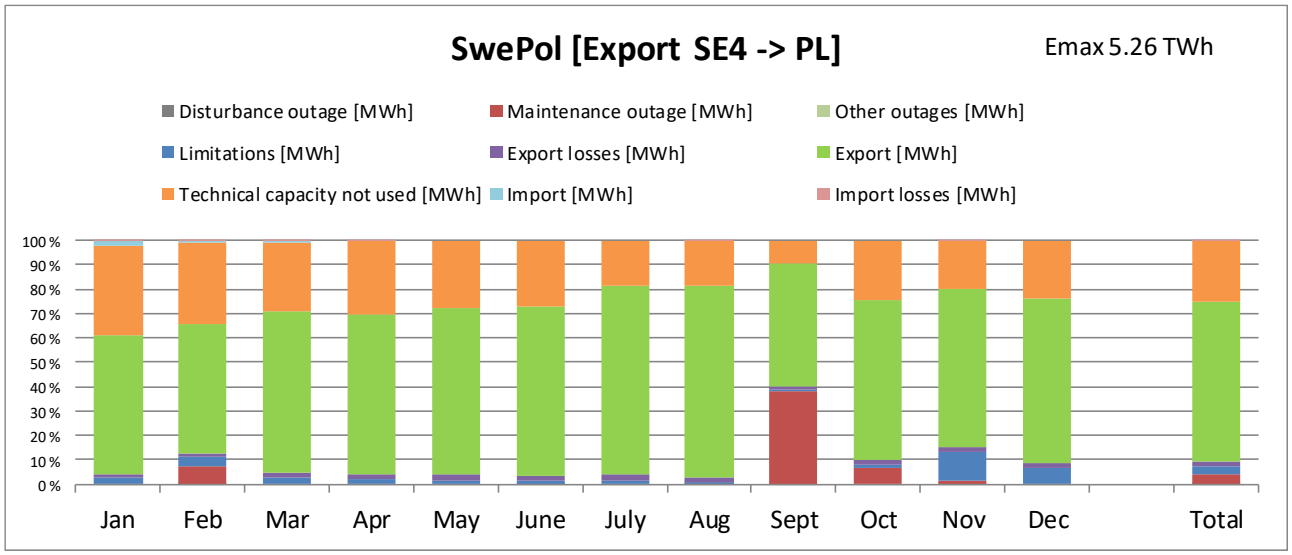


**FIGURE 6.3.15 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR SWEPOL IN 2015**

In 2015, SwePol had an available technical capacity of 92 %. The technical capacity not used was 25 %. Totally, 3.5 TWh (67 % of the technical capacity) was exported from Sweden to Poland and 20 GWh (0.4 % of the technical capacity) was imported to Sweden. Table 6.15 presents the numerical values behind Figure 6.3.15.

There were 8 disturbance outages with minor significance on SwePol. There were 4 maintenance outages of which the annual maintenance was the longest one and was performed between 19 September and 2 October. There was also maintenance on the Polish side during February.

**TABLE 6.15 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR SWEPOL IN 2015**

| SwePol [SE4 -> PL] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 200 | 84 | 87 | 52 | 0 | 0 | 0 | 6 | 0 | 0 | 25 | 0 | 0.0 |
| Export losses [MWh] | 7310 | 6033 | 8733 | 8356 | 9080 | 8891 | 10038 | 10353 | 6184 | 8440 | 7762 | 8402 | 1.9 |
| Technical capacity not used [MWh] | 168426 | 135663 | 126609 | 130196 | 127185 | 118123 | 84174 | 84470 | 40621 | 112632 | 85841 | 108516 | 25.2 |
| Import [MWh] | 8880 | 3714 | 4010 | 2205 | 0 | 0 | 0 | 246 | 0 | 0 | 1139 | 0 | 0.4 |
| Export [MWh] | 257125 | 218323 | 302067 | 289875 | 311199 | 306327 | 354847 | 358915 | 221251 | 298068 | 285862 | 307823 | 66.8 |
| Limitations [MWh] | 11969 | 16010 | 13128 | 9724 | 8023 | 7548 | 7402 | 2817 | 2107 | 7005 | 52984 | 30060 | 3.2 |
| Disturbance outage [MWh] | 0 | 693 | 0 | 0 | 0 | 33 | 0 | 14 | 72 | 0 | 790 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 28797 | 0 | 0 | 0 | 0 | 0 | 0 | 168000 | 29295 | 5385 | 0 | 4.4 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (600 MW)** | 446400 | 403200 | 445814 | 432000 | 446407 | 432031 | 446424 | 446463 | 432051 | 447000 | 432000 | 446400 | 101.9 |

