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2nd CEER Report on Power Losses

Energy Quality of Supply Work Stream

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INFORMATION PAGE

Abstract

This document (C19-EQS-101-03) is a Report on Power Losses from the Council of European Energy Regulators (CEER).

This report provides an overview of power losses (transmission and distribution) in electrical grids – the levels of losses, how they are defined, calculated and valued across 35 European countries. It is packed with key quality data such as the amount of technical and non-technical losses, losses in transmission and distribution systems, and procurement of losses. It also includes case studies on the reduction of contact voltage losses in the UK and the treatment of power losses by e-distribuzione in Italy. Reducing power losses contributes to greater energy efficiency and security of supply and is an important goal, not least because the costs of power losses are often passed on to consumers. This report contains a set of recommendations for good practices that could be adopted so as to better benchmark and reduce technical and non-technical losses. CEER's findings and recommendations are based on the results of a questionnaire sent to National Regulatory Authorities (NRAs).

Target audience

European Commission, CEER Members, National Regulatory Authorities (NRAs), Transmission System Operators (TSOs), Distribution System Operators (DSOs), Independent System Operators (ISOs), energy suppliers, traders, electricity customers, electricity industry, consumer representative groups, network operators, Member Countries, academics and other interested parties.

Keywords

Power Losses; Transmission; Distribution; Energy Efficiency Directive; Transmission Grid; Distribution Grid; Electrical Grid; Cross-Sectoral; Networks; Energy Efficiency; Market Monitoring; National Regulatory Authorities (NRAs); Transmission System Operators (TSOs); Distribution System Operators (DSOs); Independent System Operator (ISO); Independent Transmission Operator (ITO); Distributed Generation; Smart Meters

**** Please note that the report published on 23 March 2020 replaces the version published on 21 February 2020 largely due to some corrections of data from the Republic of Ireland, more information can be found here.**

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Related documents

CEER Documents

- CEER Report on Power Losses, October 2017, Ref. C17-EQS-80-03.
- CEER Benchmarking Report 6.1 on the Continuity of Electricity and Gas Supply, July 2018, Ref. C18-EQS-86-03.
  6th CEER Benchmarking Report on the Quality of Electricity and Gas Supply, September 2016, Ref. C16-EQS-72-03.

External Documents

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Table of contents

EXECUTIVE SUMMARY 6

1 INTRODUCTION 10

1.1 Background 10

1.2 Coverage and structure 10

2 OVERVIEW 11

2.1 Definition of losses 11

2.2 Determining losses 12

2.3 Level of losses 13

2.4 Additional analysis 25

2.5 Procurement of losses 29

2.6 Regulatory treatment of losses 32

2.7 Case study: Analysis of contact-voltage losses in low-voltage electricity distribution systems of the United Kingdom 37

2.8 Case study: e-distribuzione's treatment of power losses in Italy 40

3 CONCLUSIONS 41

ANNEX 1 – LIST OF ABBREVIATIONS 43

ANNEX 2 – LIST OF COUNTRY ABBREVIATIONS 45

ANNEX 3 – FACT SHEETS 47

ANNEX 4 – DATA 153

ANNEX 5 – ABOUT CEER 165

List of figures

Figure 1: Transmission losses as % of injected energy 16
Figure 2: Transmission losses as % of injected energy 17
Figure 3: Distribution losses as % of injected energy 18
Figure 4: Distribution losses as % of injected energy 19
Figure 5: Total losses as % of injected energy 20
Figure 6: Total losses as % of injected energy 21
Figure 7: Transmission losses as % of injected energy 22
Figure 8: Distribution losses as % of injected energy 23
Figure 9: Total losses as % of injected energy 24
Figure 10: Distribution losses (MWh) per kilometre of distribution lines 26
Figure 11: Distribution losses (MWh) per number of metering points in distribution 27

Figure 12: Distribution losses (%) as a function of the share of cables in distribution (%) 28
Figure 13: Distribution losses (%) as a function of revenues per km of lines in distribution .. 28
Figure 14: Distribution losses (%) as a function of km per metering point in distribution....... 29

List of tables

Table 1: Inclusion of non-technical power losses 11
Table 2: Components of non-technical losses included in definition........ 12
Table 3: Measurement/estimation of values used for calculating losses 12
Table 4: Determining losses per voltage level........ 13
Table 5: Unmetered consumption 13
Table 6: Parties responsible for procurement of energy to cover losses........ 30
Table 7: Regulatory incentives to reduce losses in distribution 32
Table 8: Regulatory incentives to reduce losses in transmission........ 33
Table 9: Penetration rate of smart meters for final customers 36
Table 10: Summary results of UKPN's Central London MAAV survey and corresponding estimated electricity losses 37
Table 11: Injections in transmission in GWh 153
Table 12: Withdrawals from transmission in GWh........ 154
Table 13: Injections in distribution in GWh 155
Table 14: Withdrawals from distribution in GWh........ 156
Table 15: Energy injected into distribution grid in GWh........ 157
Table 16: Total losses in GWh........ 158
Table 17: Losses in transmission in GWh 159
Table 18: Losses in distribution in GWh........ 160
Table 19: Low voltage losses in GWh........ 161
Table 20: Total losses in %........ 162
Table 21: Losses in transmission in % 163
Table 22: Losses in distribution in %........ 164

EXECUTIVE SUMMARY

Background

In addition to the 2017 Report[1] by the Council of European Energy Regulators (CEER), the subject of power losses has been analysed several times on a European level in the past decade or so. European Regulators' Group for Electricity and Gas (ERGEG, the predecessor of CEER) conducted a consultation (in 2008) and issued a position paper (in 2009) on the treatment of losses by network operators in Europe. Moreover, the European Commission published a Communication on energy efficiency (in 2014) and a report (in 2015) in support of the implementation of Article 15 of the Energy Efficiency Directive (2012/27/EU[2]) which gives a comprehensive overview of losses across the EU[3].

Subsequently, CEER had decided to publish a dedicated report focusing on this topic, rather than including power losses as a single chapter in another report. The result was the 1st CEER Report on Power Losses which was published in October 2017. It dealt with the definition, causes, calculation, procurement and values of power losses, in addition to the effect of smart meters and distributed generation on losses. That report was based on answers to a CEER questionnaire that were obtained from 27 CEER Member countries and many stakeholders that filled out a dedicated questionnaire.

With the aim of providing an extended and more reliable database and expanding the number of participants, this 2nd CEER Report on Power Losses also includes eight Energy Community Regulatory Board (ECRB) Contracting Parties[4], raising the total number of participants to 35. In addition, it improves the comparability of losses by using an enhanced methodology for calculation of loss percentages in distribution and transmission.

Objectives and contents of the document

As with the first edition of the Power Losses Report, this second edition analyses the way that power losses are defined, calculated, procured and treated by the regulatory framework of the responding countries. Moreover, it statistically investigates the relationship between losses and certain other variables. Most importantly, the report provides comparisons between countries' distribution, transmission and total losses as a percentage of energy injected in their distribution or transmission grid (or a total energy volume injected into a country in case of total losses). Readers should keep in mind that definitions of distribution and transmission grids are not standardised and that the voltage levels included in each differ across Europe.

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1 "CEER Report on Power Losses", October 2017, Ref. C17-EQS-80-03. https://www.ceer.eu/1271

2 "Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC", Official Journal of the European Union, November 2012. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN. Please note that this Directive has been amended by the new Energy Efficiency Directive published in 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0210.01.ENG

3 "Identifying energy efficiency improvements and saving potential in energy networks, including analysis of the value of demand response", Tractebel Engineering, Ecofys, December 2015. https://ec.europa.eu/energy/sites/ener/files/documents/GRIDEE_4NT_364174_000_01_TOTALDOC%20-%2018-1-2016.pdf

4 Of which many are also CEER Observer countries.

As a result of a 2019 CEER questionnaire, input from National Regulatory Authorities (NRAs) of 35 countries was received, eight of which are ECRB Contracting Parties. Analysis of responses revealed that there are significant differences in the treatment of losses among the responding countries.

The easiest way to categorise losses is to divide them into technical and non-technical components. The former is a consequence of the laws of physics and, although it could be reduced with more efficient equipment, it cannot be fully and economically eliminated with current technology. The latter component consists of the energy delivered but not metered or billed and often depends on socio-economic conditions of a country. Non-technical losses can be further broken down into multiple subcomponents, some of which are not considered to be part of power losses in every country due to differing definitions.

The lack of harmonised definitions and rules regarding the components included in losses presents an obstacle to straightforward benchmarking across Europe. Most responding countries simply consider power losses to be the difference between the energy injected into and withdrawn from the grid.

Losses in transmission grids are percentagewise generally lower than their distribution counterparts due to the fact that higher voltages in transmission result in lower current, the outcome of which are lower technical losses. In transmission, losses are mostly metered (or calculated from variables that are metered) whereas they are often estimated in distribution.

In this report, losses are presented as a percentage of injected energy. In transmission, this includes all energy injected in transmission system including energy imported from other countries and generation connected to transmission. Energy injected in distribution includes energy that was passed on from transmission in addition to energy injected by generation connected directly to distribution grid. Total injections in any given country consist of injections in transmission in addition to those by generation connected to distribution. This approach made sure that no energy was counted twice and that the calculated percentages portray the accurate values in each country.

Losses in transmission vary between about 0.5% and just under 3% in 2018, which was the most recent year the data was obtained for (in very few countries, older data was used due to unavailability of 2018 values). As explained above, the percentages in distribution are higher and vary between approximately 2% and 14% in 2018, not counting a specific case in Kosovo*[5] (28% in 2018) which is described in more detail in section 2.3. Finally, total losses in 2018 range between 2.5% and 11% (not counting 25% in 2018 in Kosovo*).

Nearly everywhere in Europe, system operators are tasked with forecasting losses in their grids and procuring the energy to cover them. In a few cases, different parties are responsible for procurement of losses in transmission and in distribution within the same country. The associated cost is included in network tariffs in most countries. On the other hand, there is a minority of cases where suppliers or market participants are responsible for covering the cost.

[5] Throughout this document, the term "Kosovo*" refers to the following statement: This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Advisory Opinion on the Kosovo declaration of independence.

Twenty responding countries have implemented incentives to reduce losses in distribution, while a few others are planning to introduce them in the future. Incentives to reduce losses in transmission are implemented in only 13 responding countries. One probable cause is that, unlike in distribution, losses in transmission are mostly technical and are hence, more difficult to reduce.

Brief summary of the conclusions

There are different definitions of power losses across Europe, but they are usually understood as the difference between the energy flowing into a grid and energy flowing out of it. There are very few countries that included only technical losses in the values submitted for this report. Those that include non-technical losses often include some of the possible components but not all of them. These components are included in distribution more often than in transmission, as losses in transmission are generally of technical origin. Harmonisation of definitions of power losses (or at least an agreement on which components are included in reported losses) would simplify comparison and enable proper benchmarking among countries.

Reduction of power losses is an important contributor to improvement of energy efficiency and decrease of operational expenses of power grids. Many countries employ incentives that enable NRAs to ensure that system operators limit or reduce the volume of losses and the cost of energy necessary to cover them. Incentives should be set efficiently with appropriate target and timeframe, otherwise they could have unintended consequences on system operators. Different regulatory approaches could be implemented for technical and non-technical components of losses, provided that more data on non-technical losses are available. In addition, parties responsible for procurement of energy to cover losses should be incentivised to make this process as economical and efficient as possible.

Technical losses could be reduced by implementing newer or more efficient transformers or by operating higher voltages in distribution grids, among other possible approaches. The higher voltage in distribution might be the reason for relatively low losses in countries where this type of operation is common. Non-technical losses will most likely decrease with increased penetration of smart meters. They reduce metering errors and improve identification of fraud which leads to a more accurate measurement of electricity consumption. Most countries where smart meters have already been introduced reported a significant improvement in the measurement accuracy of losses along with a reduction of losses in general. Before a full roll-out or a significant expansion of smart meters, countries with low penetration rate should increase monitoring and raise knowledge and awareness of non-technical losses.

Key recommendations

1. Harmonise definitions of power losses in order to simplify comparison and enable proper benchmarking among countries.

2. Incentivise parties responsible for procurement of energy to cover losses to make this process as economical and efficient as possible.

3. Ensure that the incentives in (2.) are set efficiently with an appropriate target and timeframe so as to avoid unintended consequences on system operators.

4. Move toward greater required transparency on technical and non-technical components of losses so as to facilitate proper regulatory treatment of those losses.

5. Where appropriate, implement newer or more efficient transformers and/or operate higher voltages on distribution grids in order to reduce technical losses.

6. Incorporate the reduction of non-technical losses in calculating the benefits of smart meter roll-out, such that smart metering is further encouraged.

7. Increase monitoring of non-technical losses with a view to gauging the effectiveness of potential solutions, such as increased penetration of smart meters.

1 Introduction

1.1 Background

Power losses are a component of every electrical grid and originate as a consequence of transmission and distribution of electricity. They constitute a significant amount of energy flows in transmission and distribution. Improvement of energy efficiency and grid reliability, in addition to economic and environmental benefits, are some of the major positive aspects of the reduction of power losses.

Article 15 of Directive 2012/27/EU[6] on energy efficiency, states that the "[EU] Member States shall ensure that network operators are incentivised to improve efficiency in infrastructure design and operation" and that the "[EU] Member States shall ensure that national energy regulatory authorities pay due regard to energy efficiency in carrying out the regulatory tasks specified in Directives 2009/72/EC and 2009/73/EC regarding their decisions on the operation of the gas and electricity infrastructure". In addition, European Commission published a Communication on energy efficiency in 2014[7], noting the need to reduce the volume of network losses to achieve the 2030 objective.

While there had been some publications on power losses on a European level in the past, the first Report on Power Losses by CEER was published in October 2017. The report was based on a 2016 questionnaire sent to National Regulatory Authorities and stakeholders and focused on the treatment of losses as well as special topics such as the impact of smart meters (SM) and distributed generation.

1.2 Coverage and structure

This second edition of the report is based on responses to the 2019 CEER questionnaire on power losses sent to National Regulatory Authorities. This time eight ECRB Contracting Parties have responded in addition to CEER Member States resulting in increased participation and better overview of the current situation across the continent. Thus, an analysis of the level and general treatment of losses in electricity networks of 35 European countries was conducted. These are: Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Kosovo*, Latvia, Lithuania, Luxembourg, Malta, Moldova, Montenegro, The Netherlands, North Macedonia, Norway, Poland, Portugal, Serbia, Slovakia, Slovenia, Spain, Sweden and Ukraine.

As in the first CEER Report on Power Losses, the objective is to make an inventory of the treatment of losses in Europe (definition, determination, levels, procurement and regulatory treatment) and to present CEER's main findings and recommendations. Each aspect of losses is presented in an individual section throughout this report. Moreover, a more-detailed analysis

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[6] "Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC", Official Journal of the European Union, November 2012. Please note that this Directive has been amended by the new Energy Efficiency Directive published in 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0210.01.ENG

[7] "Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy", The European Commission, July 2014, https://eur-lex.europa.eu/resource.html?uri=cellar:f0db7509-13e5-11e4-933d-01aa75ed71a1.0003.03/DOC_1&format=PDF

of practices in certain countries are included in the form of case studies. Finally, short country-specific fact sheets and additional graphs are presented in the annex.

2 Overview

2.1 Definition of losses

Power losses are usually understood as the difference between the energy flowing into a grid (injections) and energy flowing out of it (withdrawals). Injections consist of not only electricity generated and fed into the transmission (and increasingly distribution) system but also of energy imports from other countries. Conversely, energy withdrawals consist of not only consumption by customers (large and small) but also exports across the border, at least when analysing losses in individual countries.

The 1st CEER Report on Power Losses already analysed definitions in detail. The most common way to categorise losses is to divide them into technical and non-technical losses. While technical losses are a result of the laws of physics and are unavoidable, non-technical losses refer to energy delivered or consumed but not recorded by a meter. Responses to the questionnaire have shown that there are a few countries where only technical losses are included in the values they publish, while in others (such as Denmark and Norway), non-technical losses are implicitly included in overall losses as no distinction is made between technical and non-technical components. As seen in Table 1 most countries include non-technical losses either in distribution or both in distribution and transmission[8].

Option	No. of responses	Countries
No	(4)	DE, EE, LU, MD
Yes, in transmission and distribution	(21)	AT, BA, BE, CZ, DK, EL, ES, FI, FR, GB, GE, HU, IE, LV, NL, NO, PL, PT, RS, SE, SI
Yes, only in distribution	(10)	CY, HR, IT, KS*, LT, ME, MK, MT, SK, UA

Table 1: Inclusion of non-technical power losses

Typical components of non-technical losses are presented in Table 2, along with countries where the definition of non-technical losses includes these components. Only a few countries include all four types mentioned in this questionnaire in their definition of overall losses. The majority of the reporting countries include some of the components of non-technical losses but not all of them, which indicates that the comparison of losses might not always be straightforward.

[8] Readers should keep in mind that definitions of distribution and transmission grids are not standardised and that the voltage levels included in each differ across Europe.

Type of losses included	No. of responses	Transmission	No. of responses	Distribution
Hidden losses	(14)	AT, BA, DK, EL, FI, FR, GE, IE, LU, MD, NL, PL, RS, SE	(23)	AT, BA, BE[9], CY, DK, EL, ES, FI, FR, GE, HR, HU, IE, KS*, LU, MD, MK, MT, NL, PL, RS, SE, SI
Non-metered consumption	(9)	BA, DK, FR, GB, LV, MD, PL, SE, SI	(17)	BA, BE[9], CZ, DK, ES, FR, GB, HU, KS*, LU, LV, MD, MT, PL, RS, SE, SI
Theft	(19)	AT, BA, BE, CZ, DE, DK, EE, EL, FI, FR, GB, HU, IE, LV, NL, PL, PT, SE, SI	(33)	AT, BA, BE, CY, CZ, DE, DK, EE, EL, ES, FI, FR, GB, HR, HU, IE, IT, KS*, LT, LU, LV, MD, ME, MK, MT, NL, NO, PL, PT, RS, SE, SI, SK
Others[10]	(23)	AT, BA, BE, CZ, DK, EE, EL, FI, FR, GB, GE, HU, IE, LU, LV, MD, ME, NL, PL, PT, RS, SE, SI	(31)	AT, BA, BE, CY, CZ, DK, EE, EL, ES, FI, FR, GB, GE, HR, HU, IE, IT, KS*, LT, LU, LV, MD, ME, MT, NL, PL, PT, RS, SE, SI, SK

Table 2: Components of non-technical losses included in definition

2.2 Determining losses

As in the 1st CEER Report on Power Losses, the majority of respondents determine losses in their countries by subtracting electricity withdrawals (by final customers and other networks) from electricity injections (from generation and other networks). Out of 35 respondents, only four countries did not specify that they use this methodology (Germany, Hungary, Malta and Moldova). Even though they calculate their losses through the aforementioned way, countries such as Great Britain and Greece have additional calculations for specific parts of the network.

When determining losses, the required input values can be estimated or measured. For most countries, those values are measured on EHV and HV, but estimated on (parts of) MV and LV networks. Naturally, most countries responded that they both measure and estimate values used to calculate losses, as seen in Table 3.

Option	No. of responses	Countries
Measure	(5)	MK, NO, PT, RS, SE
Estimate	(7)	FI, IT[11], ME, MT, PL, SI, UA
Both	(23)	AT, BA, BE[12], CY, CZ, DE, DK, EE, EL, ES, FR, GB, GE, HR, HU, IE, KS*, LT, LU, LV, MD, NL, SK

Table 3: Measurement/estimation of values used for calculating losses

This also leads to 7 countries (Austria, Czech Republic, Greece, Great Britain, Hungary, Malta and the Netherlands) reporting different methodologies for determining losses per voltage level based on measurement versus estimation, out of 14 with different methodologies per voltage level. Categorised responses are presented in Table 4.

9 Only Flanders and Brussels regions.
10 Such as metering errors, differences in metering, billing, and data processing.
11 Standard losses are estimated (pre-set target level).
12 Estimation for Wallonia region, measurement for other regions.

Option	No. of responses	Countries
Yes, same method	(13)	BA, BE[13], CY, FR, GE, IE, IT, ME, NO, PL[14], PT, SK, UA
No, different method	(14)	AT, CZ, DE[15], DK, EE, EL, GB, HU, KS*, LU, LV, MD, MT, NL
No calculations per voltage level	(7)	ES, FI, HR, MK, RS, SE, SI

Table 4: Determining losses per voltage level

When considering measurement and estimation of values used in determining losses, it is also important to know of any national rules/obligations for having meters for each final customer. As shown in Table 5, responses on unmetered consumption are evenly divided among countries.

Option	No. of responses	Countries
No	(16)	AT, CY, DK, EE, EL, ES, GE, HR, IE, IT, ME, MK, NO, PT, RS, SI
Yes	(16)	BE[16], CZ, DE, FR, GB, HU, LT, LU, LV, MD, MT, NL, PL, SE, SK, UA

Table 5: Unmetered consumption

Regarding new developments in calculation of losses, Greece has increased the number of LV connected load and generation facilities that employ advanced metering, leading to an overall increase in data quality used for calculating losses. In Cyprus, the TSO's station transformers are now considered to be part of electricity withdrawals, according to the new legislation. Their DSO has developed a methodology for estimation of distribution losses, which was approved by the regulator.