## 6.3.16 VYBORG LINK

Figure 6.3.16 presents the availability and utilisation of the Vyborg Link for 2015. The Vyborg Link is a back-to-back HVDC connection between Russia and Finland. The HVDC substation is situated in Vyborg, Russia. The 400 kV lines from Vyborg are connected to substations Yllikkälä and Kymi in southern Finland. The commissioning years were 1981, 1982, 1984, and 2000. Each commissioning included a capacity of 350 MW. The total technical capacity today is 4 × 350 MW and the commercial transmission capacity is 1.3 GW. Fingrid Oyj, the Finnish transmission system operator, allocates 100 MW for reserves. Earlier, the direction of transmission has been only to Finland but during September 2014, one 350 MW unit was successfully tested to be able to export electricity to Russia. The commercial trade from Finland to Russia started on 1 December 2014.

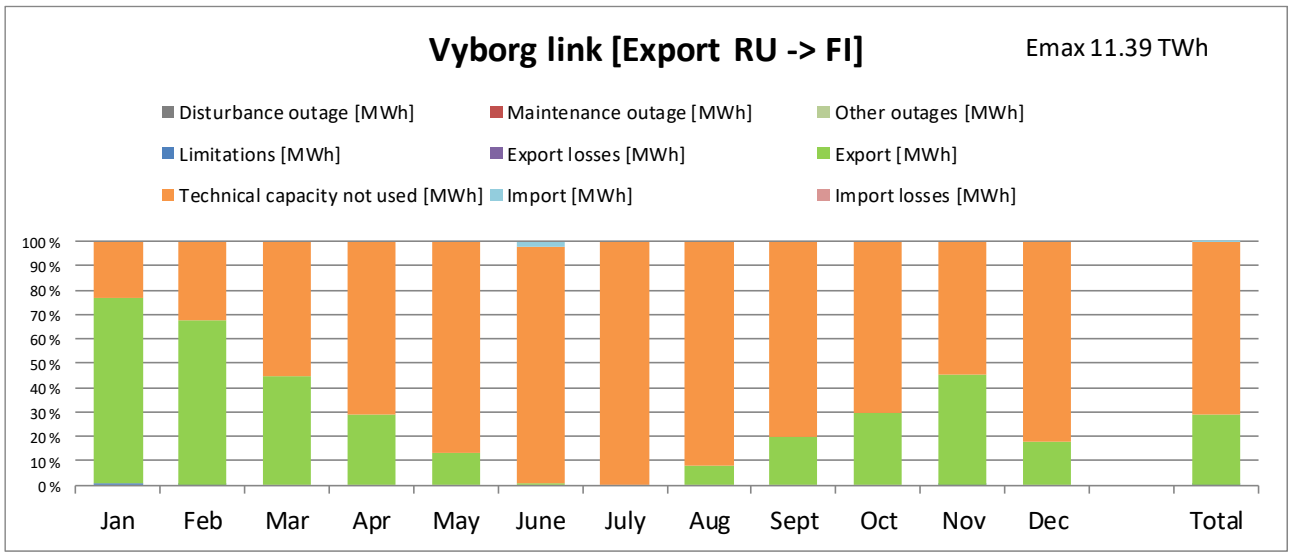


**FIGURE 6.3.16 PERCENTAGE DISTRIBUTION OF THE AVAILABILITY AND UTILISATION CATEGORIES DEFINED IN CHAPTER 4 ACCORDING TO MONTH FOR VYBORG LINK IN 2015**

In 2015, the Vyborg Link had an available technical capacity of 100 %. The technical capacity not used was 71 %. Totally, 3.3 TWh (29 % of the technical capacity) was exported from Russia to Finland and 22 GWh (0.2 % of the technical capacity) was imported to Russia. Table 6.16 presents the numerical values behind Figure 6.3.16.