Italy introduced a new regulation in 2016, which further expands the usage of standard loss factors to non-technical losses, introduces measures for mitigating non-technical losses and differentiates standard losses (a pre-set target level) on the basis of different operating conditions of the network. Furthermore, the Italian NRA ARERA intends to review the standard loss factor taking into account the detection and mitigation of commercial losses by DSOs and the influence of distributed generation. Hungary plans to develop a new methodology for estimating the level of technical losses on the distribution network because of the emerging penetration of solar power plants.

2.3 Level of losses

When analysing data, it is important to remember that there are differences in the way losses are defined across Europe. This means that the components might not be the same and what is considered a loss in one country, might be considered delivered energy in another. This should always be kept in mind when making direct comparison between countries.

[13] For federal transmission and distribution in Wallonia. No data for other distribution regions.
[14] Except for purposes of regulation.
[15] Since every method is allowed, the methods may vary from situation to situation.
[16] In transmission every final customer is metered, but there are some customers on distribution which are not metered.

Losses in the following figures are presented as a percentage of injected energy even in countries where losses are typically calculated as a percentage of withdrawn energy (as is the case in Slovenia). The reasoning behind this is that losses occur before energy reaches customers and thus focusing on percentage of withdrawn energy would be equivalent to discarding a share of losses. Therefore, only injected energy was used in calculations performed to obtain any percentages presented in this report. In transmission, this includes all energy injected in the transmission system including imported energy from other countries and generation connected to transmission. Energy injected in distribution includes energy that was passed on from transmission in addition to energy injected by generation connected directly to distribution grid. Total injections in any given country consist of injections in transmission in addition to those by generation connected to distribution. This made sure that no energy was counted twice and that the calculated percentages portray the accurate values in each country.

Since 35 countries provided data for this report, it was decided to split them into two groups in each time series figure. This has no effect on data and was done only for reasons of clarity. The analysed timeframe was between 2010 and 2018 and includes values for each year for which data was obtained. Some countries were excluded from certain figures. Malta does not operate a transmission grid, which means that their total losses are equal to their losses in distribution. Great Britain was unable to separately provide energy injected in transmission and distribution and was therefore, not included in percentage calculations. They are, however, included in figures and tables in Annex 3 and Annex 4 where losses are also presented as absolute numbers.

Losses in transmission vary between about 0.5% and just under 3% in the latest available year (2018). For clarity, the countries were divided into those where transmission losses did not exceed 2% in any year in the times series and those where the threshold of 2% was exceeded in at least one year since 2010.

While many countries show a decreasing trend in distribution, losses have increased over time in Spain, Finland and Greece. The largest reduction is evident in Kosovo* which managed to cut down their distribution losses by a third between 2010 and 2018. Their distribution losses are still very high (approx. 28% in 2018) compared to those of the most efficient countries (approx. 2%). In Kosovo*, most power generating plants are at the end of their technical life as there has been very little construction of new generation capacities since the 1980s. Most of the recent capital investments have been oriented towards electricity generation in order to improve the electricity supply. There were improvements initially, but these were followed by new issues, either due to lack of generation or technical problems in the grid. In order to encourage new investments, the distribution grid in Kosovo* has been privatised. From 2013 to 2018, around 121 million euros were invested in the grid, resulting in a significant reduction of losses. A similar target to decrease the level of losses is in effect in the current investment plan (2018-2022) during which investments will amount to 131.4 million euros. Non-technical losses in Kosovo* are still quite high and represent a significant percentage of their total losses. One of the reasons for this is unbilled energy in the northern municipalities which is, due to political situation, treated as power losses.

In Finland, some DSOs operate high voltage lines which might be the reason for relatively low losses despite the high length of distribution power lines. French distribution values include only data from the DSO Enedis, which constitutes 95% of distribution grid in France. Similarly, Greek data do not include non-interconnected islands. In Lithuania, total losses and transmission losses appear to be nearly identical. The reason for this is that both the distribution losses (in absolute terms) and injections by generation connected directly to distribution are very low (less than 1 GWh in either case) making them nearly negligible compared to losses and injections in transmission. As consequence, the total and transmission losses have very similar values in Lithuania. Distribution losses, as expected, are significantly higher percentagewise.

The boxplot figures below include all countries in each figure provided that data was available. Without illustrating development of losses over time, they instead indicate the minimum, maximum and average values as well as the latest available value. In most cases, this applies to 2018 but the latest available values for distribution (and total) losses in Greece and for total losses in Finland were from 2017 and 2015, respectively.

In order to ensure reliable benchmarking, countries where total injections could not be calculated (those that were unable to provide energy injected by producers connected to distribution) were excluded from the time series and boxplot figures that illustrate total losses. These countries are: Cyprus, Georgia, Germany, Italy, Luxembourg, Moldova, the Netherlands, Slovenia and Ukraine. More information including graphical presentation (with a disclaimer) can be found in Annex 3.

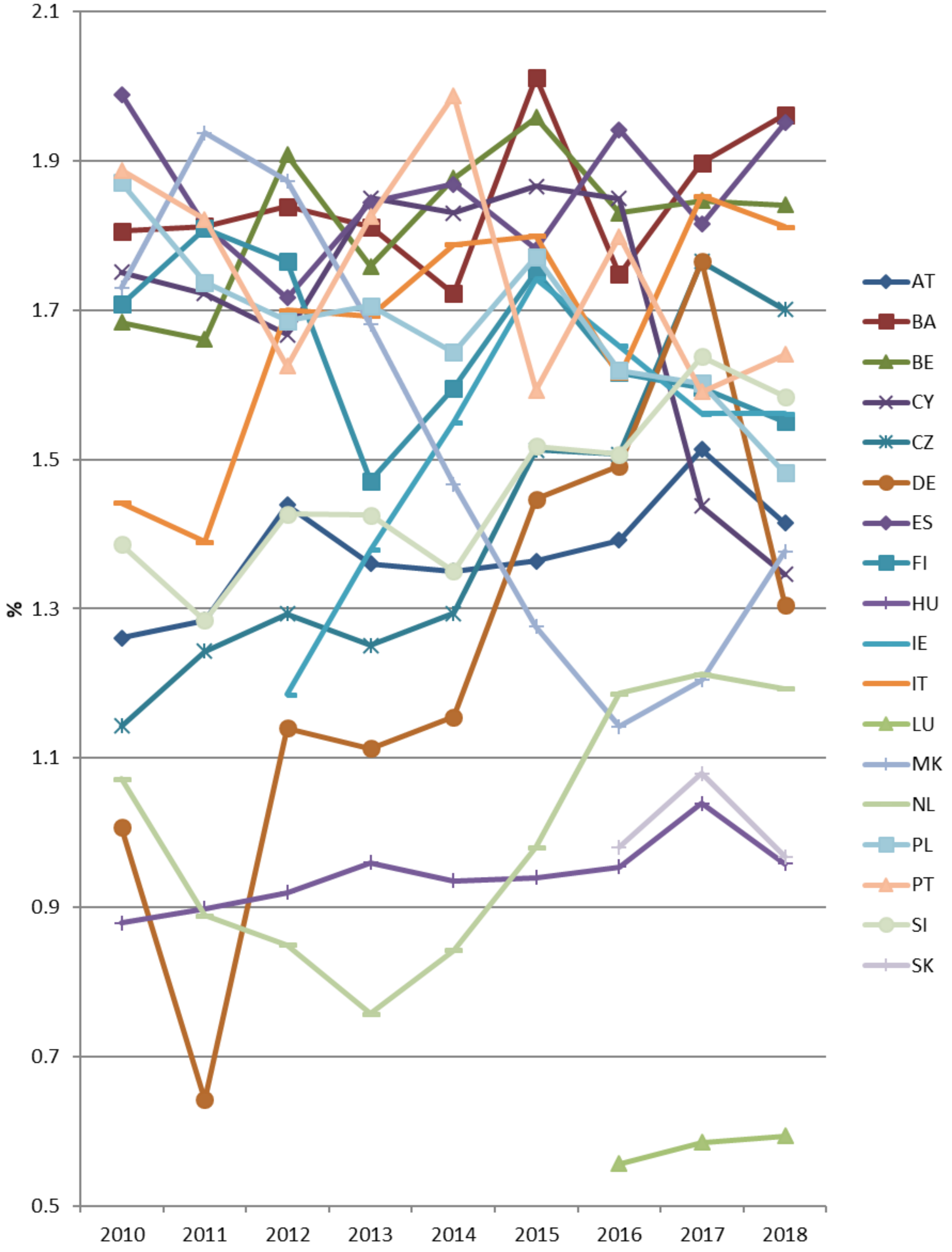


Figure 1: Transmission losses as % of injected energy
(countries not exceeding 2% in any year data was obtained for)

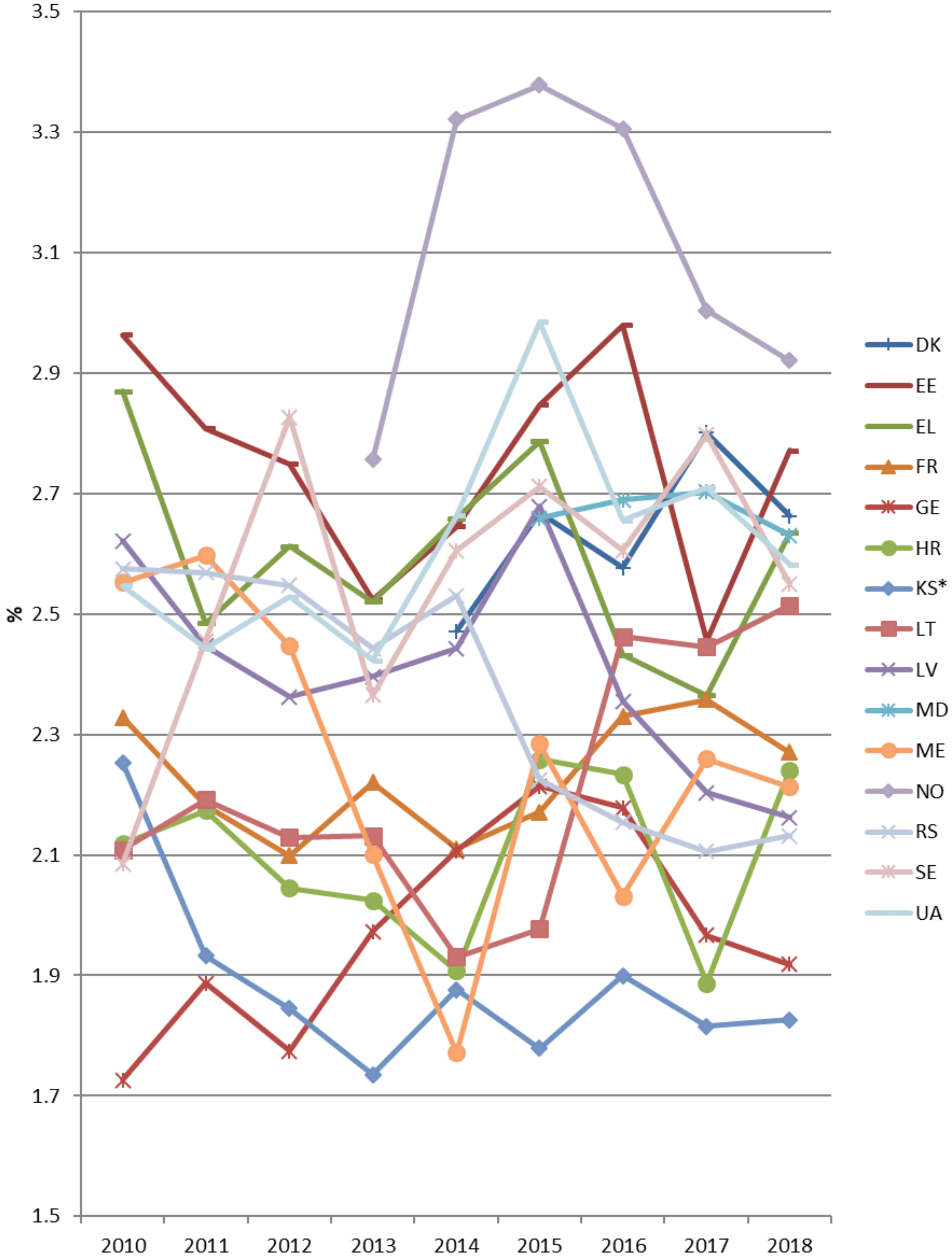


Figure 2: Transmission losses as % of injected energy
(countries exceeding 2% in at least one of the years data was obtained for)

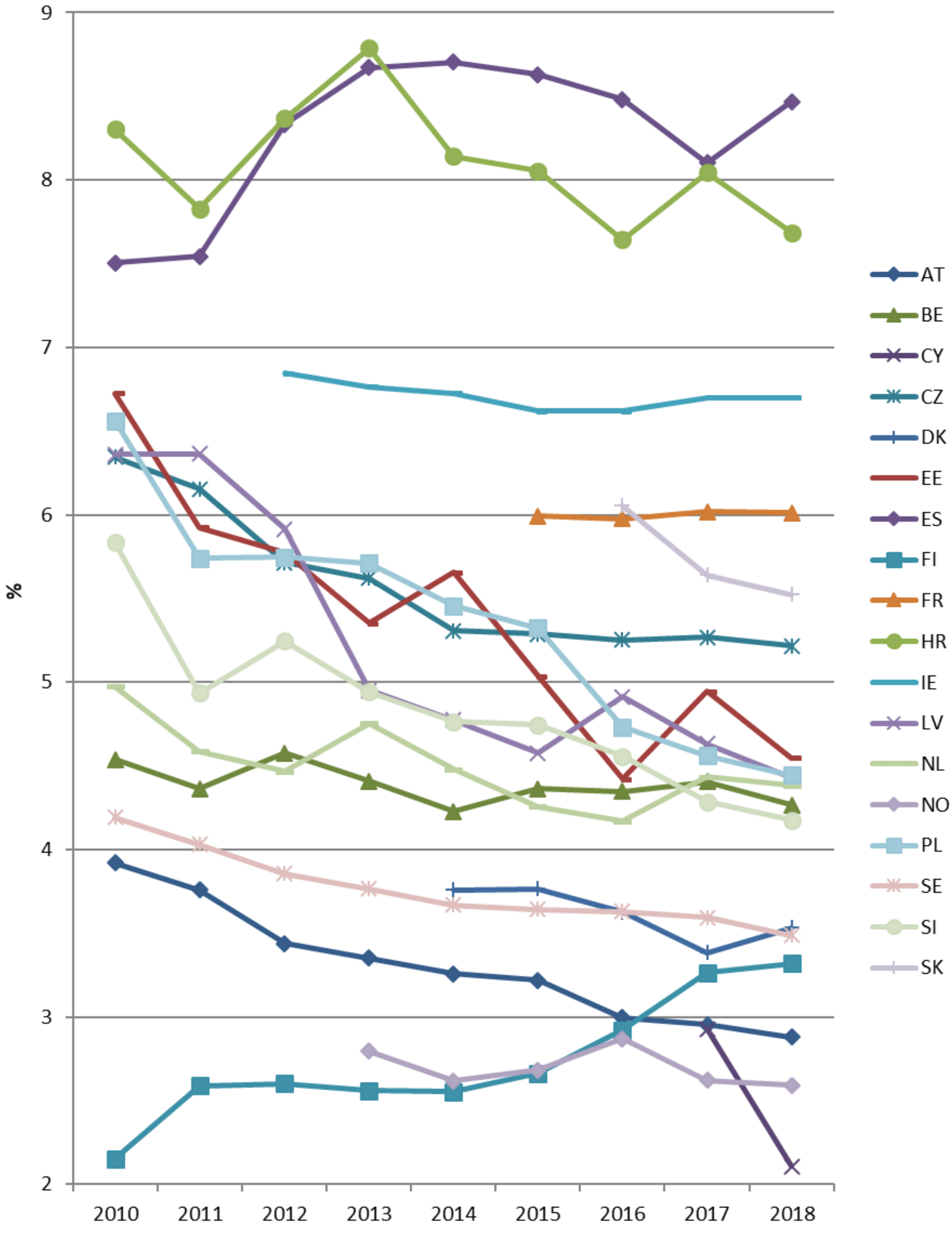


Figure 3: Distribution losses as % of injected energy
(countries not exceeding 9% in any year data was obtained for)

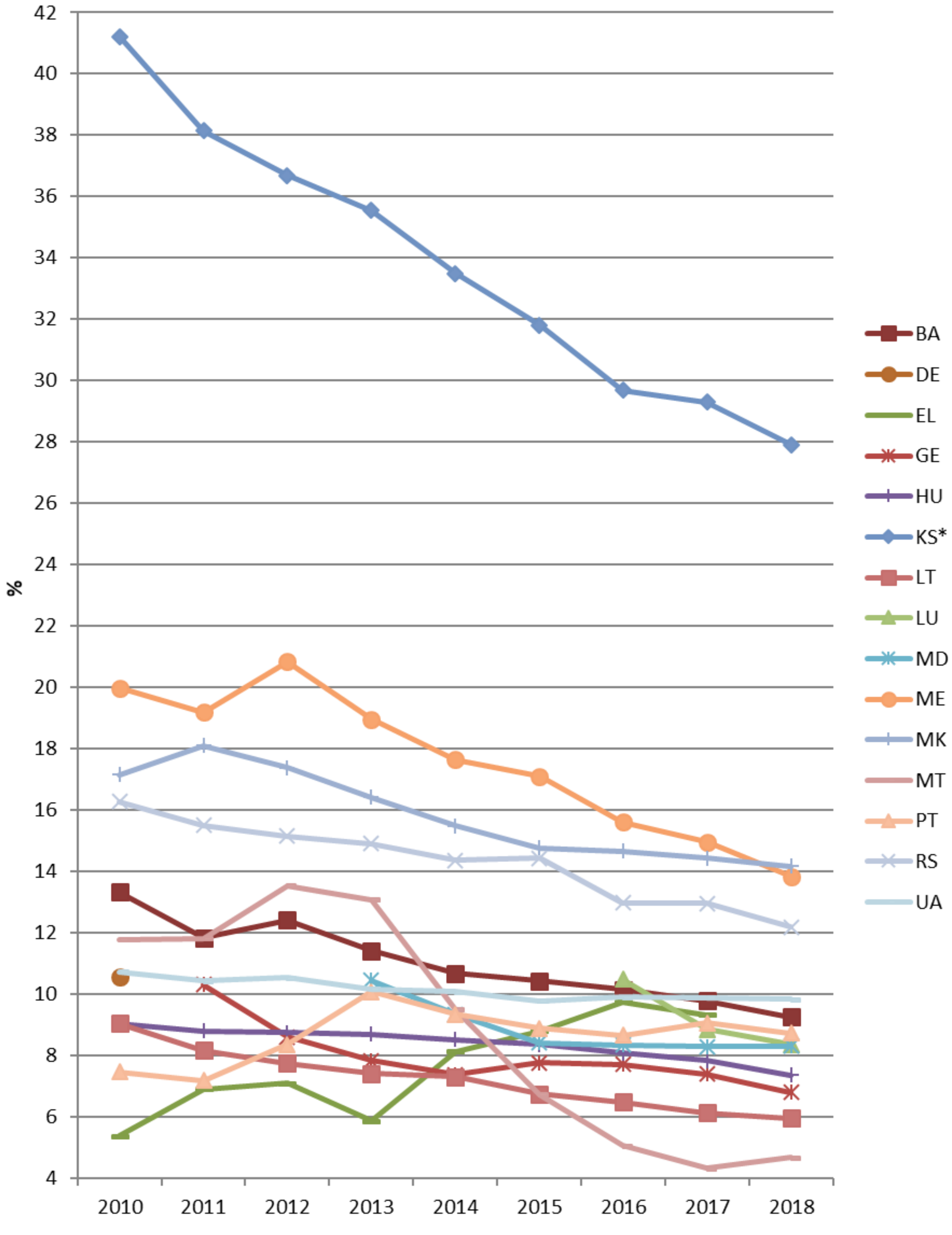


Figure 4: Distribution losses as % of injected energy
(countries exceeding 9% in at least one of the years data was obtained for)

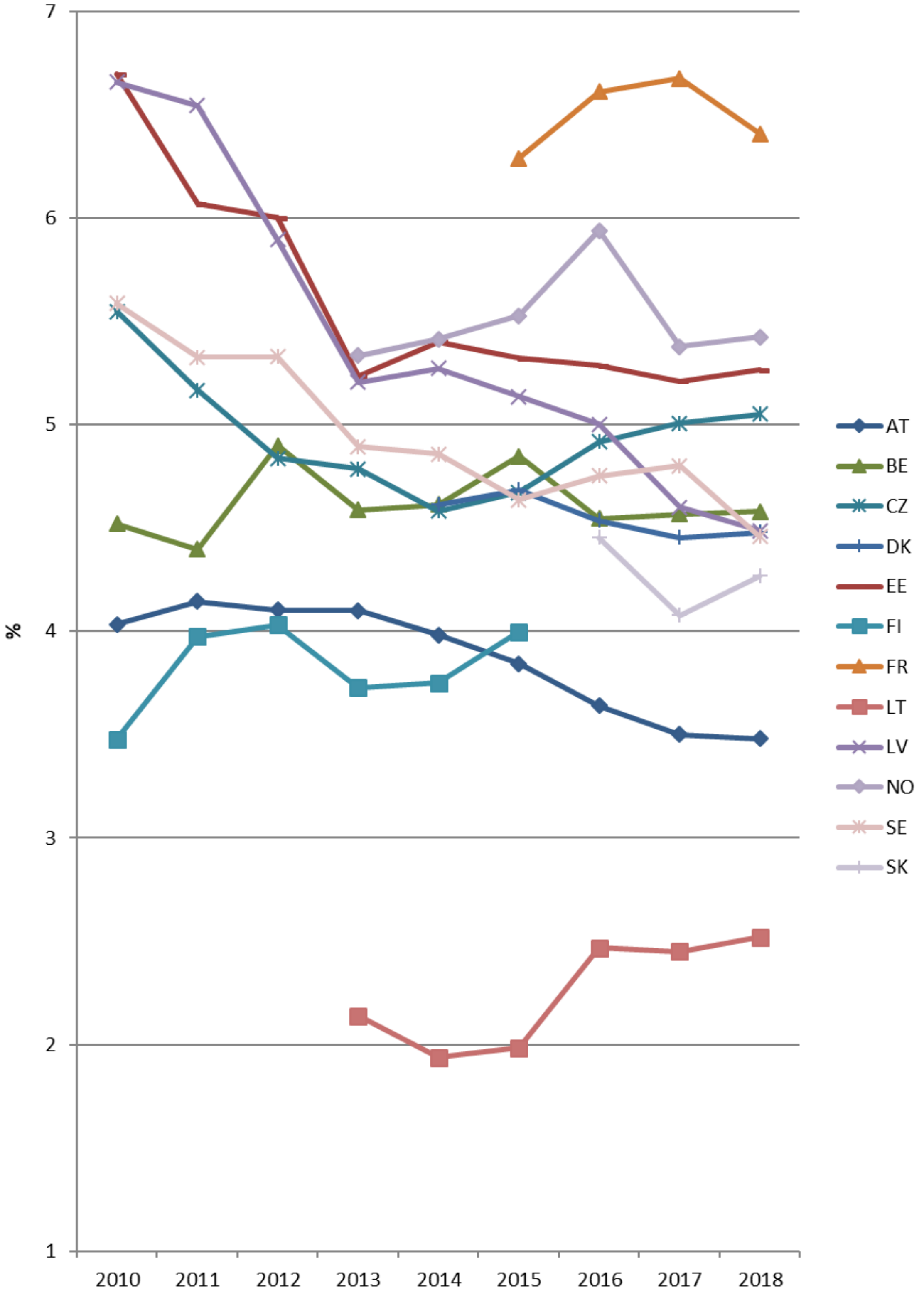


Figure 5: Total losses as % of injected energy
(countries not exceeding 7% in any year data was obtained for)

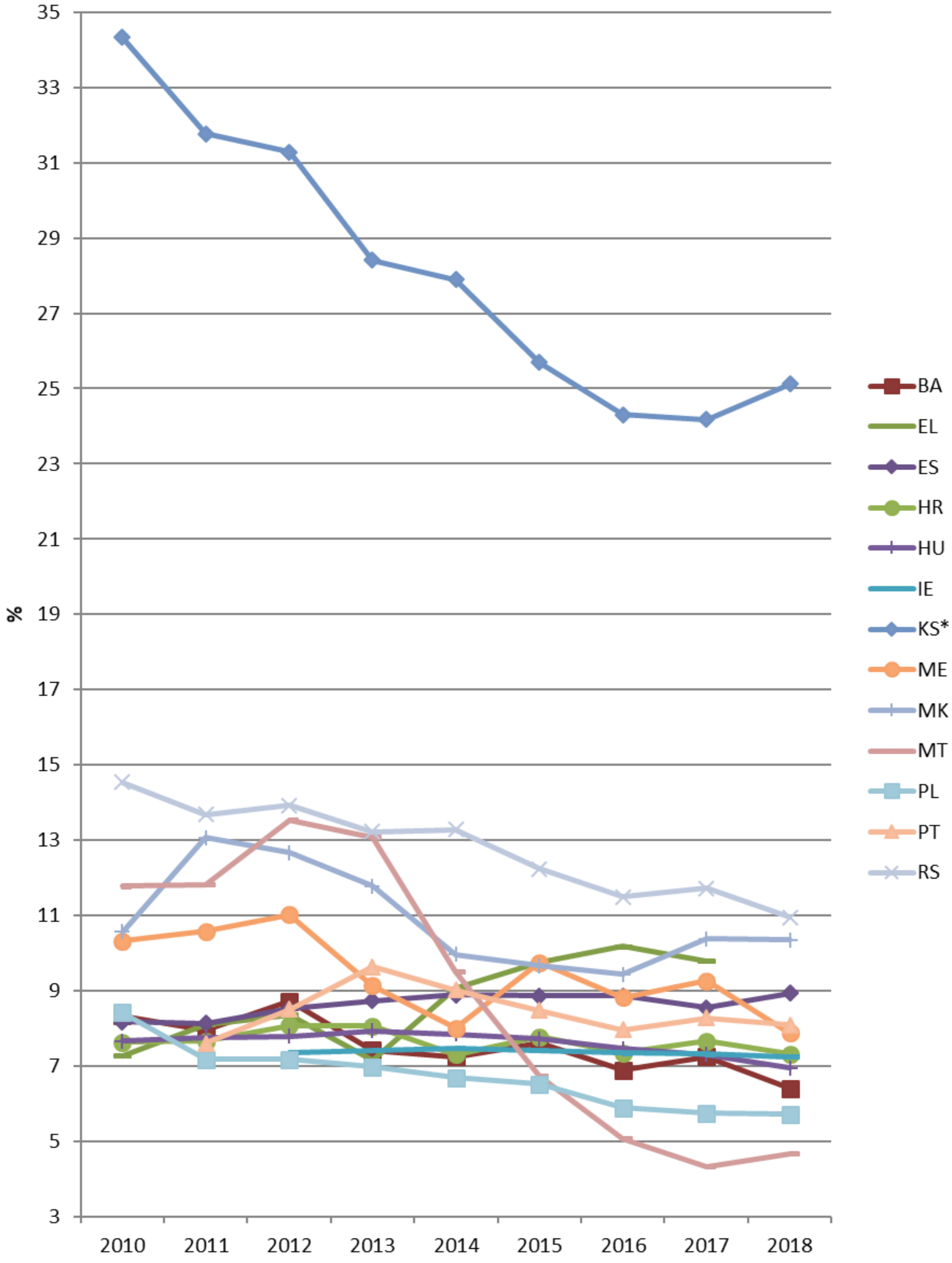


Figure 6: Total losses as % of injected energy
(countries exceeding 7% in at least one of the years data was obtained for)

Figure 7: Transmission losses as % of injected energy

Figure 8: Distribution losses as % of injected energy

Figure 9: Total losses as % of injected energy

2.4 Additional analysis

In addition to questions explicitly dealing with power losses, the 2019 CEER questionnaire included questions about line length, the number of metering points and revenues in each country's distribution system. A basic analysis was performed investigating the relationship between losses in distribution and a few other parameters.

The first two figures in this section represent the losses in MWh per length of lines or the number of metering points in distribution. Without normalising the losses, longer lines would typically result in higher technical losses as energy would have to cover greater distance. Similarly, the higher number of metering points would indicate a higher number of customers which would also add up to higher losses, at least in absolute terms. However, looking into distribution losses divided by another variable, differences between countries are not as striking with a few exceptions including outliers like Kosovo* and Lithuania (whose specific situations were already described). Readers should keep in mind that the length of distribution lines was calculated as the sum of low and medium voltage lines and might not necessarily correspond to actual length of distribution lines if a country includes part (or all) of high voltage in its distribution, as is sometimes the case (Luxembourg, Norway, Romania, Spain, Sweden).

Next, correlation between distribution losses (in percent) and share of cables in distribution was examined for the year 2016 for 21 countries where data was available for (see Figure 12). Cable percentages vary from low (under 30%) to extremely high (nearly 100%). While it is true that countries with higher percentage of cables have less losses on average, the lower losses might be explained by other factors in addition to a high degree of cables in distribution. The correlation coefficient of -0.32 might have been higher if high voltage was considered in countries where HV is part of distribution. Unfortunately, data on cable length in HV networks was not available during the preparation of this report.

Further, losses as a function of DSO revenues per kilometre (km) of lines were analysed (see Figure 13). As above, the goal was to normalise the revenues for easier comparison among countries. The goal was to assess whether system operators with higher revenue invest in more efficient technology that results in lower power losses. A negative correlation coefficient of -0.27 reveals that losses in distribution are indeed lower in countries with higher DSO revenue per km. However, it is also possible to attribute this correlation to other factors.

Finally, losses as a function of kilometres per metering point in distribution were assessed (see Figure 14). Lower distance per metering point represents countries with higher population density and vice versa. The negative correlation of -0.25 signifies that countries with lower population density (Nordic countries, for instance) have lower distribution losses (in percent) even though longer distances between metering points result in higher losses in MWh. It is important to keep in mind that non-technical losses probably have higher share of total losses in countries with higher population density than in those where distances between customers are longer. Since technical losses are proportional to conductor resistance, longer distances between customers (higher total conductor resistance) would result in technical losses having a more prominent share of total losses.

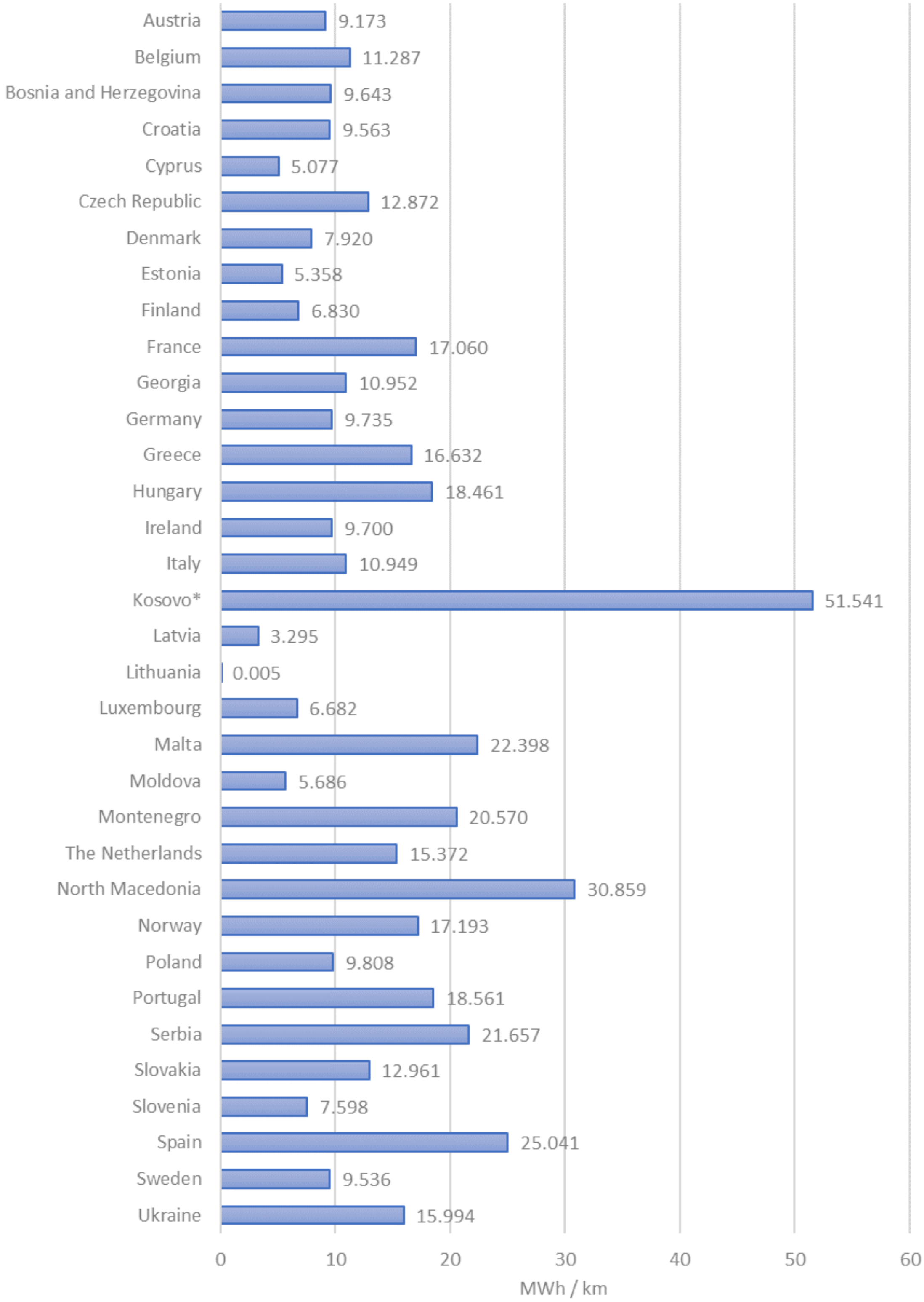


Figure 10: Distribution losses (MWh) per kilometre of distribution lines

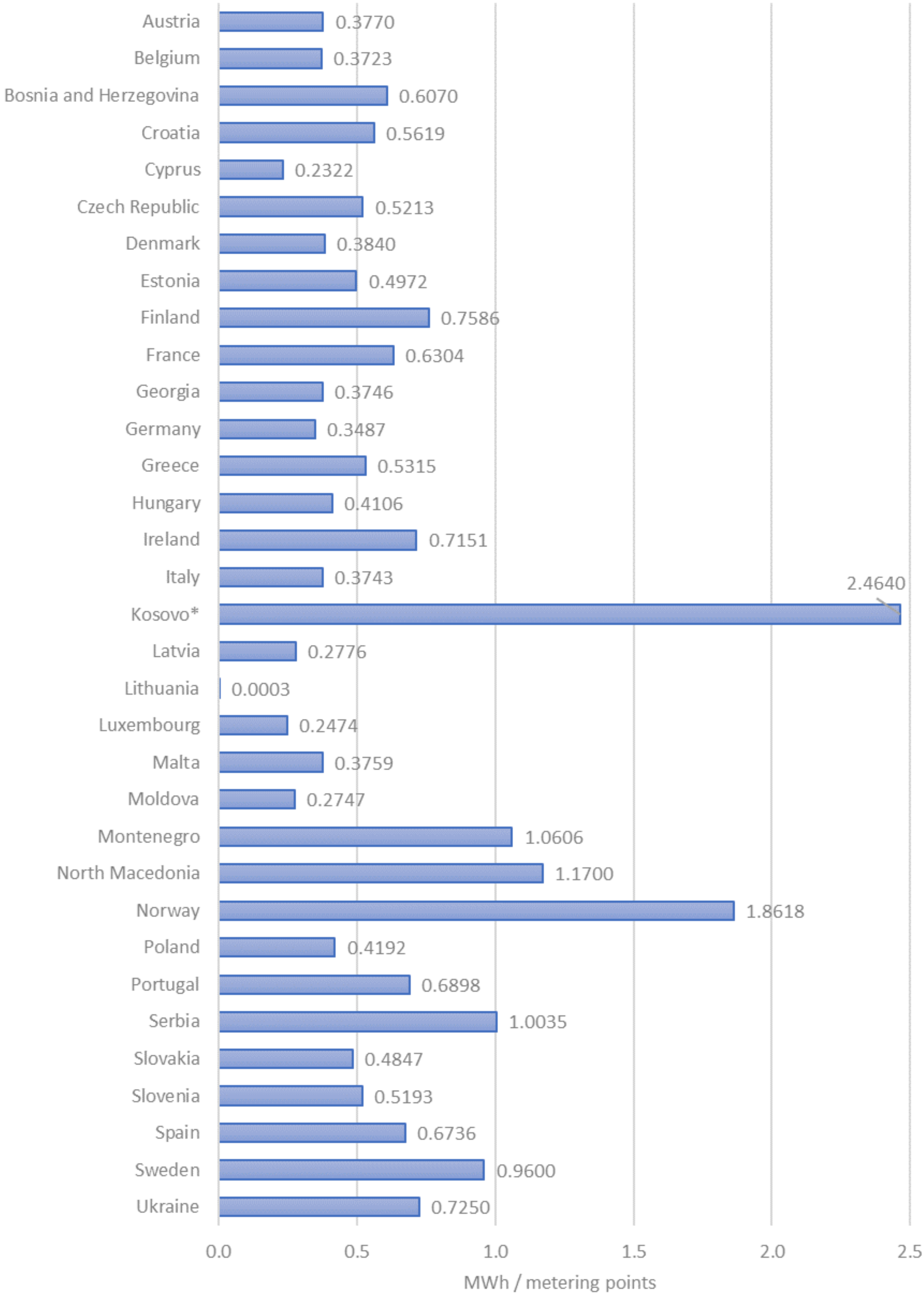


Figure 11: Distribution losses (MWh) per number of metering points in distribution

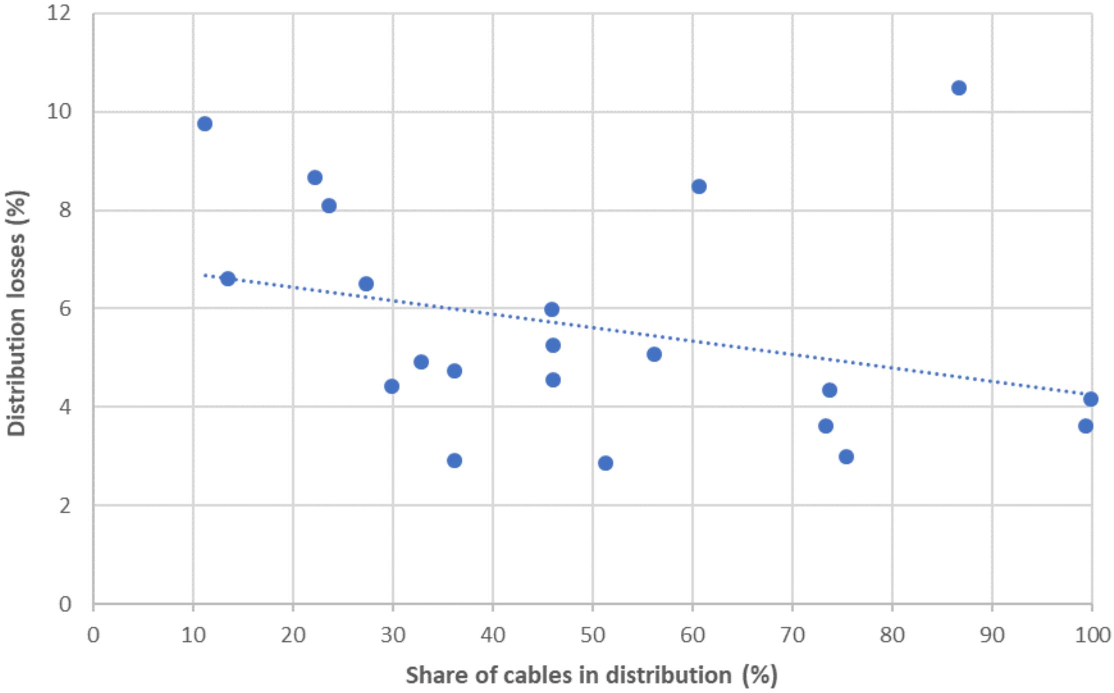


Figure 12: Distribution losses (%) as a function of the share of cables in distribution (%)

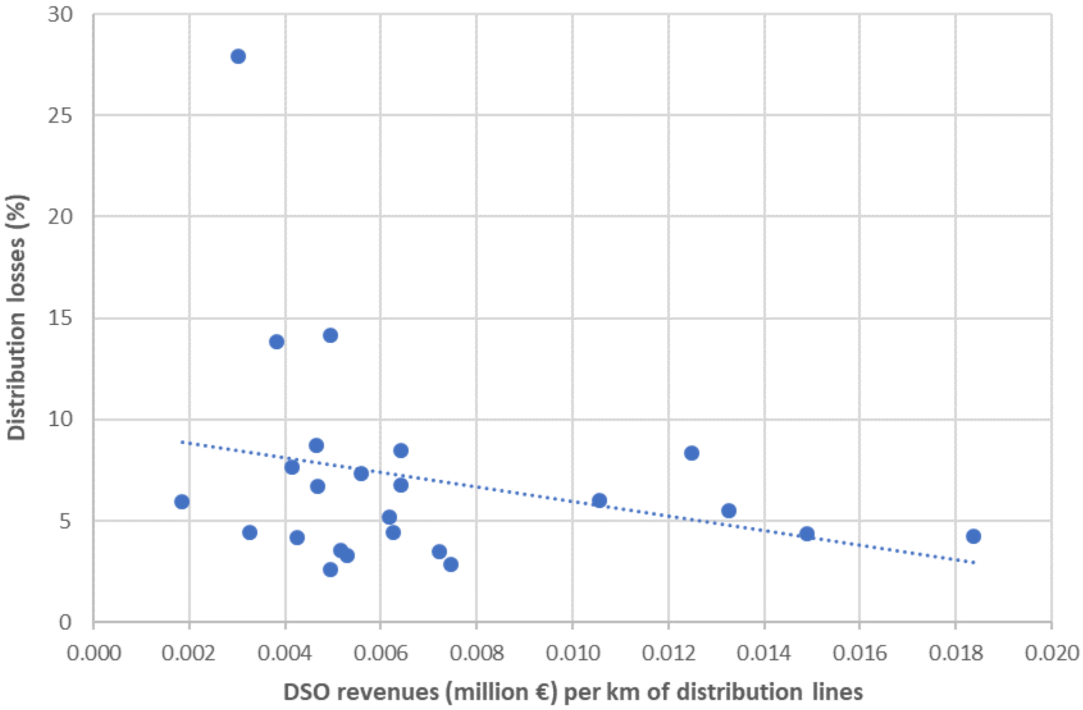


Figure 13: Distribution losses (%) as a function of revenues per km of lines in distribution