There were no disturbance outages on the Vyborg link. Maintenance work did not cause any outages but caused minor limitations instead.

**TABLE 6.16 MONTHLY DISTRIBUTION OF THE TECHNICAL CAPACITY $E_{MAX}$ FOR VYBORG LINK IN 2015**

| Vyborg link [RU -> FI] | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | % (of $E_{max}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import losses [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Export losses [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Technical capacity not used [MWh] | 221699 | 281565 | 534200 | 662530 | 841450 | 909347 | 967200 | 892420 | 753720 | 680380 | 508765 | 796843 | 70.7 |
| Import [MWh] | 0 | 0 | 0 | 0 | 0 | 21573 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |
| Export [MWh] | 740437 | 591460 | 431700 | 273470 | 125750 | 5080 | 0 | 74780 | 182280 | 288120 | 426835 | 170357 | 29.1 |
| Limitations [MWh] | 5064 | 575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 400 | 0 | 0.1 |
| Disturbance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Maintenance outage [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Other outages [MWh] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| **$P_r$ (1300 MW)** | 967200 | 873600 | 965900 | 936000 | 967200 | 936000 | 967200 | 967200 | 936000 | 968500 | 936000 | 967200 | 100.0 |

# 7 REFERENCES

[1] ENTSO-E, “The ENTSO-E Interconnected System Grid Map,” [Online]. Available: https://www.entsoe.eu/publications/order-maps-and-publications/electronic-grid-maps/Pages/default.aspx. [Accessed 19 October 2015].

# Appendix A SCHEMATIC PRESENTATION OF HVDC LINKS

Figure A-1 shows a schematic presentation of an HVDC link with line commutated converters (LCC) and Figure A-3 shows a similar presentation of a link with voltage source converters (VSC). Figure A-2 and Figure A-4, show the converter stations for HVDC links having line commutated converters and voltage source converters, respectively. All the figures also show definitions for the origin of an event. The origin of each event is used for categorizing a disturbance or a limitation for statistical purposes. The figures also show how the terms 'local' and 'remote' are defined and the locations of the circuit breakers and measurement points for transferred energy on a link.