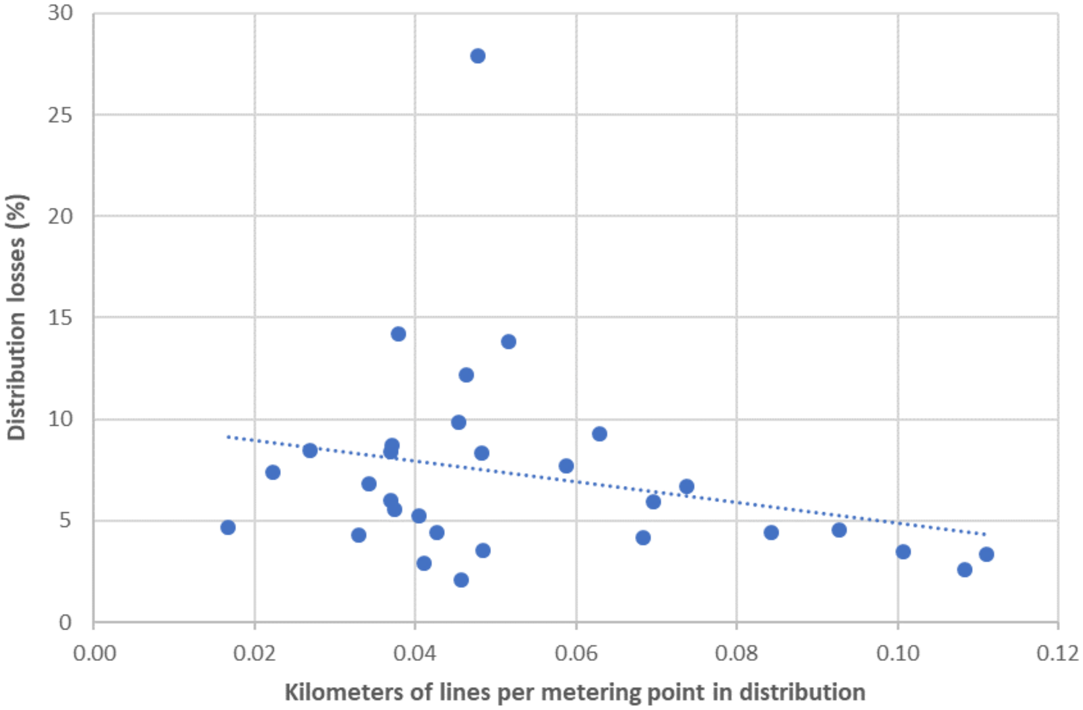


Figure 14: Distribution losses (%) as a function of km per metering point in distribution

2.5 Procurement of losses

Procurement of losses or acquisition of energy necessary to cover power losses is an important element of electrical grid's operation. The provisions of European Directive 2009/72/EC and more recent amending directives[17] oblige electricity system operators to procure the energy they use to cover power losses according to transparent, non-discriminatory and market-based procedures whenever they have such a function. Consequently, in most European countries system operators are responsible for procurement of losses in their respective grids. However, there are some exceptions to this.

Austria's largest TSO Austrian Power Grid (APG) procures about 98% of energy to cover losses. Only some DSOs do their own procurement. In Belgium, losses in the transmission grid are included in the balancing position of the balance responsible party (BRP). However, it is possible that these losses will have to be procured by the Belgian TSO in the future. Distribution system operators (DSOs) in Belgium are responsible for procuring losses in their grids.

In countries like Cyprus, Great Britain, Ireland, Portugal and Spain, a different methodology is in effect as suppliers are obliged to cover the losses. In this case, there is no need for a separate procurement system. In Great Britain, it is expected that the Line Loss Factor built

[17] Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, Official Journal of the European Union, August 2009, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0072&from=EN Please note that this Directive was extensively amended by the new Electricity Market Directive (2019/944/EC) published in 2019, which has the same requirements for procurement of losses by system operators. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0944

into the distribution use of system (DUoS) methodology covers for network losses. By including it in the DUoS calculations, the burden for payment of losses is (indirectly) passed on to suppliers.

In Greece, procurement is done by market participants. This term refers both to entities that inject (i.e. generators and importers) and withdraw (i.e. suppliers) energy from the market. The first category bears the cost of transmission losses for their injections while the second category bears the cost of distribution losses for their withdrawals. Market transactions are considered cleared at the boundary between transmission and distribution. Therefore, generators connected to distribution system and load connected to transmission system are not charged with losses.

In Italy, actual losses consist of standard losses (the most relevant ones) and the residual part (the difference between actual and standard losses). Standard losses are procured by BRPs in the wholesale market and the cost is then passed on to their clients. The difference between actual and standard losses in transmission is procured by the TSO and it is finally paid/received by BRPs. The difference between actual and standard losses in distribution is procured by the single buyer (the party responsible for procuring energy for vulnerable consumers) and it is finally paid/received by DSOs.

In Kosovo*, procurement of losses by transmission and distribution system operators started in late 2017. Starting from 2012, system operators in North Macedonia started purchasing losses on free market under non-discriminatory and competitive procedures approved by their National Regulatory Authority ERC. Recent developments in Serbia had the TSO purchasing energy to cover losses in the first half of 2018. After 1 July 2018, energy for compensation of losses was purchased at the auctions that the TSO conducted on the electronic auction platform and the missing quantity was purchased on the organised day-ahead electricity SEEPEX. Distribution system operators in Luxembourg organise a tender for supplying the energy to compensate for losses.

Practices regarding procurement of losses are presented in Table 6. Readers should keep in mind that there are countries that use a mixture of methodologies and are consequently listed multiple times.

Option	No. of responses	Countries
System operator (DSO and/or TSO)	(29)	AT, BA, BE[18], CZ, DE, DK, EE, FI, FR, GE, HR, HU, IT[19], KS*, LT, LU, LV, MD, ME, MK, MT, NL, NO, PL, RS, SE, SI, SK, UA
Supplier	(5)	CY, ES, GB, IE, PT
BRP	(2)	BE[20], IT[21]
Market participants	(1)	EL
Single buyer	(1)	IT[22]

Table 6: Parties responsible for procurement of energy to cover losses

In almost all European countries, system operators are tasked with forecasting losses. In Bosnia and Herzegovina, forecasting (and procurement) on the HV level is done by their

[18] In distribution.
[19] Difference between actual and standard losses in transmission.
[20] In transmission.
[21] Standard losses.
[22] Difference between actual and standard losses in distribution.

Independent System Operator (ISO BiH) whereas the DSO is responsible for forecasting (and procuring) losses on MV and LV levels. The Croatian DSO uses the average of past four years to forecast losses for the following year. Load forecast in Italy includes losses with the day-ahead load forecast being based on a mixed model of forecasts including linear regression and neural network. In distribution in the Czech Republic, there is a norm of losses (defined by percentage from injected energy), which is set for the whole regulatory period based on the level of network losses from the three previous years. In Czech transmission, the forecast is done yearly based on the estimation of their TSO.

A different approach is used in Georgia, Portugal and Slovenia where the NRA forecasts losses. The Portuguese NRA ERSE publishes losses adjustment factors based on proposals of network operators in transmission and distribution. In Slovenia, the NRA sets a methodology to evaluate quantities of losses and the price to purchase energy to cover those losses based on market-related future prices.

When examining acquisition of energy to compensate for losses, an important topic is how the cost of procurement is covered. In most European countries, this cost is included in network tariffs. Sometimes, it is paid for by the final customers even if there is no dedicated tariff. On the other hand, there is a minority of countries where suppliers (for all grids in Portugal and Spain and for distribution grid in Ireland) or network users (for all grids in Greece and for transmission grid in Belgium and Ireland) are responsible for covering the costs of procurement.

While the cost of procurement of losses is included in the network tariff in Austria, only producers with capacity higher than 5 MW pay for losses. In Belgium, there is no network tariff to cover the cost of procurement in transmission system because these losses are included in the balancing position of BRPs. In general, they are compensated by producers and reflected in the electricity price by suppliers. However, there are network tariffs (charged to final customers) to cover the cost of procurement in distribution systems. In Bosnia and Herzegovina, costs are market-based on the HV level, but are included in tariffs on the MV and LV levels.

The cost of network losses is borne directly by market participants in Greece and is proportional to the energy injected to or withdrawn from the system. The cost per unit of losses is the same for all market participants and is equal to the market clearing price. In practice, this works by remunerating injections after deducting transmission losses and by charging withdrawals while including network losses.

Even though there is no dedicated tariff in Italy, standard losses are covered by BRPs in the wholesale market and then passed on to their clients. For LV consumers, for example, standard losses are equal to 10.4% and the final price of energy for LV customers is increased by this value.

Each supplier in Spain buys its own energy to compensate for losses caused by consumption of its clients. As such, estimated losses are priced at the same level as the wholesale market price for electricity supplied to consumers. No dedicated tariff for losses is used in the Netherlands but the costs of procuring energy for losses are included in total DSO costs.

Ireland uses loss adjustment factors in their treatment of losses. Transmission Loss Adjustment Factors (TLAFs) are applied to generators' outputs in a way that the costs of transmission losses are borne by the individual market participants who cause them. TLAFs are site-specific to account for the fact that some generators are responsible for more transmission losses than others, depending on their point of connection to the grid. They apply to all generators (connected to both transmission and distribution) and are designed to support efficient real-time dispatch of the system and help promote efficient location selection of generating plants. Distribution Loss Adjustment Factors (DLAFs) are applied to the metered customer consumption and to generation connected directly to distribution. In the electricity market, suppliers must pay for losses (DLAFs) in addition to energy measured at customer's meter. For generators connected to distribution, the loss factor is calculated as a Combined Loss Adjustment Factor (CLAF) which is the product of TLAF and DLAF. For generators connected to transmission, the same method is applied but the value of DLAF is set to one (1).

2.6 Regulatory treatment of losses

The question of regulatory approach to power losses can be addressed in several ways. Since incentive-based regulation is typically implemented for European DSOs, the regulatory choice would be to decide how to incentivise system operators to reduce their losses (or in some cases maintain them at a low level) and whether such incentives are reasonable and beneficial. There is an additional option of introducing incentives in order to ensure that energy to cover losses is purchased at the lowest (or optimal) price.

The aim of incentives is to enable NRAs to ensure that TSOs and DSOs implement all economically efficient operational and investment decisions aimed at limiting/reducing the volume of power losses and the costs of energy necessary to cover them. However, in order to be efficient, incentives should set adequate targets on a timeframe relevant to the matter. Inefficient incentives could lead to inefficient operational and investment decisions in addition to either a degradation of system operators' tariff income (if the targets are set at too high a level) or undue gains (if targets are set at too low a level).

Answers to the CEER questionnaire show that 20 responding countries have implemented incentives to reduce losses on the distribution level, as illustrated in Table 7.

Response	No. of responses	Countries
Yes	(20)	BE[23], CZ, DK, EL, ES, FR, GE, HU, IT, KS*, ME, NL, NO, PL, PT, RS, SE, SI, SK, UA
No	(16)	AT, BA, BE[24], CY, DE, EE, FI, GB, HR, IE, LT, LU, LV, MD, MK, MT

Table 7: Regulatory incentives to reduce losses in distribution

The analysis of current regulatory practices illustrates the following methods in regulatory treatment of power losses in distribution networks:

The Czech Republic implements a correction factor for previously estimated values of losses, where the normative of losses is adjusted by actual annual network losses. The difference between the normative and real losses (if these are lower than normative losses) is multiplied by the price of losses and divided (50:50) between a DSO and its customers. There is no significant impact yet, but these incentives were only introduced in 2016 and not enough time has passed to evaluate them properly.

[23] Flanders and Wallonia.
[24] Brussels region.

An incentive mechanism to reduce network losses in distribution networks is also applied in Italy. This mechanism allows the DSO to be rewarded (or penalised) whenever losses are below (or above) a pre-set target level (standard losses). This mechanism is performed annually on the basis of the data that result from the reconciliation process. In Montenegro, non-technical losses are not recognised as part of network tariffs, resulting in an intrinsic motivation of network operators to reduce them. In addition, the rate of return on planned investments takes into account a reduction of technical losses.

In 2018, Denmark introduced a relatively new system of incentivising loss reduction. As part of the revenue cap, DSOs are given an amount to cover their cost-related grid losses. The amount is calculated based on a historic relationship between the level of losses and the delivered amount of energy. Hence, DSOs have an incentive to become more efficient as this entails an economic benefit. Greece has introduced a new incentive scheme which has not been activated yet. Their Distribution Network Code includes provisions for a penalty/reward scheme to incentivise DSOs to control network losses.

In Sweden, a new system of revenue cap regulation will enter into force in 2020. Among other things, new regulation's incentive scheme will take reduction of network losses into account. The NRA of the Slovak Republic sets the maximum allowed amount of losses (in %) for each voltage level, which is annually reduced by an efficiency factor of an officially determined formula. By this regulatory intervention, DSOs are encouraged to make investments in the distribution system that increase energy efficiency and reduce losses. In Slovenia, an incentive for both transmission and distribution system operators has been introduced in the new methodology for regulatory period 2019-2021. An incentive is applied if the achieved price for the purchase of electricity to cover losses is lower than the reference price set by the regulator.

While presently not using incentives to reduce losses, the NRA of Great Britain wants to reintroduce a direct financial incentive on losses once smart metering data is available. Their current policies are designed to incentivise DSOs to better understand and manage their losses through innovative solutions and better data management. In North Macedonia, the NRA has approved a plan for reduction of recognised losses in distribution network in the future.

Answers regarding incentives to reduce losses in transmission (presented in Table 8) show that these incentives are not implemented in as many countries as incentives regarding losses in distribution. One probable cause is that, unlike in distribution, losses in transmission are mostly technical and are hence, more difficult to reduce.

Response	No. of responses	Countries
Yes	(13)	DK, FR, GE, HU, KS*, ME, NL, NO, PL, RS, SE, SI, SK
No	(20)	AT, BA, CY, CZ, DE, EE, EL, ES, FI, GB, HR, IE, IT, LT, LU, LV, MD, MK, PT, UA
N/A	(2)	BE, MT

Table 8: Regulatory incentives to reduce losses in transmission

The analysis of current regulatory practices shows the following methods in regulatory treatment of power losses in transmission networks:

The Danish TSO faces a cost-cover regulatory framework which sets targets for reducing costs to network losses. Currently, this target is a reduction by 50 million Danish kroner over a period of 8 years. In Hungary, the transmission network operator is incentivised to reduce both the level of losses and the costs of the procurement of losses. In the starting year of each four-year price regulation period, both the accepted level of losses (in %) and the accepted price (per kWh) are set by the NRA. In the remaining years, the accepted level is reduced by a pre-defined percentage. The difference between the actual cost and the predetermined cost of procurement of network losses is not completely covered by network charges.

In Montenegro, the TSO's rate of return on planned investments is dependent on the reduction of technical losses. Kosovo* uses incentives for loss reduction through multi-year tariff reviews. If the cost of losses is below the specified target, the TSO can keep the difference between the actual cost and the targeted cost of losses as an extra profit.

In order to stimulate the Dutch TSO to procure energy to cover losses more efficiently, the TSO is partially reimbursed for the difference between the realised costs (in the year t-2) and estimated purchasing costs (in the current year). If the difference between the realised costs and the estimated purchasing costs does not exceed 20%, the reimbursement is equal to 75% of that difference. Any cost beyond this is passed through in its entirety, limiting the risk for the TSO.

The level of losses in Poland is set in the tariff by using historical data combined with an efficiency improvement factor. In case the TSO reaches a higher efficiency level (reduced losses), a profit in the amount of that difference is allowed.

Countries such as Georgia, Norway, Serbia, Slovakia, Slovenia and Sweden apply the same regulatory treatment of losses in transmission and in distribution.

Another regulatory instrument to reduce losses to an economically optimal level is requiring network operators to consider a capitalised value of losses in their investment decisions. Nine responding countries have such provisions in place with 8 out of 9 additionally requiring a statement from network operators about the expected reduction of losses caused by the new investments.

Annual losses in Ireland are estimated from power flow simulations. They are monetised using an average system marginal price and capitalised by reflecting a present value of those (saved or reduced) losses attributed to the investment. Although there is no specific methodology or obligation for considering the capitalised value of losses in Latvia, the price of losses due to system operator's internal policies is considered when evaluating new investment decisions. Network operators in North Macedonia are obliged to provide an explanation of each investment in excess of 100,000 Euros. The explanation is to include an expected reduction of losses, among others.

In Norway, all network assets on voltage levels greater than 22 kV require a licence and network losses are part of the assessment by the licensing authorities. Furthermore, loss calculations are required in case losses play a significant factor in investment decision. There are no licensing requirements for voltage levels lower than 22 kV, but network operators are still (indirectly) incentivised to consider the value of losses in investment decisions. Network operators in Kosovo* are obliged to prepare annual plans for loss reduction with corresponding investments being presented in five-year investment development plans. Similarly, network operators in Montenegro have to provide an estimate of a loss reduction caused by an investment while the estimated reduction of losses in Portugal is a criterion for selection of investment decisions.

Transparency can also be a part of regulatory framework dealing with power losses. There are a few options to make losses public such as publishing them or separately listing them on energy bills.

In most reporting countries, no differentiation is made between technical and non-technical losses when it comes to publication and regulatory treatment. In 31 out of 35 responding countries, non-technical losses are included in published values and in regulation. Even though only one country (Cyprus) explicitly reported that non-technical losses are solely determined for distribution system operators, it is very likely that this is true for the majority of countries, since non-technical losses are more prominent in distribution than in transmission.

Only four countries have stated that there is a legal obligation to publish losses as a separate item on the invoice: Austria, Montenegro, Norway and Slovakia. Even though there is no such legal obligation in Hungary, the DSOs are obligated to indicate the price for network losses. Among countries that have a legal obligation to separately list losses on invoices, Norway reported that there is a dedicated tariff which covers marginal loss in all points of energy exchange including consumption and generation in transmission grid and parts of high voltage level in distribution grid. In addition, final customers on lower voltage levels in distribution grid have energy-dependent tariff that includes marginal loss.

One critical issue for system operators is that non-technical losses cannot be precisely calculated. They are usually estimated as the difference between the total amount of energy fed into the distribution system and the total amount of energy metered.

With respect to energy efficiency objectives, the proper use and measurement of electricity is very important. Penetration of distributed generation, the related need for restructuring of power systems and the correct measurement of energy consumption are going to be key challenges in the near future. Improvements in metering of electricity consumption are thus essential since they affect losses in at least two ways:

- First, they help reduce metering errors and identify fraud which directly leads to a more accurate measurement of electricity consumption. Hence, the estimation or calculation of non-technical losses will be more exact; and

- Second, real-time (or near real-time) reading of energy consumption and an establishment of dynamic tariffs might help to reduce the gap between peak demand and the available power at any given time, since it encourages consumers to use their appliances during off-peak hours. Enabling network operators to use this combination of real-time reading of consumption and dynamic tariffs to a greater extent would necessitate further improvements in current metering systems.

A higher penetration rate of smart meters (SM) may therefore have advantages for the future. Smart meters collect real-time consumption readings, enable better monitoring of the volume of electricity delivered and aid the detection of non-technical losses. It should be mentioned that the legal framework in support of increased usage of smart meters might differ from country to country. The following table illustrates the latest available penetration rates of SM for final customers across Europe.