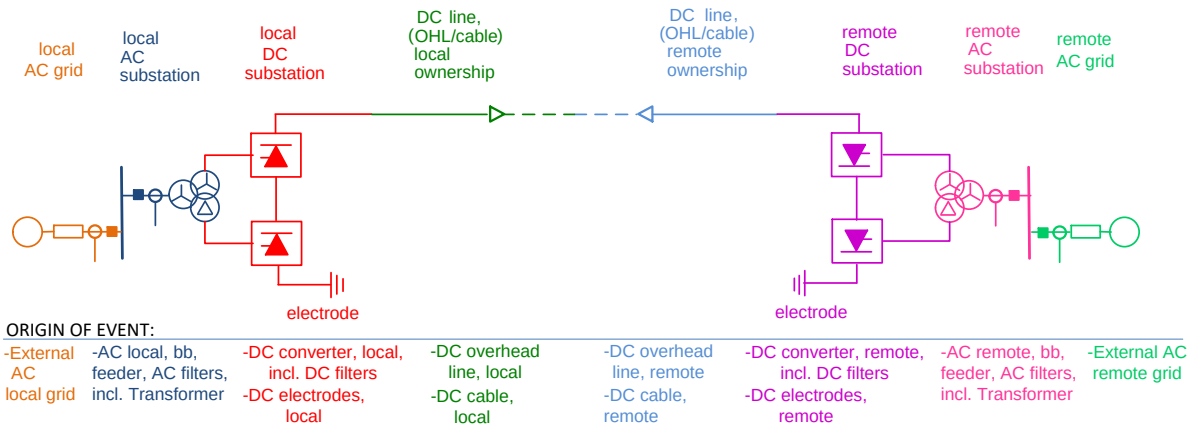


**FIGURE A-1 A SCHEMATIC PRESENTATION OF A HVDC LINK WITH LINE COMMUTATED CONVERTERS (LCC)**

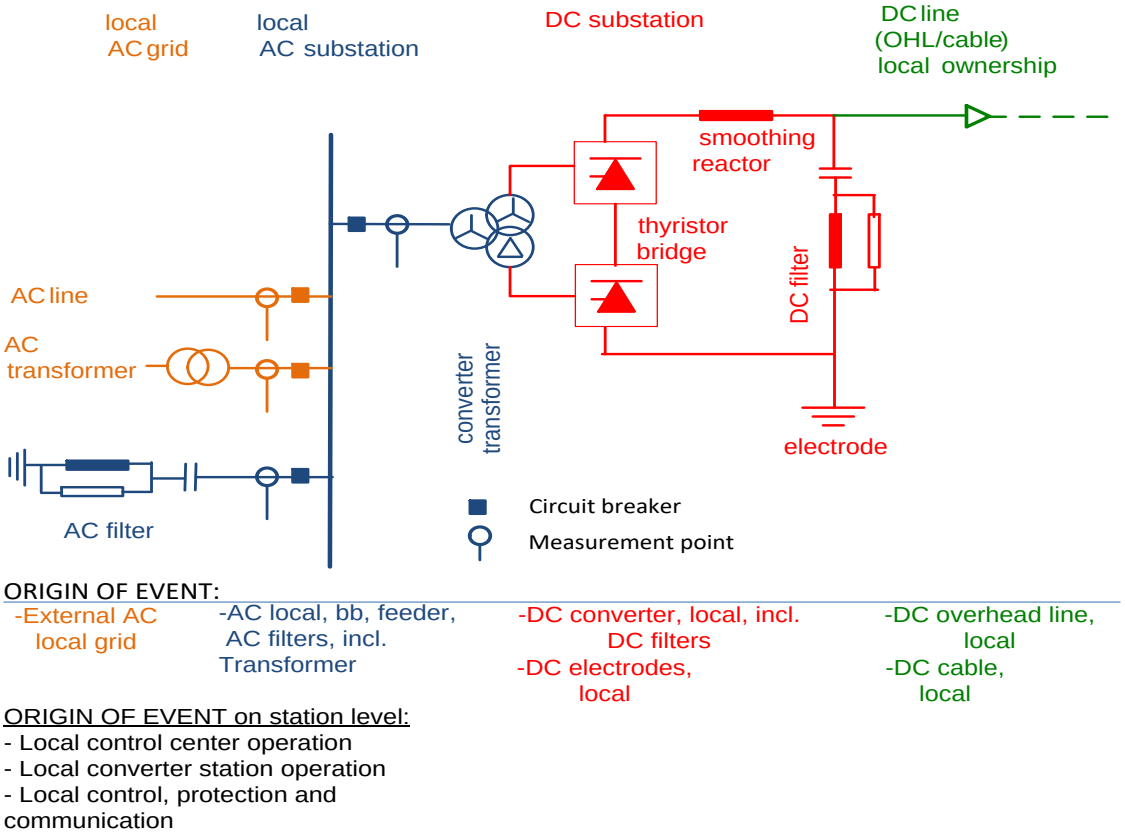


**FIGURE A-2 A CONVERTER STATION OF A LINE COMMUTATED CONVERTER HVDC LINK WITH THE CONNECTION TO THE AC GRID**

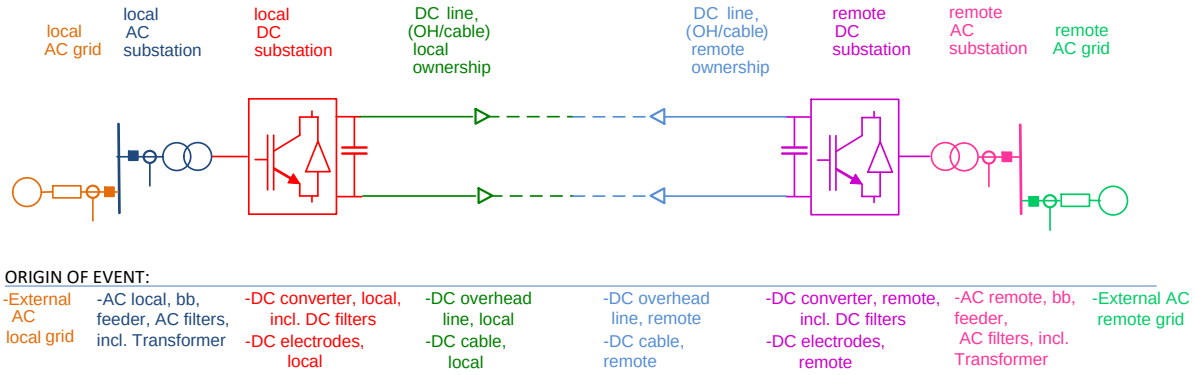