Rate	No. of responses	Countries
0% to 10%	(10)	BE, CZ, DE, GE, HR, HU, IE, KS*, PL, UA
10% to 50%	(8)	AT, BA, FR, GB, LV, NL, PT, SK
50% to 75%	(1)	SI
75% to 100%	(12)	DK, EE, EL, ES, FI, IT, LU, ME, MT, NO, RS[25], SE
N/A	(5)	CY, DK, LT, MD, MK

Table 9: Penetration rate of smart meters for final customers

Among the countries that have not yet implemented a roll-out of smart meters, a full roll-out or at least a significant increase in the use is planned in Cyprus, Denmark, Ireland and Lithuania. In Denmark, it has been politically decided that all customers must have smart meters by the end of 2020, which will increase accuracy in determining losses. The DSO of Kosovo* is developing a feasibility study for installation and cost-benefit analysis of SM in order to justify the investment to the NRA. To support this study, a pilot project on their 0.4 kV voltage level is being run with expectations of more accurate determination of losses in distribution. The Lithuanian DSO is planning to start a mass roll-out of smart meters at the end of 2020 which will influence the calculation methodology of losses. In Slovakia, it is planned that 80% of customers at LV level with an annual consumption of more than 4 MWh will have a continuous measurement installed by the end of 2020. However, benefits of introducing SM are still difficult to appraise in many countries, mostly due to lack of time for a reliable evaluation (as in the Czech Republic, Luxembourg, Norway, Portugal and Spain). Most countries where smart meters have already been introduced reported a significant improvement in the measurement accuracy of losses (Denmark, Malta, Montenegro and Slovakia) along with a reduction of losses in general (Estonia, Malta and Montenegro). Those planning a roll-out or an expansion expect higher penetration of SM to have a positive effect on the level of accuracy when determining losses.

Additional information from Montenegro shows that the installation of new, modern meters with remote reading began during the regulatory period 2012 - 2015 when the first phase of the AMM (Advanced Meter Management) Project implementation was approved by the National Regulatory Agency of Montenegro (175,000 meters). The AMM project continued through the second phase, which planned the installation of 80,000 additional meters, approved by the NRA for the period 2015 - 2016. Meanwhile, in January 2016, a new Energy Law came into force, which obliged the DSO to equip at least 85% of their customers with modern measuring systems by 1 January 2019. After this, the NRA approved the third phase of the project for the period 2017 - 2018, which consisted of procurement of another 60,000 meters, of which 45,000 would be installed while the remaining units would serve as spares. Through three phases of the project, 300,875 new meters were installed at consumer metering points by 31 December 2018. The new meters facilitate remote communication, which has enabled more efficient and accurate reading and increased the degree and reliability of disconnections of non-paying customers (which, in turn, incentivised more customers to pay on time). The implementation of this project, among other investments and interventions, led to a decrease of distribution losses (both technical and commercial) from 2012 to 2018 as can be seen in the fact sheets in Annex 3.

[25] Transmission only. The NRA does not collect data for SM in distribution.

2.7 Case study: Analysis of contact-voltage losses in low-voltage electricity distribution systems of the United Kingdom

The Institute of Electrical and Electronics Engineers (IEEE)[26] defines contact voltage (CV) as "a voltage resulting from electrical faults that may be present between two conductive surfaces that can be simultaneously contacted by members of the general public or animals. Contact voltage can exist at levels that may be hazardous". While CV faults can occur on both overhead lines and underground cables, the focus of this study was underground faults in the most populated urban areas of the United Kingdom (UK). The study was originally published in January 2018 by Princeton University and prepared under contract for UK Power Networks (UKPN)[27].

The main cause of underground CV is a break in the insulation of an underground conductor. This can be a result of chemical corrosion, degradation with aging, accidental damage during construction work or other external factors. The break allows electricity to leak to ground and/or to energise conducting objects such as manhole covers or lighting columns. Although the impact of such breaks on grid's operation is minor, they lead to public safety concern and leak energy into the surroundings until detected and repaired. The continuous leakage of energy can represent substantial cumulative losses.

A so-called Mobile Asset Assessment Vehicle (MAAV) enables rapid detection of CVs and a general estimation of their condition. A MAAV can detect electric fields arising from very small voltage differentials at a distance of 10 metres while driving 40 kilometres per hour. UKPN commissioned a MAAV trial of central London at the end of 2016. The survey covered 425 centreline road miles within the London Power Network (LPN) service territory and detected 62 CV occurrences that were energising 155 objects. The number of different types of CVs and estimated losses caused by them are shown in Table 10.

Location of contact voltage	No. of MAAV-detected CVs	Estimated loss per CV (watts)	Projected no. of CVs for entire LPN	Estimated losses for entire LPN (MWh/year)
Customer-side, phase	8	1,380	284	3,436
Low-voltage cable, neutral	10	150	355	467
Low-voltage cable, phase	9	6,144	320	17,210
Lighting column, neutral	24	0.625	853	5
Lighting column, phase	11	4,839	391	16,566
Total	**62**		**2,203**	**37,684**

Table 10: Summary results of UKPN's Central London MAAV survey and corresponding estimated electricity losses

The estimated losses per CV in Table 10 were developed as follows: losses from customer-side phase faults were assumed to be no higher than the level that would trip a customer's smallest fuse or circuit breaker which is typically 6 amperes (6 A x 230 V = 1,380 W).

[26] https://www.ieee.org/
[27] https://acee.princeton.edu/wp-content/uploads/2018/06/Princeton-Contact-Voltage-Report-FINAL-1-30-18.pdf

Fixed values were assigned to neutral cable and neutral lighting column losses. The largest losses are those of phase-side cable (6,144 W) and phase-side lighting column contact voltages (4,839 W). These were determined from H.B. Dwight's formulas which were developed in the 1930s based on electromagnetic field analysis and are still widely-accepted for estimating impedances to ground from energised cylinders. As part of the Central London MAAV survey work, direct measurements of the current on phase cable faults were made. The measurements confirmed that losses estimated using H.B. Dwight's formulas are reasonable. For estimating phase-side lighting-column CV losses, impedance to ground was calculated for each of 18 different lighting column designs used in London. The average of the 18 values was then used to estimate phase-side CV losses from lighting columns. For estimating phase-side CV losses from cables, the average value of location-specific soil resistivity at each CV occurrence was taken. For the Princeton Report, resistivity values were obtained by purchase from the British Geological Survey soil database.

The estimated 2,203 CV occurrences represents an average of 9.2 CV occurrences per 100 miles (approx. 161 km) of cable in the LPN area, which in this study is assumed to be representative across all distribution network areas in the UK. This assumption is supported by the evidence that the number of energised objects found in the central London MAAV survey (per 100 roadway miles) was surprisingly close to the number of energised objects found per 100 roadway miles in MAAV surveys in 2016 and in 2017 in the Consolidated Edison company's territory in the New York City (USA) suburbs of White Plains, Yonkers, New Rochelle, and Mount Vernon. This suggests that LV underground distribution infrastructures are similar in diverse regions.

To estimate UK-wide CV losses, the same assumptions were used as in the central London survey except the soil resistivity values, which were changed for different areas. Considering the 12 out of 14 distribution network regulatory license areas for which sufficient data were available, the total electricity losses that would be avoided across the UK by detecting and repairing CVs is estimated to be 591 GWh per year. Of this total, 116 GWh are metered losses, since they occur due to contact voltages on the customer side of the meter. For comparison, distribution losses in Great Britain (England, Scotland and Wales) in 2017 were approx. 19,000 GWh.

The estimated unmetered CV losses on UK distribution networks (474 GWh/year) represent 2.5% of what are traditionally called technical losses on distribution systems across the UK. This makes contact voltage losses the single largest avoidable loss in the distribution system. In the cost-benefit analysis of MAAV-based CV detection and repair, the costs of implementing a measure are compared against the costs that would have been incurred if the measure had not been implemented ("business-as-usual" (BAU) scenario). Consolidated Edison Company of New York, Inc. has been conducting annual MAAV surveys of its entire service territory and remediating all energised objects for a decade. The number of CV faults detected annually is significant (between 6,871 and 11,041 from 2009 until 2016) but approximately constant. This assumption was adopted for the BAU scenario. Since losses from an unrepaired CV fault in this scenario would continue until the CV fault is repaired, an additional assumption was made about the length of time that a CV fault would have persisted before it would have been repaired. This average "lifetime" of a CV fault is assumed to range between one and three years.

Costs included in the cost-benefit analysis are the annual cost for MAAV services (including detection and repair of CV faults) and the annual greenhouse gas (GHG) emissions associated with operating the MAAV truck. Avoided costs include those that a DNO would have incurred to repair CVs in the BAU scenario, as well as costs it would have incurred in responding to fuse trips due to unrepaired CV faults. Additionally, the following societal avoided costs were included in the MAAV scenario:

1) electricity generation losses;
2) GHG emissions associated with the avoided electricity losses;
3) local air pollutant emissions associated with the avoided electricity losses;
4) a reduced number of customer interruptions caused by fuse trips resulting from unrepaired CVs;
5) customer electricity-supply minutes lost due to fuse trips;
6) reduced risk of fatalities from electrical shock caused by a CV fault; and
7) reduced risk of serious injury from a shock caused by a CV fault.

The analysis was performed for a single MAAV unit operating over a program period of eight years starting with 2018 and an assumption that CV faults would have persisted for one year before being repaired, had the program not been implemented. The results revealed that by far the largest benefit each year is the avoided losses. Reduced risks of fatalities are a distant second largest benefit. The other benefits are each relatively small individually, but the avoided CO_2 emissions grows to become the second largest benefit in the 7^{th} and 8^{th} years of the program. In the cost-benefit analysis used here, the value of a loss-reduction investment is judged by the cumulative discounted net benefit resulting from its implementation. The cumulative discounted net benefit for the MAAV program grows from £0.77 million in the first year to £3.65 million at the end of the program (year 8). If the CV lifetime assumed for the BAU scenario were two years instead of one, the cumulative discounted net benefit in year 8 grows to £10.6 million, and if a BAU CV lifetime of three years were assumed, the net benefit grows to £17.5 million.

The evolution of electricity grids might impact the frequency of CV losses in the future. If some of existing distribution cables were taken out of service due to increased distributed renewable generation, CV losses would diminish. Readers should also keep in mind that, unlike some types of technical losses, CV losses are not dependent on the flow of energy. They depend only on line voltage and the impedance to ground. If energy flows were to decrease due to greater self-generation and associated self-consumption, traditional technical losses would diminish resulting in CV losses having a larger fraction of total losses.

2.8 Case study: e-distribuzione's treatment of power losses in Italy

e-distribuzione is the DSO of the vertically integrated Enel Group[28] operating in Italy.

The electricity smart meter roll-out programme started in Italy in 2001 due to a company decision of Enel distribuzione (now e-distribuzione). It consisted of the installation of 32 million of "first-generation" smart meters across the grid within five years of the launch, with features of bi-directional communication, remote control, anti-tampering, remote customer supply activation and de-activation etc. In 2017, after ARERA's (the Italian NRA) decision, e-distribuzione started the deployment of the second-generation smart meter that entails higher efficacy and new functionalities. This second generation of smart meters allows customers to manage energy tools and receive data in real time, enabling them to play an active role in the rational use of energy.

A fully capacity-based (€/kW) distribution network tariff has been introduced by the regulator in 2017. Moreover, the regulation challenges DSOs to reduce both their technical and non-technical losses. e-distribuzione used the following tools to reduce losses:

- **High quality of data measurements**
  Thanks to smart meter roll-out, some of the problems related to power losses, mainly those involving estimation and data accuracy, were progressively overcome and non-technical losses were considerably reduced.

- **Data mining to optimise inspections**
  In 2015, e-distribuzione introduced data mining tools devoted to fraud detection and error measurements. Furthermore, artificial intelligence also allowed to determine mismatches and, when needed, initialise subsequent inspections on the low voltage network to discover electricity thefts.

- **Infrastructural initiatives**
  The installation of advanced and efficient devices plays a key role in building up a resilient and energy-efficient distribution network. In 2018, around 152,000 GJ (approx. 42.2 GWh) were saved due to installation of transformers, optimisation of the network layout, installation of new substations and reconstruction/upgrading of LV/MV lines, resulting in reduction of technical losses.

- **Customer awareness**
  With the second generation of SM, customers are enabled to pay less with consideration of their time of use of energy. Consequently, a further decrease of technical losses can be expected due to reduction of peak load, also as an effect of the new fully capacity based (€/kW) distribution network tariff.

[28] https://www.enel.com.co/en/about-enel/enel-group.html

3 Conclusions

Power losses are an inevitable part of any traditional electrical system. Whether they are caused by the laws of physics (technical losses) or other factors such as fraud or inaccurate metering (non-technical losses), they constitute a relevant amount of energy flows and play a significant role in energy transmission and distribution. Reduction of power losses would thus be an important contributor to improvement of energy efficiency and decrease of operational expenses of power grids.

There are different definitions of power losses across Europe, but they are usually understood as the difference between the energy flowing into a grid and energy flowing out of it. There are very few countries that included only technical losses in the values submitted for this report. Those that include non-technical losses often include some of the possible components but not all of them. These components are included in distribution more often than in transmission as losses in transmission are generally of technical origin. Harmonisation of definitions of power losses (or at least an agreement on which components are included in reported losses) would simplify comparison and enable proper benchmarking among countries.

When determining losses, the required input values can be estimated or measured. For most countries, those values are measured on EHV and HV, but estimated on (at least part of) MV and LV networks.

Nearly everywhere in Europe, system operators are tasked with forecasting losses in their grids and procuring the energy to cover them. In a few cases, different parties are responsible for procurement of losses in transmission and in distribution within the same country. The associated cost is included in network tariffs in most countries. On the other hand, there is a minority of cases where suppliers or market participants are responsible for covering the cost. Parties responsible for procurement of energy to cover losses should be incentivised to make this process as economical and efficient as possible.

Twenty responding countries have implemented incentives to reduce losses in distribution, while a few others are planning to introduce them in the future. Incentives to reduce losses in transmission are implemented in only 13 responding countries. One probable cause is that, unlike in distribution, losses in transmission are mostly technical and are hence more difficult to reduce. The aim of incentives is to enable NRAs to ensure that system operators limit or reduce the volume of power losses and the cost of energy necessary to cover them. Incentives should be set efficiently with appropriate target and timeframe, otherwise they could have unintended consequences on system operators. Different regulatory approaches could be implemented for technical and non-technical components of losses, provided that more data on non-technical losses are available. Transparency can also play a role in regulatory treatment of power losses. However, only four countries have stated that there is a legal obligation to publish losses as a separate item on invoices.

Technical losses could be reduced by implementing newer or more efficient transformers or by operating higher voltages in distribution grids, among other possible approaches. The higher voltage in distribution might be the reason for relatively low losses in countries where this type of operation is common. Non-technical losses will most likely decrease with increased penetration of smart meters. They reduce metering errors and improve identification of fraud which leads to a more accurate measurement of electricity consumption. Hence, the estimation or calculation of non-technical losses will be more exact. Most countries where smart meters have already been introduced reported a significant improvement in the measurement accuracy of losses along with a reduction of losses in general. However, even in countries with high penetration of smart meters, it is too early to reliably evaluate their full benefits. Those planning a roll-out or an expansion expect higher penetration of SM to have a positive effect on the level of accuracy when determining losses. Before that happens, those countries should, if possible, increase their monitoring of non-technical losses.

Annex 1 – List of abbreviations

Term	Definition
AMM	Advanced Meter Management
ARERA	L'Autorità di Regolazione per Energia Reti e Ambiente (National Regulatory Authority of Italy)
BAU	Business as Usual
BRP	Balance Responsible Party
CEER	Council of European Energy Regulators
CI	Customer Interruptions
CLAF	Combined Loss Adjustment Factor
CML	Customer Minutes Lost
CV	Contact Voltage
DLAF	Distribution Loss Adjustment Factor
DNO	Distribution Network Operator
DSO	Distribution System Operator
DUoS	Distribution Use of System
EC	European Commission
ECRB	Energy Community Regulatory Board
EHV	Extra High Voltage
EQS WS	Energy Quality of Supply Work Stream
ERC	Energy Regulatory Commission of the Republic of North Macedonia (National Regulatory Authority of North Macedonia)
ERGEG	European Regulators' Group for Electricity and Gas
ERSE	Entidade Reguladora dos Serviços Energéticos / Energy Services Regulatory Authority (National Regulatory Authority of Portugal)
GHG	Greenhouse Gas
HV	High Voltage
IEEE	Institute of Electrical and Electronics Engineers
ISO	Independent System Operator
kVA	Kilovolt-ampere
LPN	London Power Network
LV	Low Voltage
MAAV	Mobile Asset Assessment Vehicle
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hour

Term	Definition
N/A	Not Applicable
NRA	National Regulatory Authority
Ofgem	Office of Gas and Electricity Markets (National Regulatory Authority of Great Britain)
SM	Smart Meter
SMP	System Marginal Price
TLAF	Transmission Loss Adjustment Factor
UKPN	UK Power Networks

Annex 2 – List of country abbreviations

Term	Definition
AT	Austria
BE	Belgium
BA	Bosnia and Herzegovina
HR	Croatia
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
FI	Finland
FR	France
GE	Georgia
DE	Germany
GB	Great Britain (GB is used for Great Britain: England, Scotland and Wales)
EL	Greece
HU	Hungary
IE	Ireland
IT	Italy
KS	Kosovo*
LV	Latvia
LT	Lithuania
LU	Luxembourg
MT	Malta
MD	Moldova
ME	Montenegro
NL	The Netherlands
MK	North Macedonia
NO	Norway
PL	Poland
PT	Portugal
RS	Serbia
SK	Slovakia
SI	Slovenia
ES	Spain

Term	Definition
SE	Sweden
UA	Ukraine
UK	United Kingdom of Great Britain and Northern Ireland (UK is used for England, Scotland, Wales and Northern Ireland)

Annex 3 – Fact sheets

AUSTRIA

GENERAL INFORMATION

Network length of distribution networks	251,508 km (voltage levels up to and including 110 kV)
Number of metering points in distribution network	6,120,000
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injected and consumed energy
Is the same method used to determine losses on every voltage level?	Losses are indirectly metered on higher voltage levels

PROCUREMENT OF LOSSES

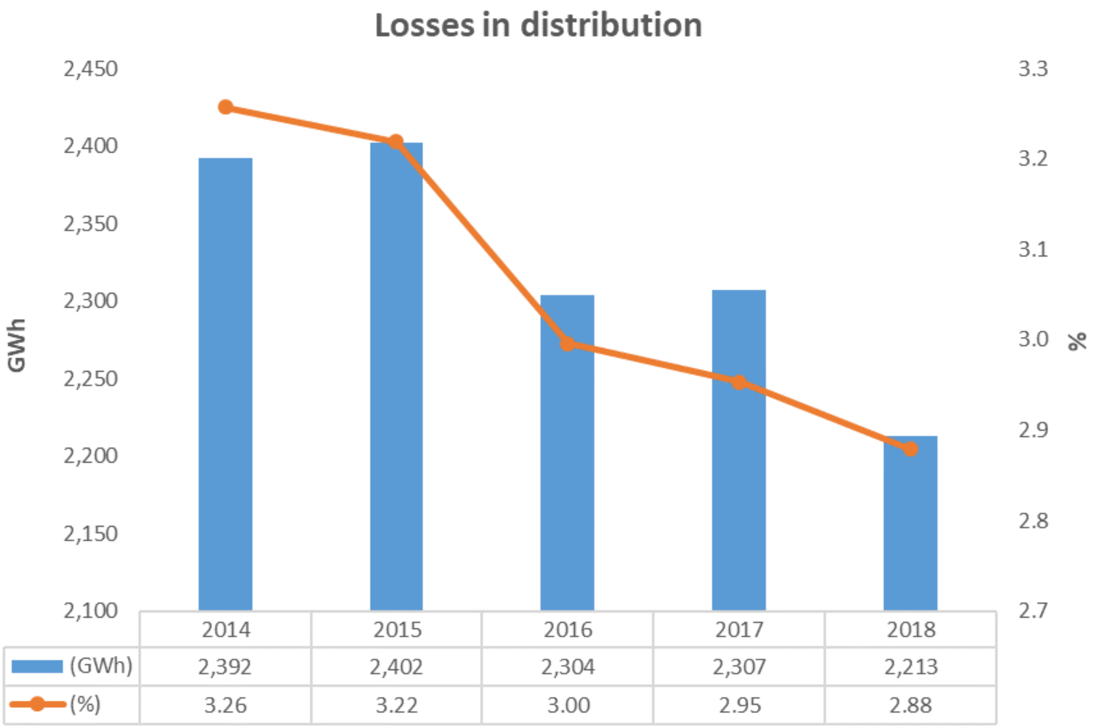
Party responsible for procurement of power losses	TSO (some DSOs are responsible for procurement of their own losses but about 98% of losses are procured by the TSO)

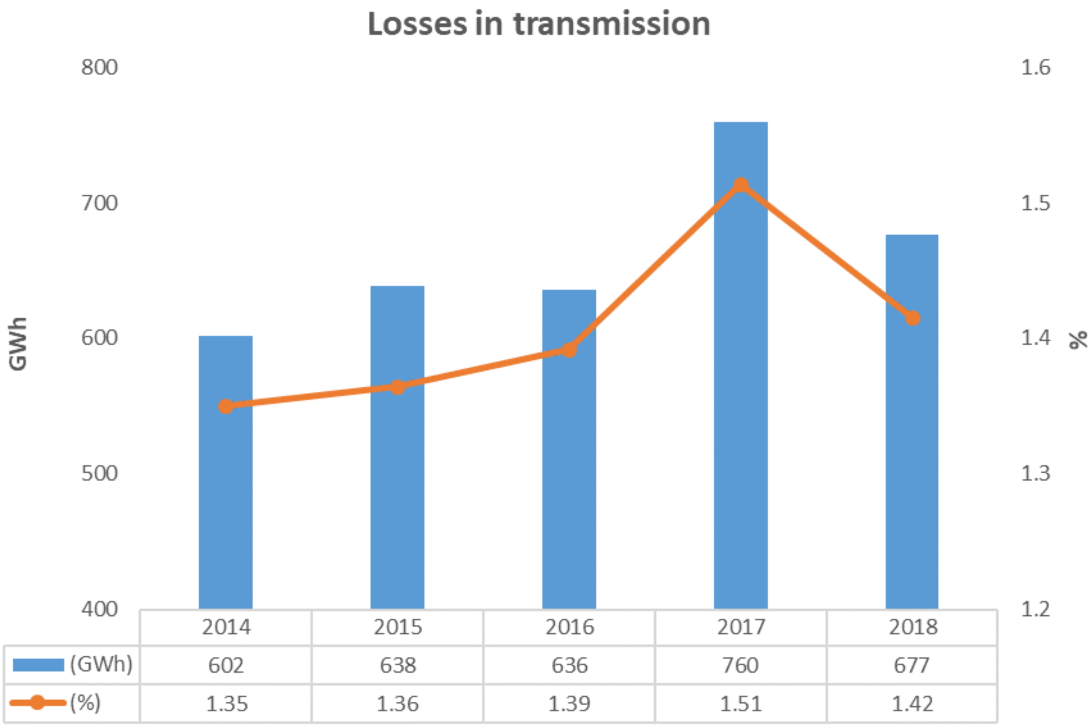
Party responsible for forecasting power losses	DSO and TSO
How are costs of procuring losses covered?	Cost is included in network tariff. All consumers pay for losses. Only producers >5MW pay for losses.

REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Incentives are not directly aimed at reducing losses but at reducing the overall cost of which losses are a part of.
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	Yes
Different prices of losses for different network users?	Yes

VALUES OF LOSSES




Losses in transmission
800
700
600
500
400
1.6
1.5
1.4
1.3
1.2
GWh
%
2014
2015
2016
2017
2018
(GWh) 602 638 636 760 677
(%) 1.35 1.36 1.39 1.51 1.42


Total losses
3,100
3,050
3,000
2,950
2,900
2,850
2,800
4.1
3.9
3.7
3.5
3.3
GWh
%
2014
2015
2016
2017
2018
(GWh) 2,994 3,040 2,940 3,067 2,889
(%) 3.98 3.84 3.64 3.50 3.48

BELGIUM

GENERAL INFORMATION

Network length of distribution networks	Flanders: 129,316 km. Wallonia: 68,027. Brussels: 6,424.2
Number of metering points in distribution network	Flanders: 3,674,673. Wallonia: 1,846,000. Brussels: 656,990
Year	Flanders: 2018. Wallonia: 2017. Brussels: 2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution (Flanders and Brussels)
- Non-metered consumption (e.g. public lighting)	Yes, in distribution (Flanders and Brussels)
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injected and consumed energy
Is the same method used to determine losses on every voltage level?	Yes (federal transmission and distribution in Wallonia). No data for other distribution regions.

PROCUREMENT OF LOSSES

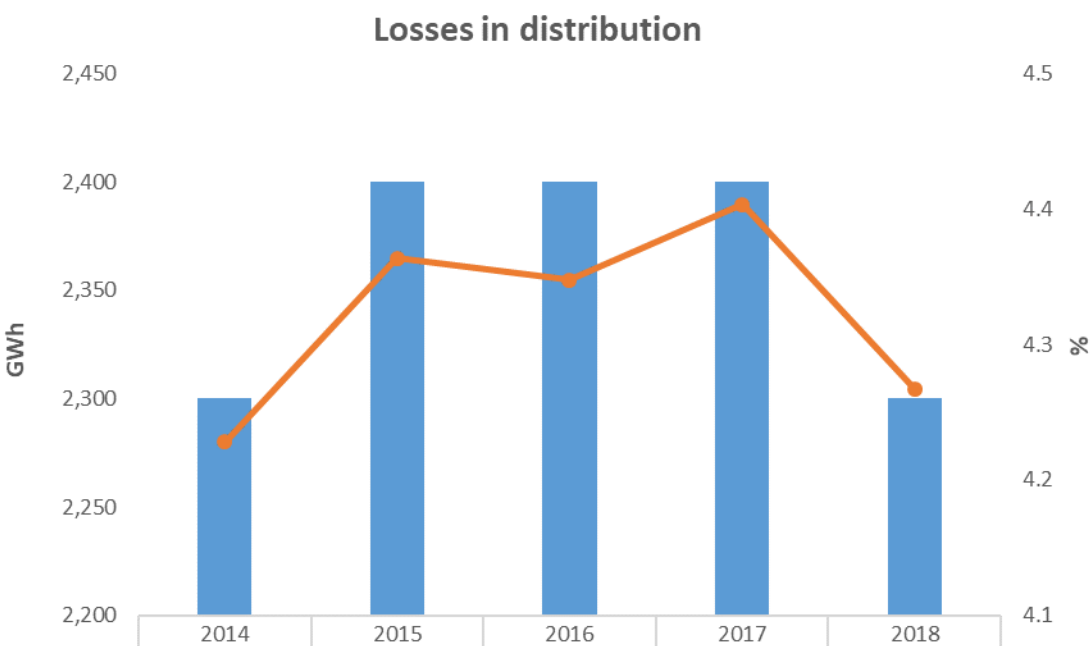
Party responsible for procurement of power losses	Transmission: BRP Distribution: DSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Transmission: included in energy price (billed to producers and reflected in the price of electricity suppliers). Distribution: tariffs.

REGULATORY FRAMEWORK

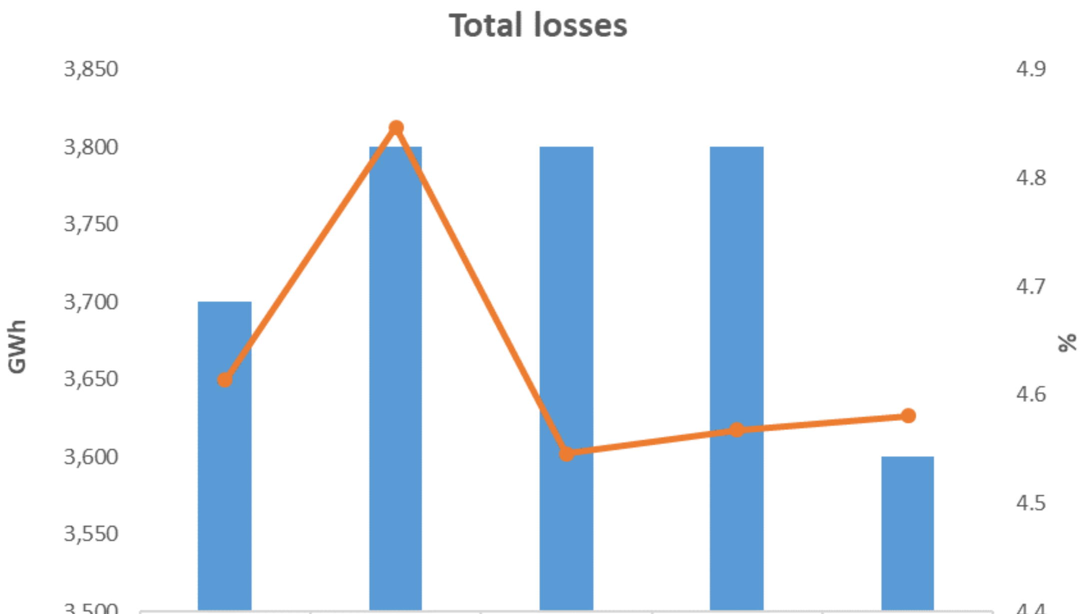
Regulatory incentives to reduce losses or costs related to losses in distribution?	Flanders and Wallonia: yes. Brussels: no.
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	2,300	2,400	2,400	2,400	2,300
(%)	4.23	4.36	4.35	4.40	4.27

	2014	2015	2016	2017	2018
(GWh)	1,400	1,400	1,400	1,400	1,300
(%)	1.88	1.96	1.83	1.85	1.84



	2014	2015	2016	2017	2018
(GWh)	3,700	3,800	3,800	3,800	3,600
(%)	4.61	4.85	4.55	4.57	4.58

BOSNIA AND HERZEGOVINA

GENERAL INFORMATION

Network length of distribution networks	98,522 km
Number of metering points in distribution network	1,565,000
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission (applies only to non-metered consumption. Public lighting not considered a loss)
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injected and consumed energy
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

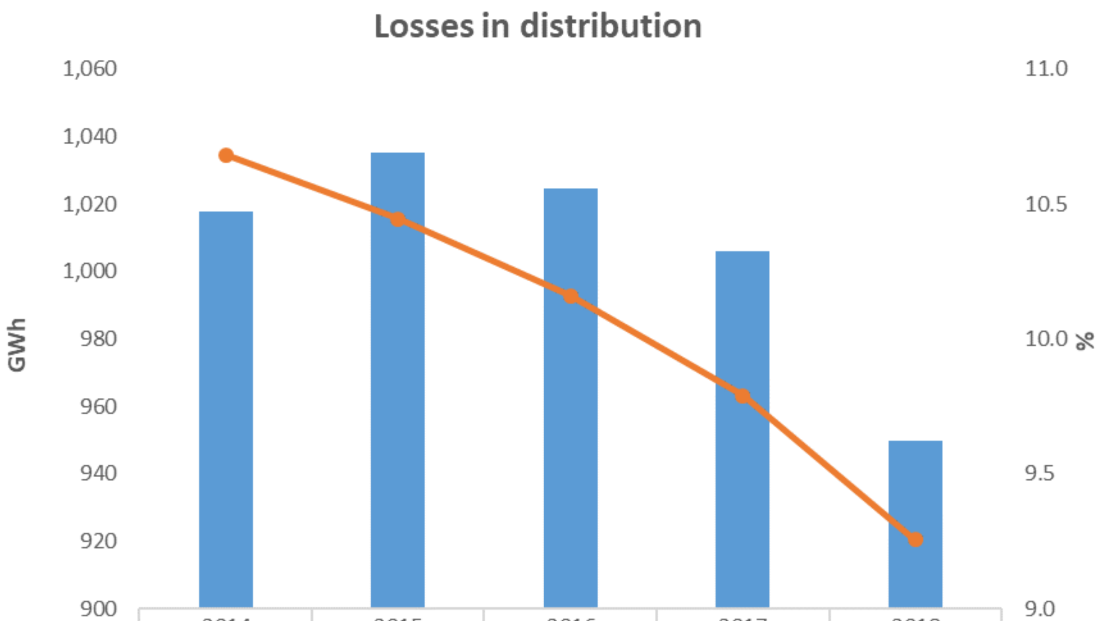
Party responsible for procurement of power losses	DSO on LV and MV level. TSO on HV level (110 kV and above).
Party responsible for forecasting power losses	DSO on LV and MV level. TSO on HV level (110 kV and above).

How are costs of procuring losses covered?	On HV level, they are market based. On MV and LV level, they are also market based through the tariff.

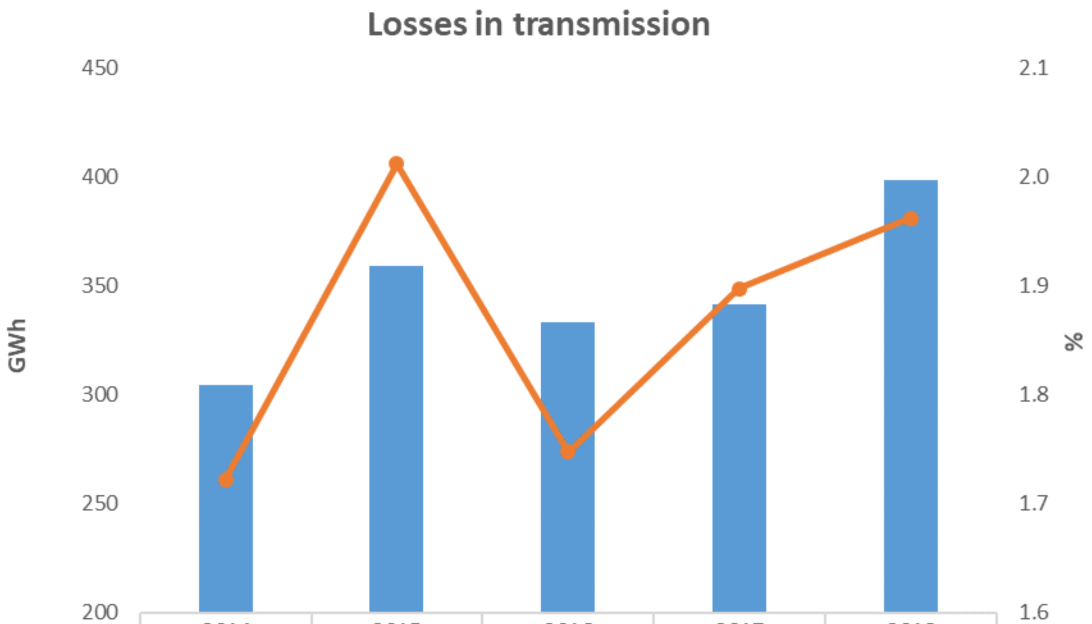
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

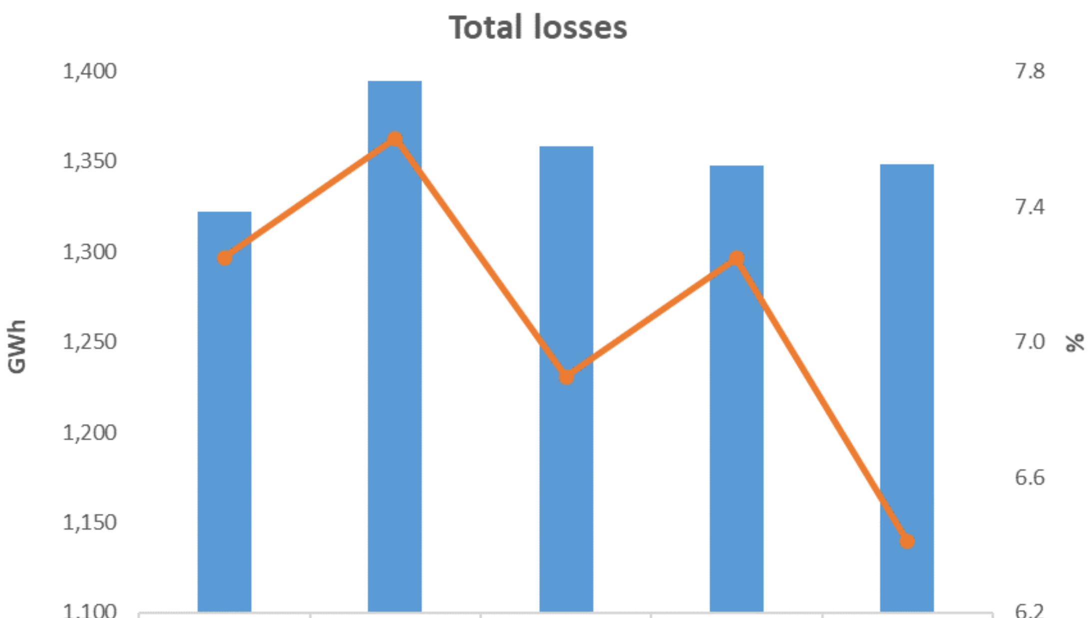
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	1,018	1,035	1,025	1,006	950
(%)	10.68	10.45	10.16	9.79	9.26



	2014	2015	2016	2017	2018
(GWh)	305	359	333	342	399
(%)	1.72	2.01	1.75	1.90	1.96



	2014	2015	2016	2017	2018
(GWh)	1,322	1,395	1,358	1,347	1,349
(%)	7.25	7.60	6.90	7.25	6.41

CROATIA

GENERAL INFORMATION

Network length of distribution networks	140,435 km
Number of metering points in distribution network	2,390,287
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- "hidden" non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level.

PROCUREMENT OF LOSSES

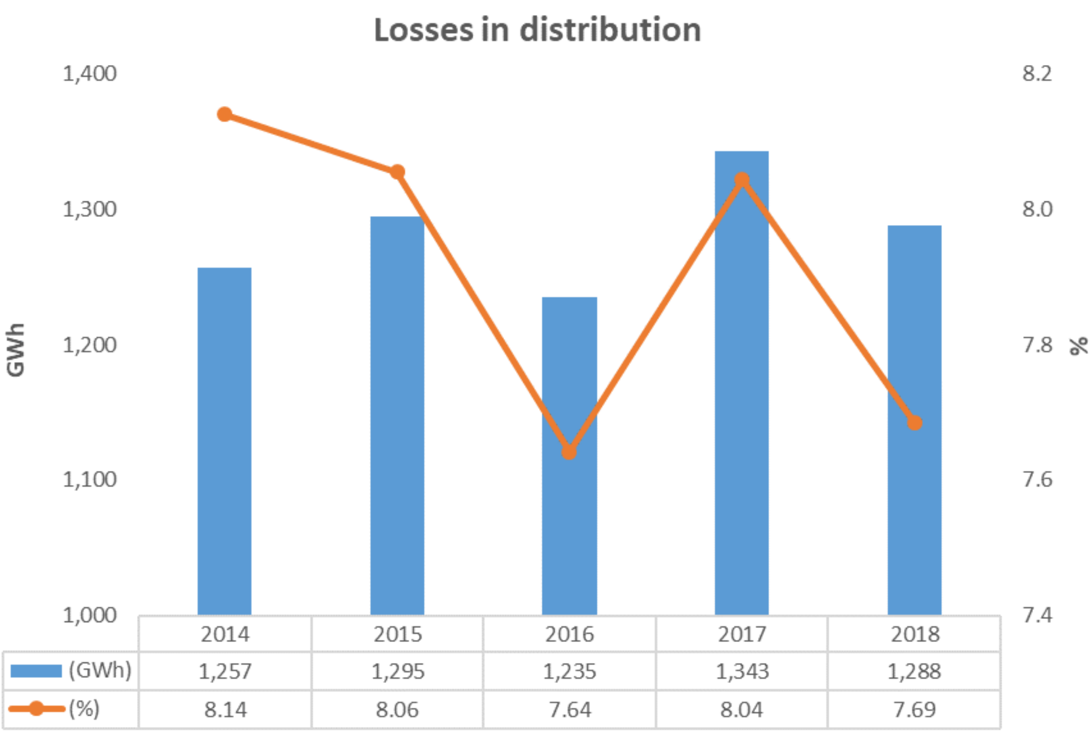
Party responsible for procurement of power losses	DSO and TSO (each for their network)
Party responsible for forecasting power losses	DSO and TSO (each for their network)

How are costs of procuring losses covered?	Through network tariffs.