**FIGURE A-3 A SCHEMATIC PRESENTATION OF A HVDC LINK WITH VOLTAGE SOURCE CONVERTERS (VSC)**

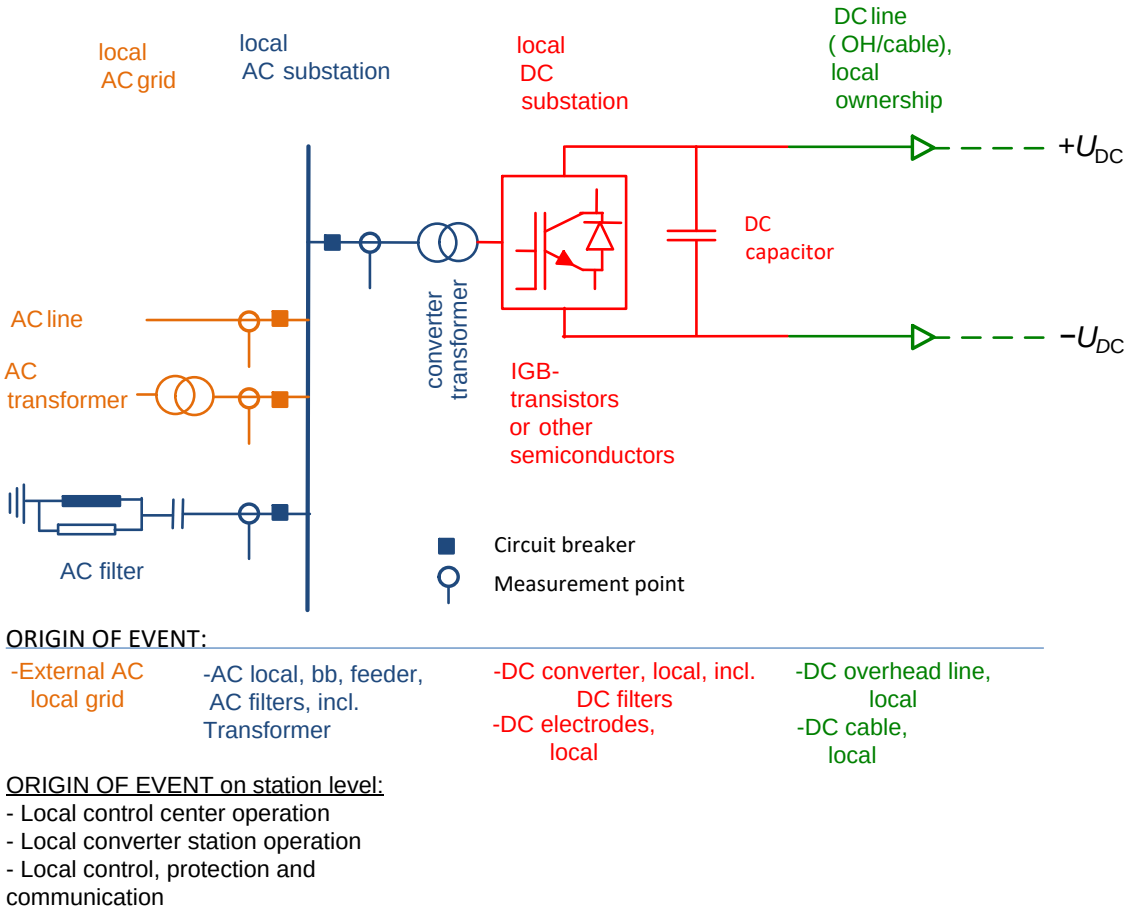


**FIGURE A-4 A CONVERTER STATION OF A VOLTAGE SOURCE CONVERTER HVDC LINK WITH THE CONNECTION TO THE AC GRID**

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# Appendix C ANNUAL OVERVIEW OF ALL HVDC DATA WITH SORTED CATEGORIES

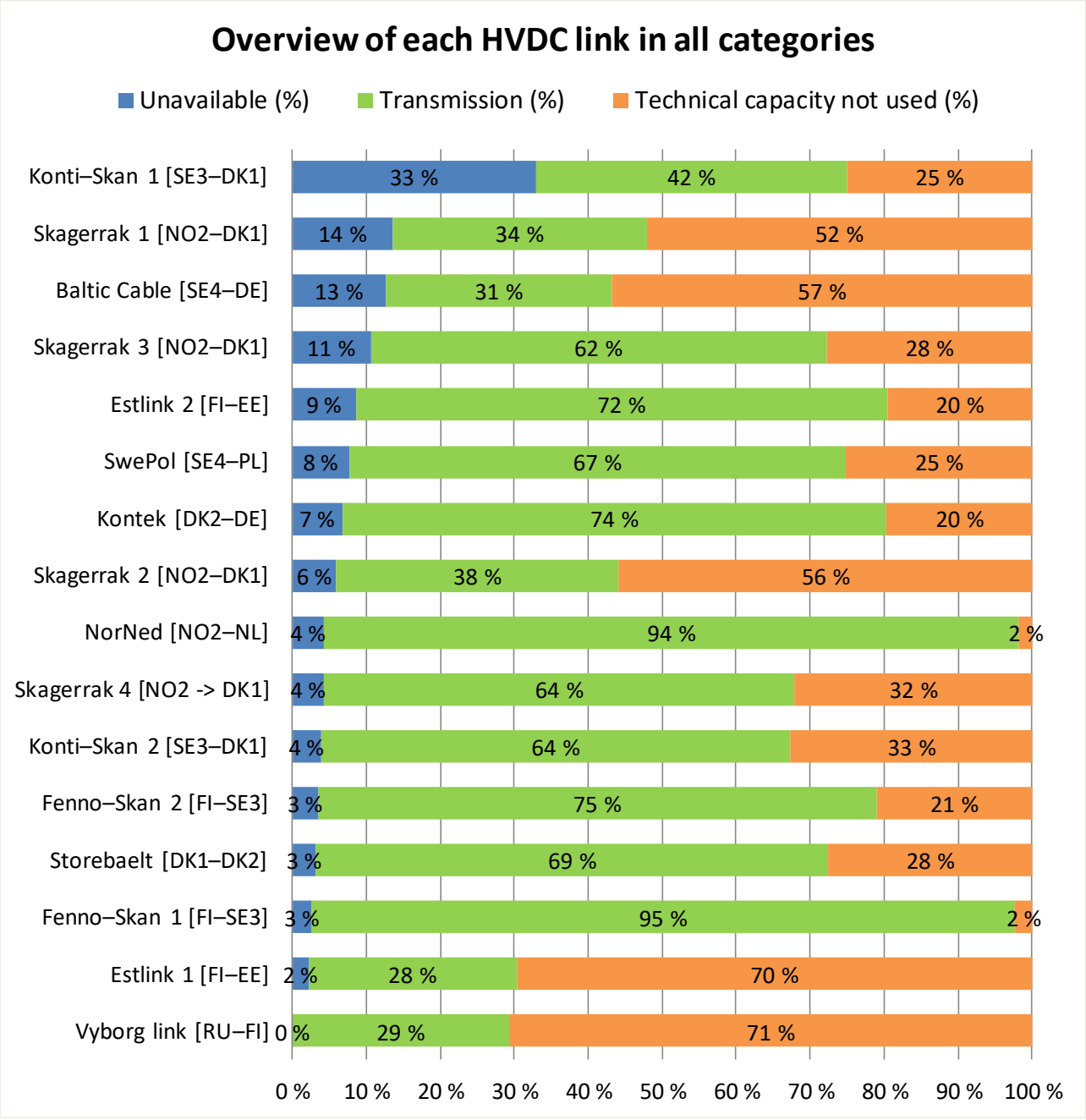


**FIGURE C-1 ANNUAL OVERVIEW OF EACH HVDC LINK SORTED BY DESCENDING UNAVAILABLE TECHNICAL CAPACITY ($E_U$) IN 