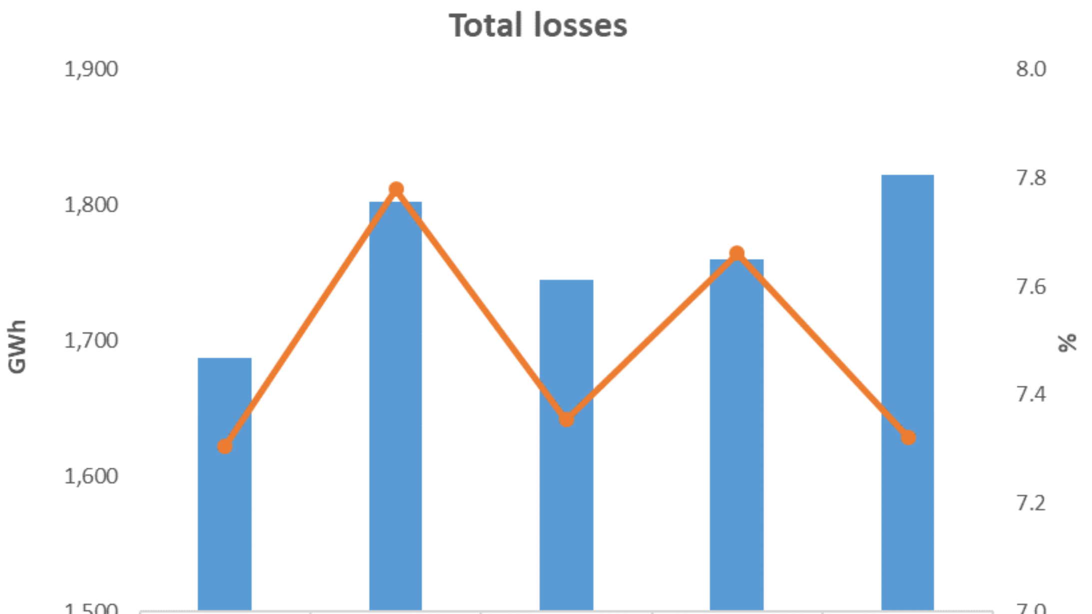
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	430	507	510	417	534
(%)	1.91	2.26	2.23	1.89	2.24



	2014	2015	2016	2017	2018
(GWh)	1,687	1,802	1,745	1,760	1,822
(%)	7.31	7.78	7.35	7.66	7.32

CYPRUS

GENERAL INFORMATION

Network length of distribution networks	26,000 km
Number of metering points in distribution network	568,500
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes (in distribution)
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

Party responsible for procurement of power losses	Supplier
Party responsible for forecasting power losses	TSO

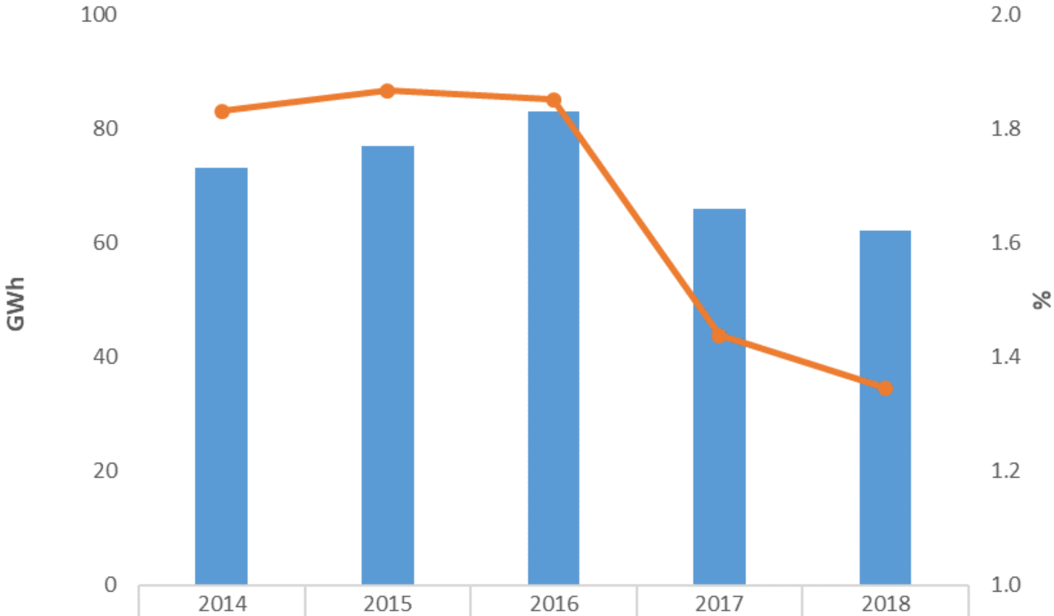
How are costs of procuring losses covered?	Through network tariffs.

REGULATORY FRAMEWORK

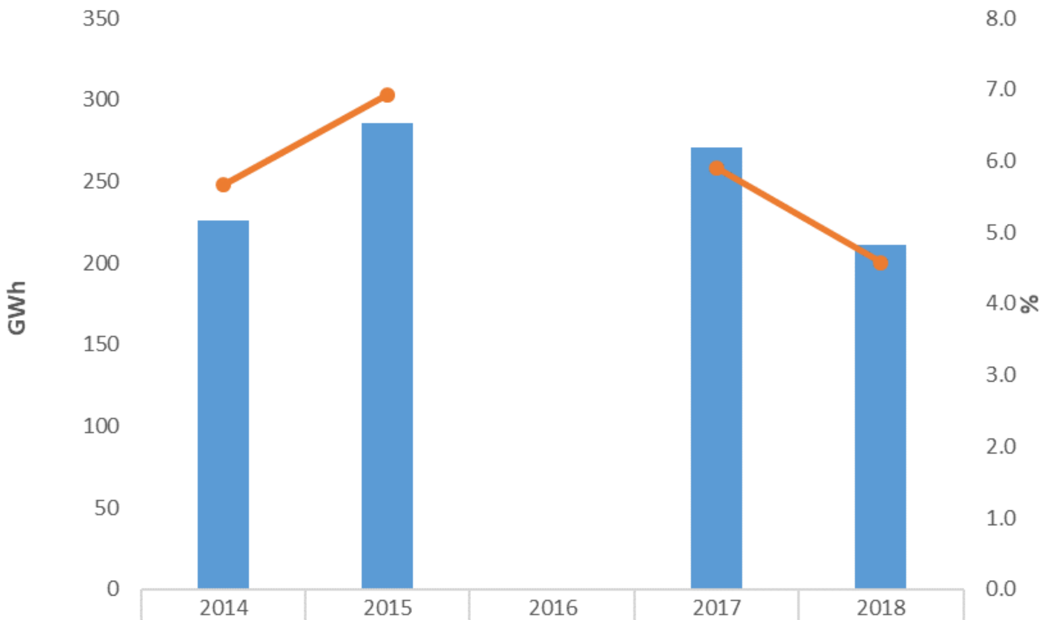
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES

	2014	2015	2016	2017	2018
(GWh)	99	135		132	96
(%)				2.93	2.11



	2014	2015	2016	2017	2018
(GWh)	73	77	83	66	62
(%)	1.83	1.87	1.85	1.44	1.35



	2014	2015	2016	2017	2018
(GWh)	226	286		271	211
(%)	5.67	6.93		5.90	4.58

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

CZECH REPUBLIC

GENERAL INFORMATION

Network length of distribution networks	243,184 km
Number of metering points in distribution network	6,004,321
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- "hidden" non-technical losses	No
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Losses are determined by direct metering (in transmission) or combination of metering and estimation (in distribution).
Is the same method used to determine losses on every voltage level?	No (see above).

PROCUREMENT OF LOSSES

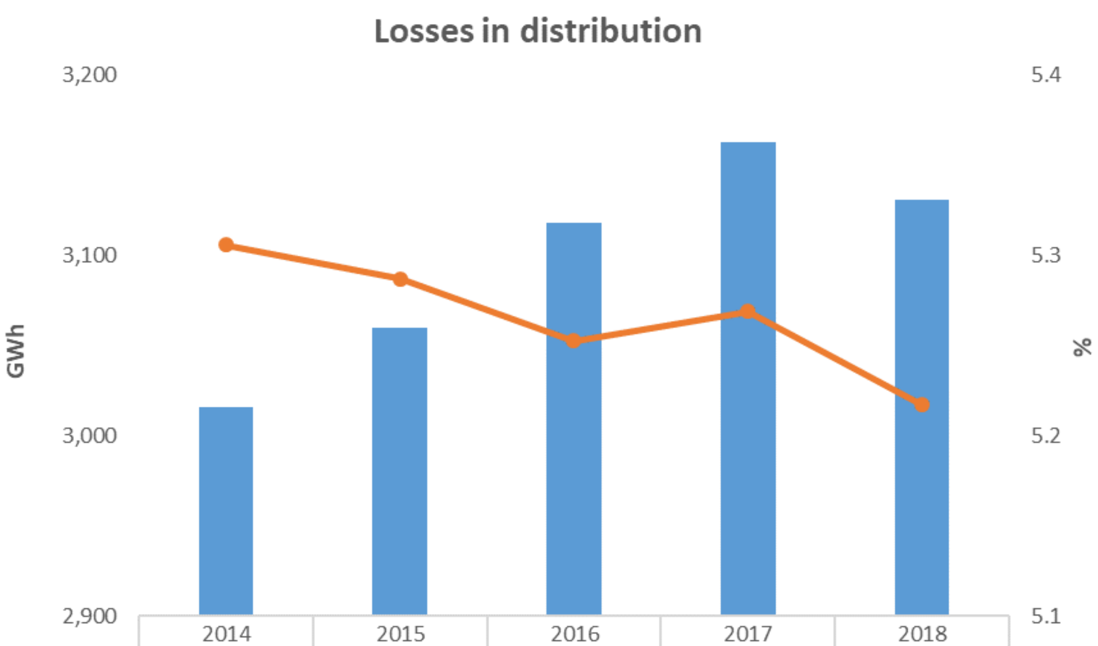
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs (distribution and transmission)

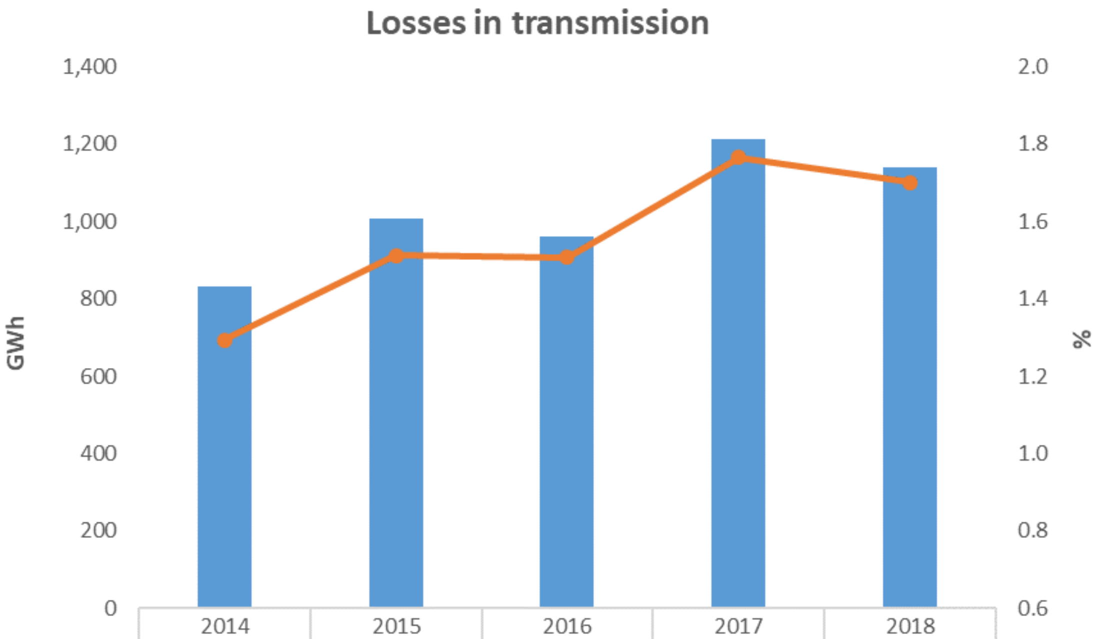
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

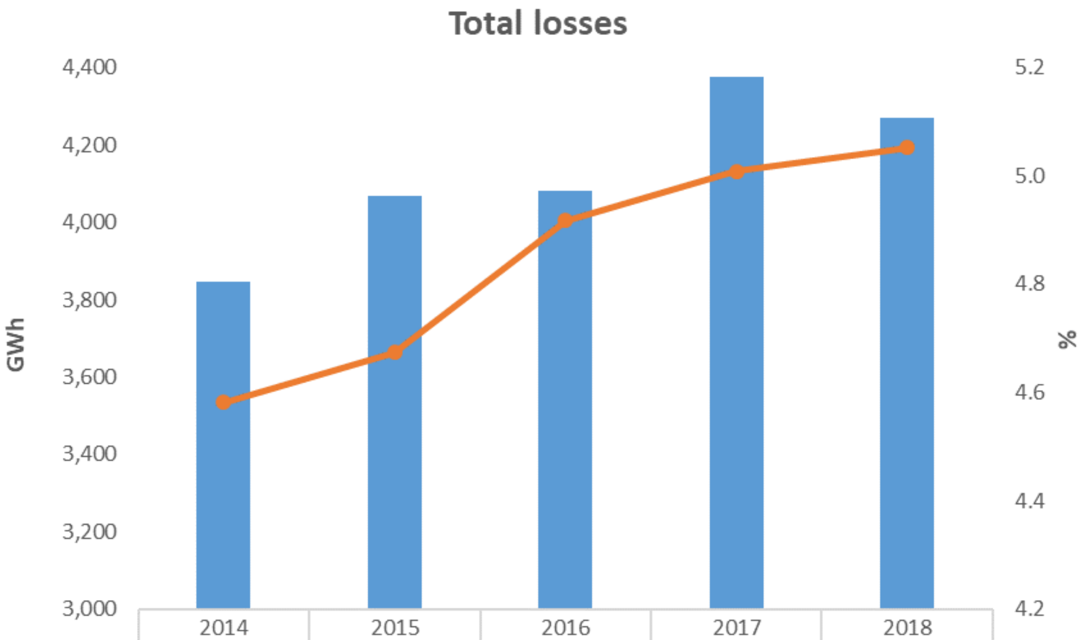
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	3,015	3,060	3,118	3,163	3,130
(%)	5.31	5.29	5.25	5.27	5.22



	2014	2015	2016	2017	2018
(GWh)	831	1,007	963	1,212	1,139
(%)	1.29	1.51	1.51	1.77	1.70



	2014	2015	2016	2017	2018
(GWh)	3,847	4,067	4,080	4,375	4,269
(%)	4.58	4.67	4.92	5.01	5.05

DENMARK

GENERAL INFORMATION

Network length of distribution networks	163,000 km
Number of metering points in distribution network	3,361,816
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Calculated based on measured values (production, consumption and exchange). Loss = Sum(production) + Sum(exchange) - Sum(consumption), where the Sum(exchange) can be both positive and negative.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

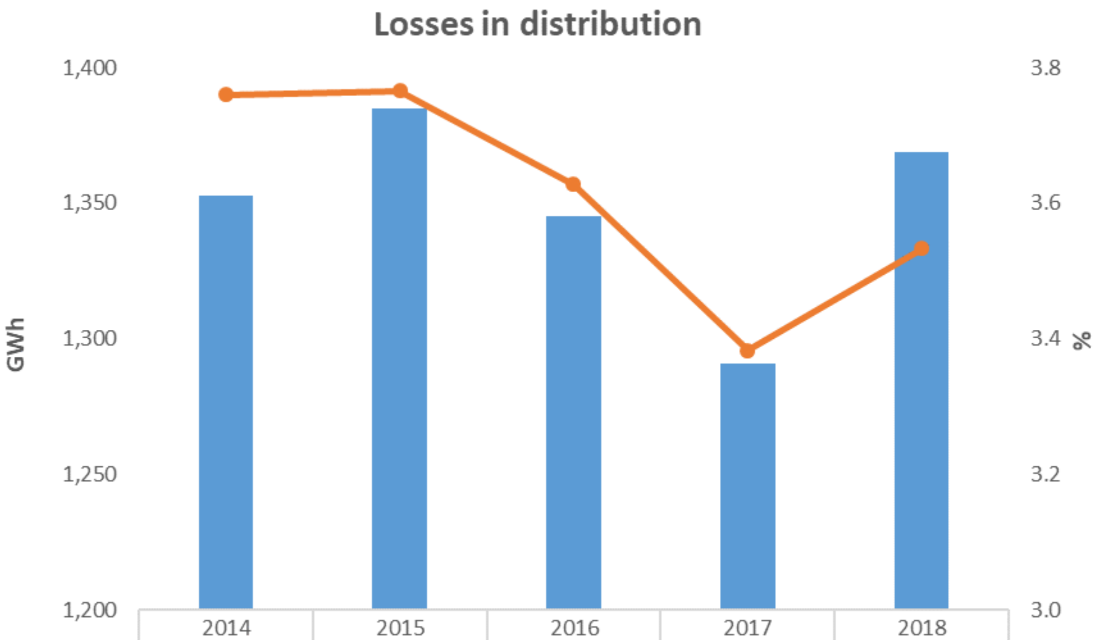
Party responsible for procurement of power losses	DSO and TSO

Party responsible for forecasting power losses	DSO and TSO
How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

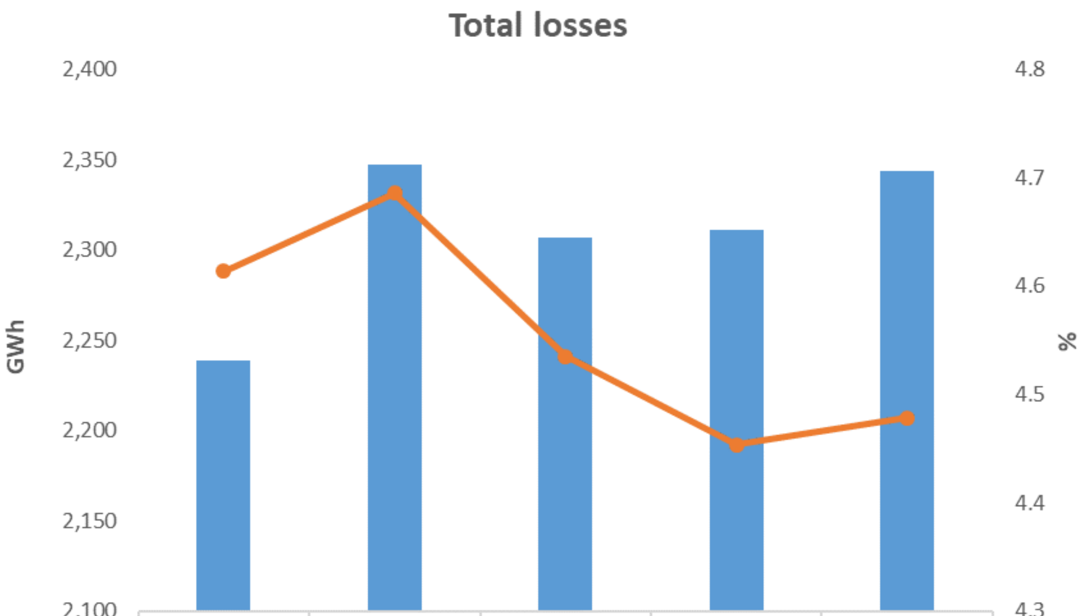
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	1,353	1,385	1,345	1,291	1,369
(%)	3.76	3.77	3.63	3.38	3.53

	2014	2015	2016	2017	2018
(GWh)	886	962	962	1,020	975
(%)	2.47	2.67	2.58	2.80	2.66



	2014	2015	2016	2017	2018
(GWh)	2,239	2,347	2,307	2,311	2,344
(%)	4.61	4.69	4.54	4.45	4.48

ESTONIA

GENERAL INFORMATION

Network length of distribution networks	65,700 km
Number of metering points in distribution network	707,900
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	No
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	No
Method for determining losses	Measured - the difference between energy injections and withdrawals. Non-technical losses are usually estimated.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

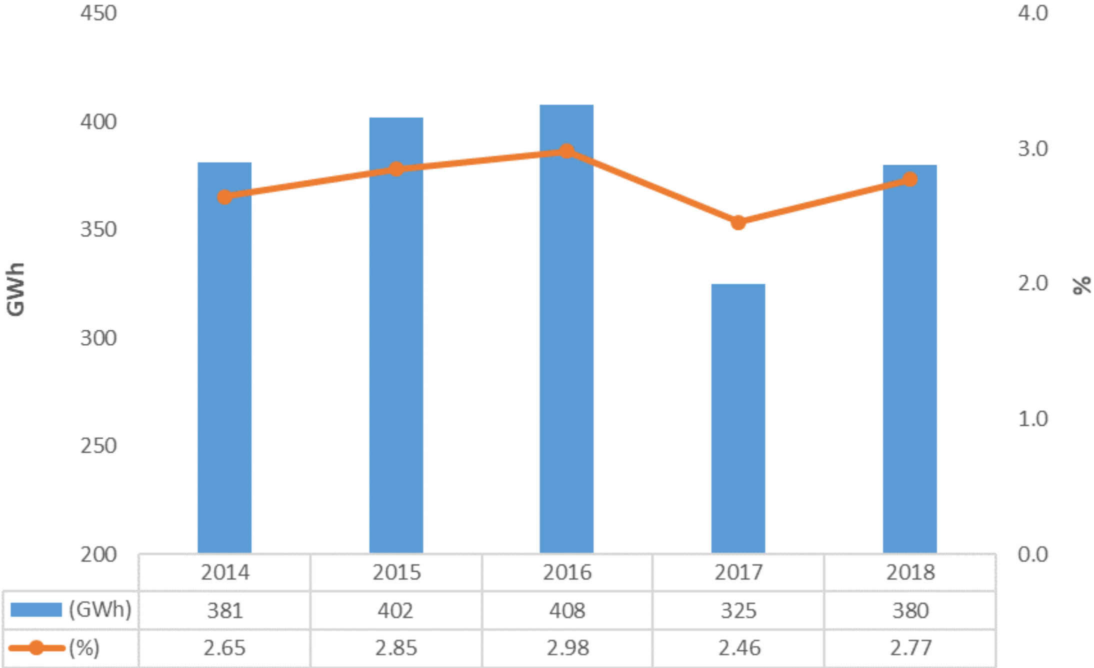
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES

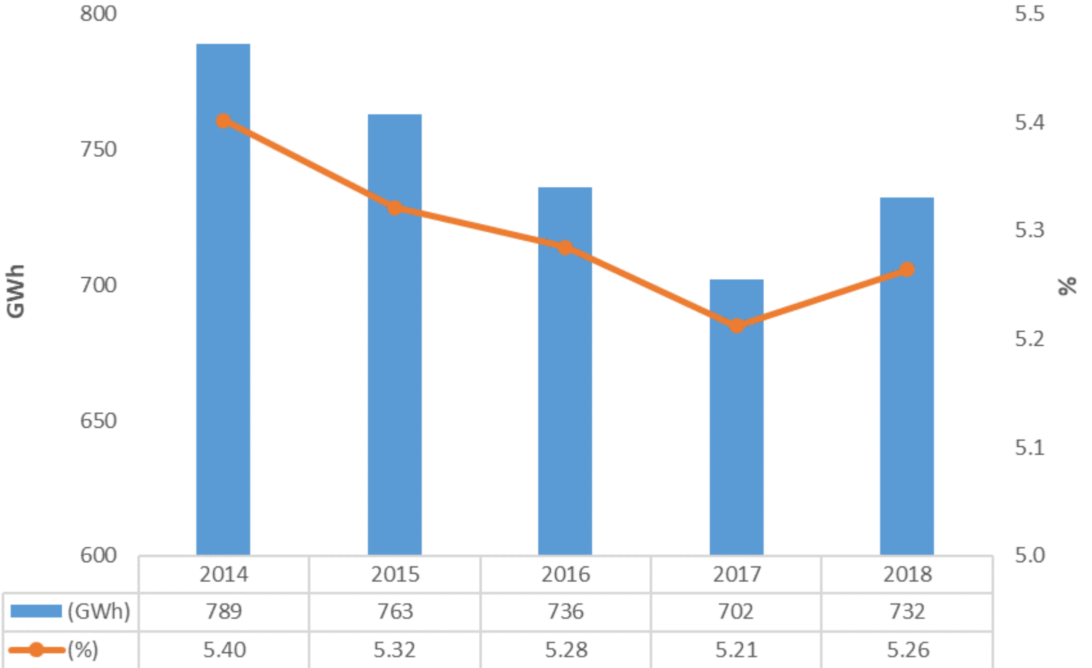
	2014	2015	2016	2017	2018
(GWh)	408	361	328	377	352
(%)	5.65	5.03	4.42	4.95	4.55

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	381	402	408	325	380
(%)	2.65	2.85	2.98	2.46	2.77

Total losses



	2014	2015	2016	2017	2018
(GWh)	789	763	736	702	732
(%)	5.40	5.32	5.28	5.21	5.26

FINLAND

GENERAL INFORMATION

Network length of distribution networks	400,161 km
Number of metering points in distribution network	3,602,781 (there are additionally 224 high voltage DSO metering points)
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between network injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not calculated per voltage level.