2015**

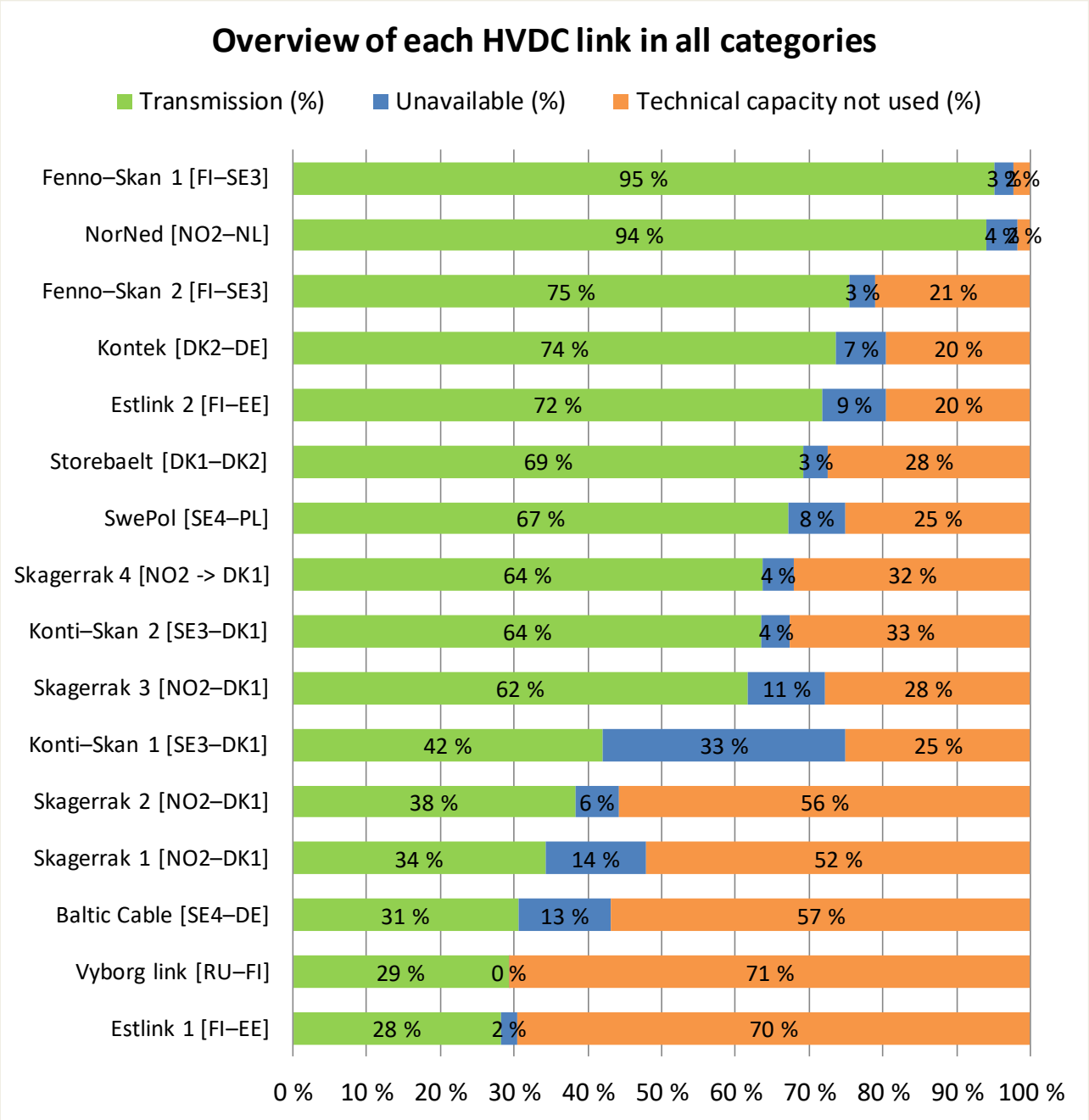


**FIGURE C-2 ANNUAL OVERVIEW OF EACH HVDC LINK SORTED BY DESCENDING TRANSMISSION ($E_T$) IN 2015**

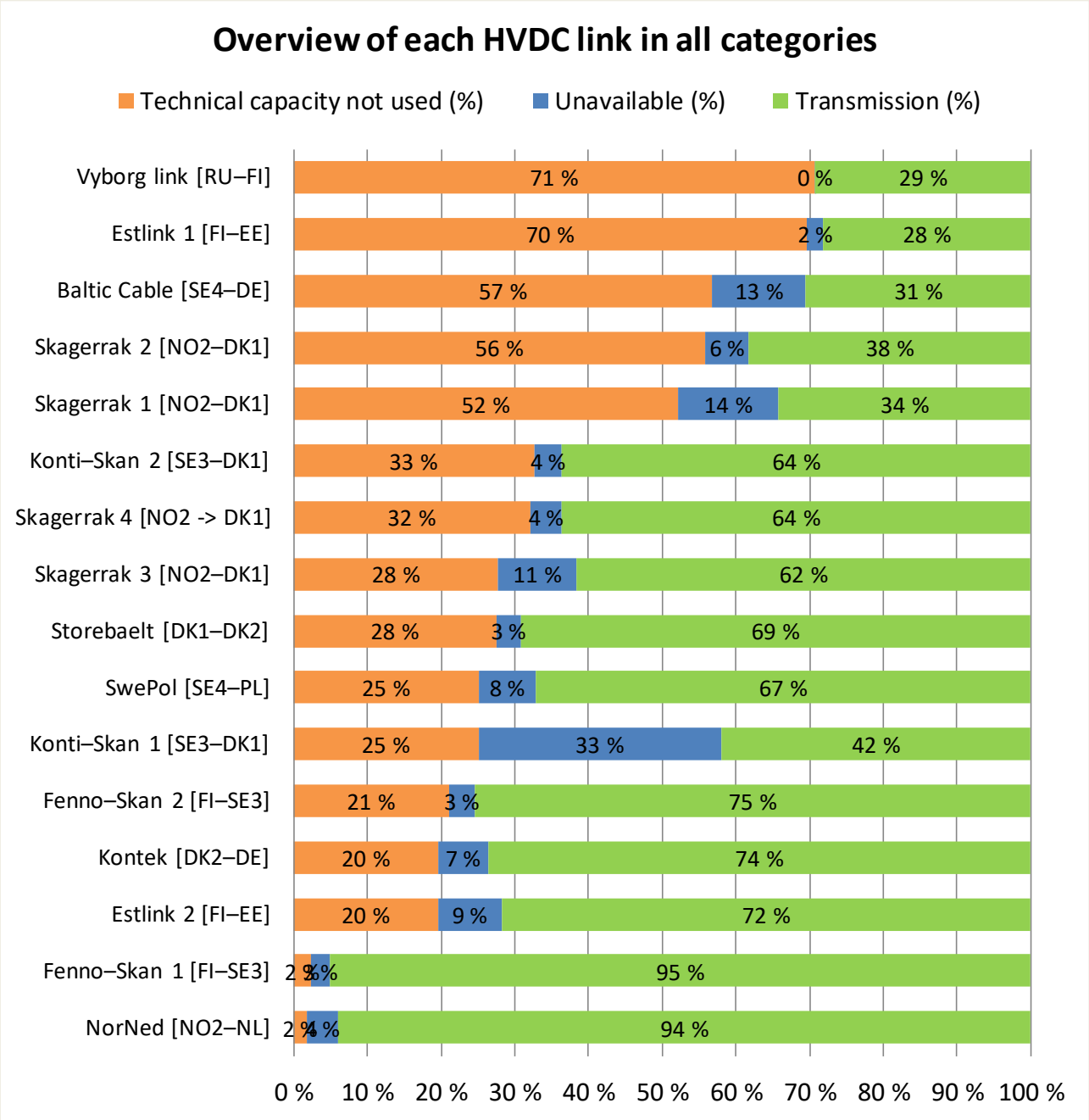


**FIGURE C-3 ANNUAL OVERVIEW OF EACH HVDC LINK SORTED BY DESCENDING TECHNICAL CAPACITY NOT USED ($E_{TCNU}$) IN 2015**