PROCUREMENT OF LOSSES

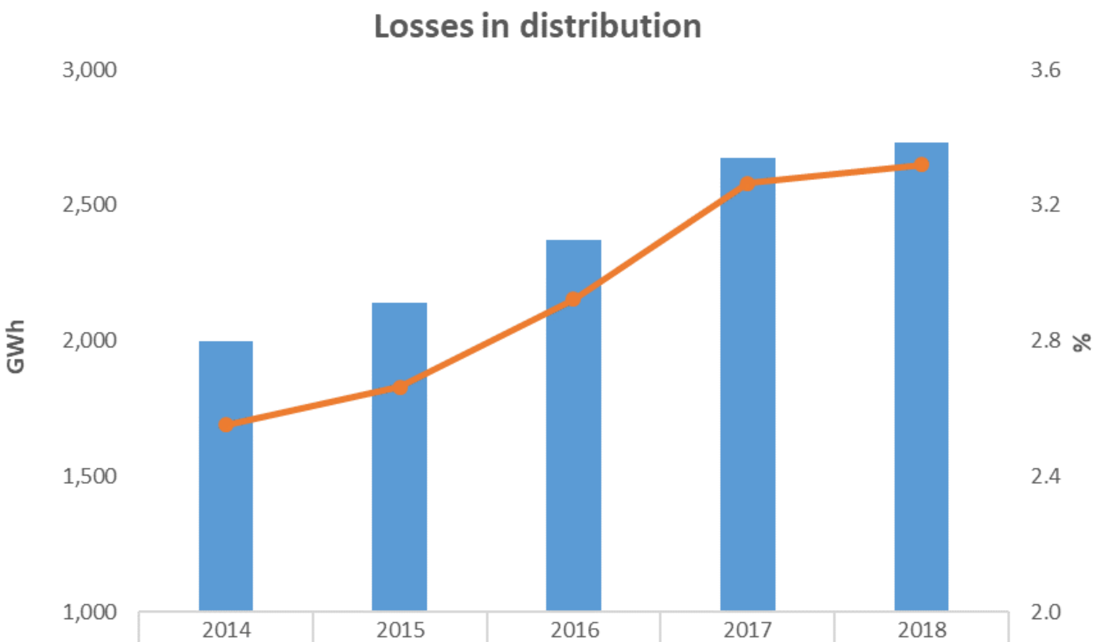
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

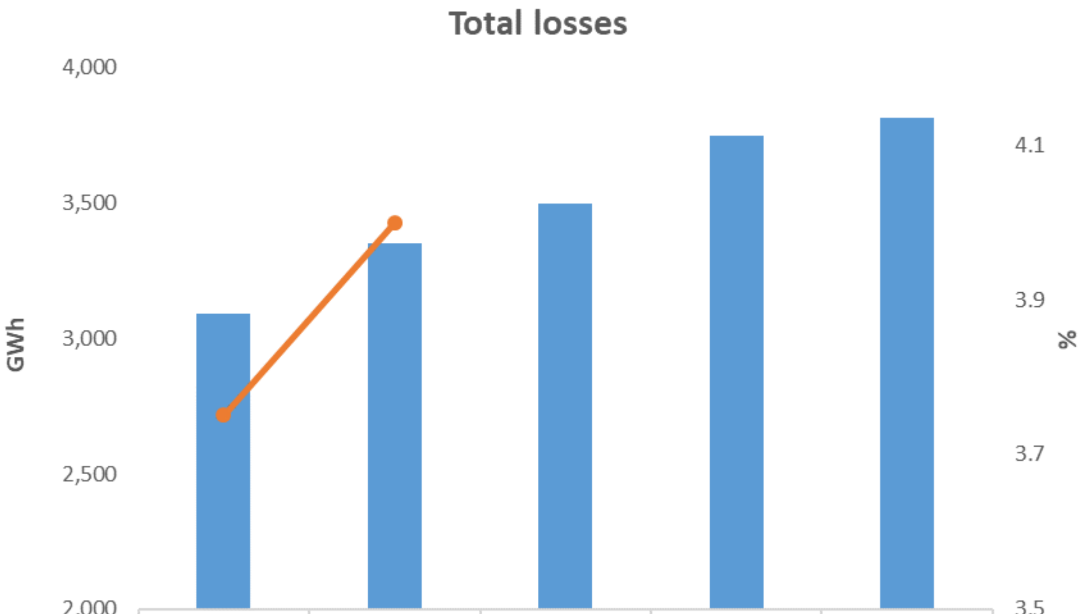
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	2,000	2,139	2,372	2,672	2,733
(%)	2.55	2.66	2.92	3.27	3.32

	2014	2015	2016	2017	2018
(GWh)	1,089	1,211	1,126	1,074	1,080
(%)	1.60	1.75	1.62	1.60	1.55



	2014	2015	2016	2017	2018
(GWh)	3,089	3,350	3,498	3,745	3,813
(%)	3.75	4.00			

FRANCE

GENERAL INFORMATION

Network length of distribution networks	1,365,884 km
Number of metering points in distribution network	36,965,248
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

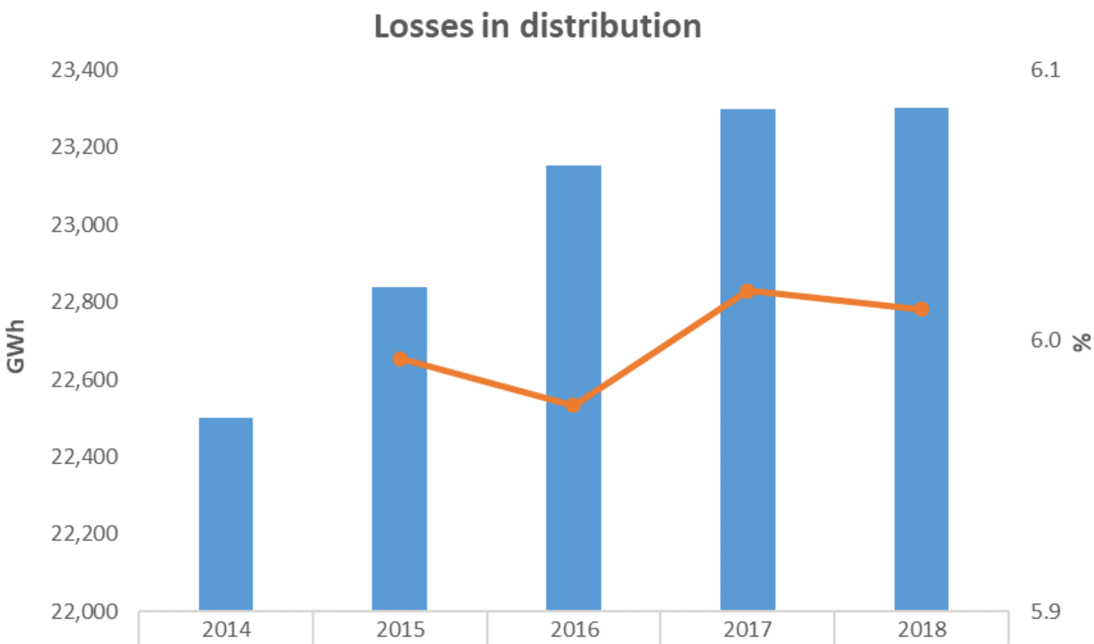
Party responsible for procurement of power losses	DSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

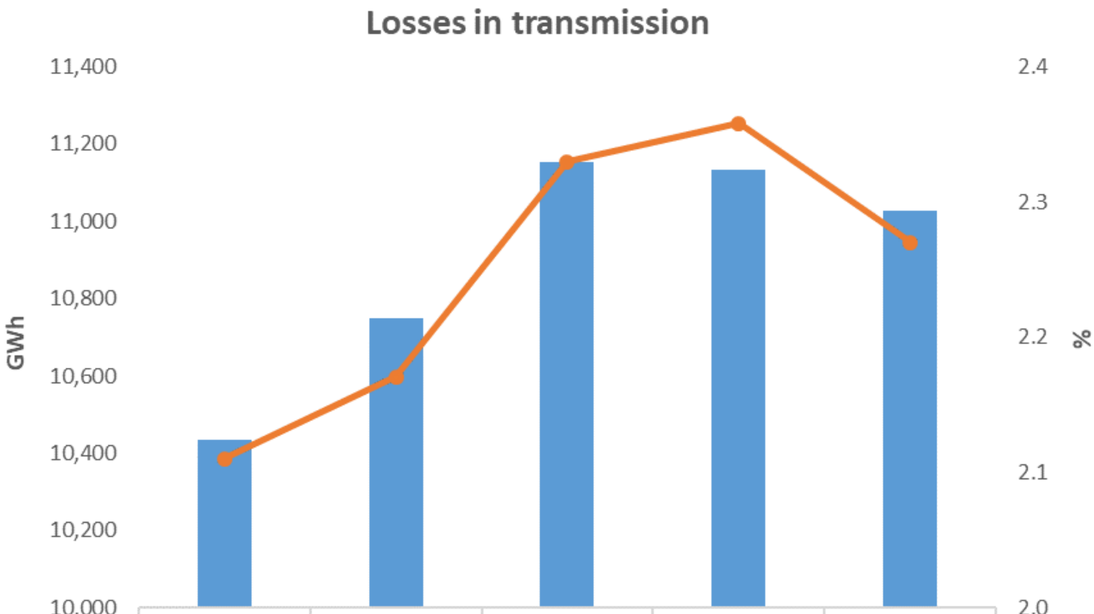
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

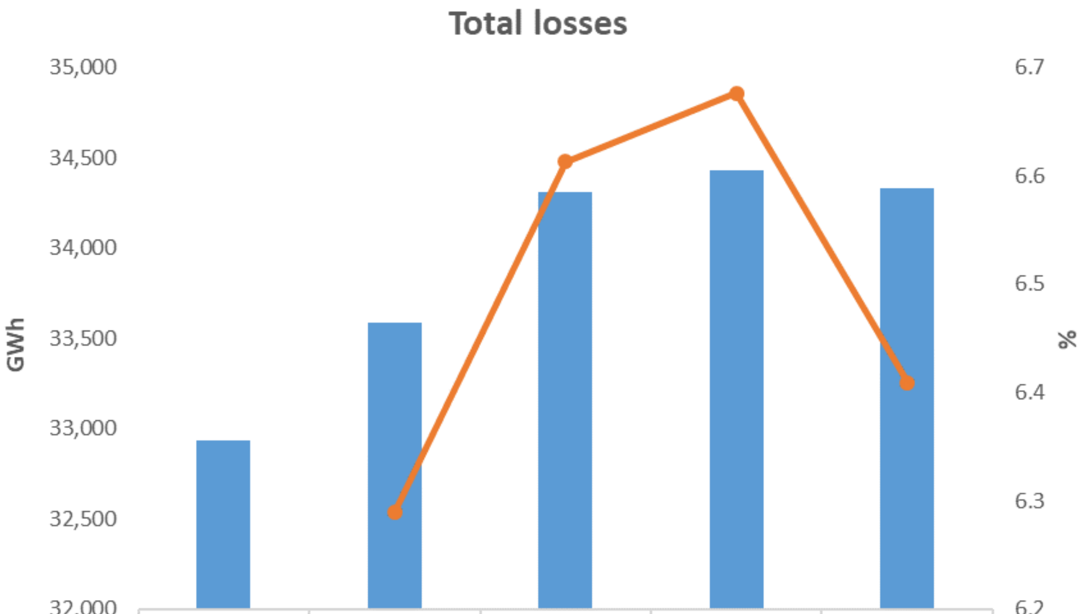
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	22,500	22,839	23,153	23,299	23,302
(%)		5.99	5.98	6.02	6.01



	2014	2015	2016	2017	2018
(GWh)	10,434	10,749	11,154	11,133	11,027
(%)	2.11	2.17	2.33	2.36	2.27



	2014	2015	2016	2017	2018
(GWh)	32,934	33,588	34,307	34,432	34,329
(%)		6.29	6.61	6.68	6.41

GEORGIA

GENERAL INFORMATION

Network length of distribution networks	59,523.71 km
Number of metering points in distribution network	1,740,334
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	No
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

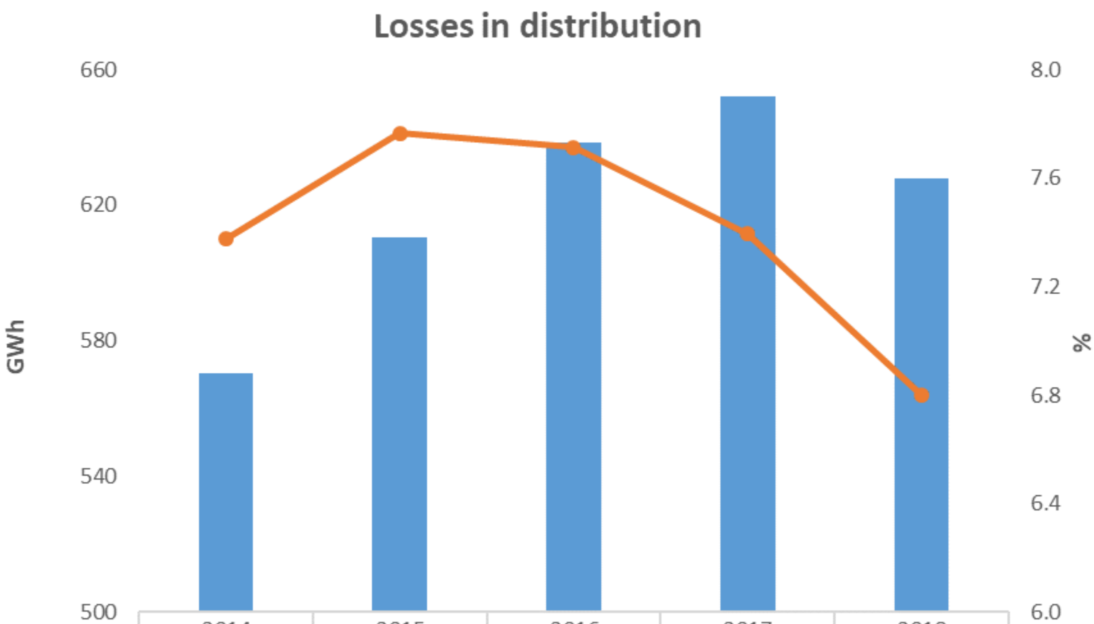
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	NRA

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

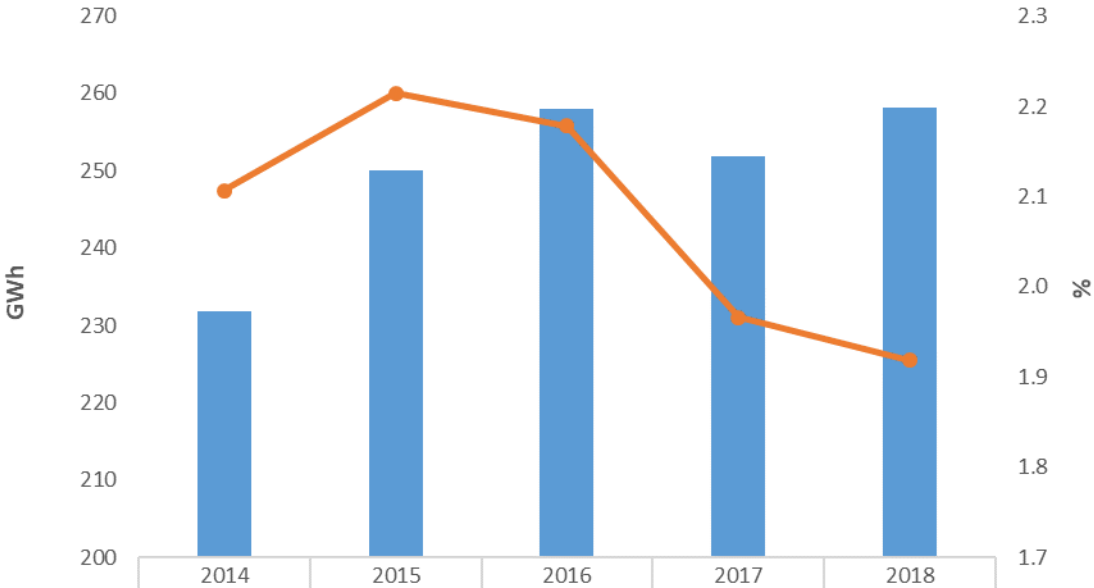
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

VALUES OF LOSSES



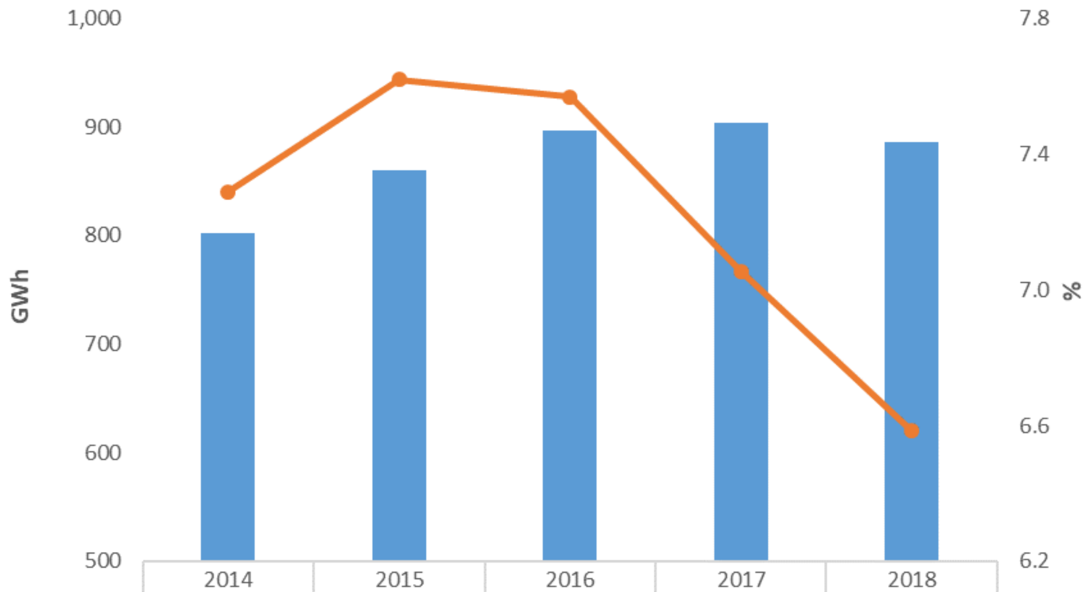
	2014	2015	2016	2017	2018
(GWh)	570	610	639	652	628
(%)	7.38	7.76	7.71	7.39	6.80

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	232	250	258	252	258
(%)	2.11	2.21	2.18	1.97	1.92

Total losses*



	2014	2015	2016	2017	2018
(GWh)	802	860	896	904	886
(%)	7.29	7.62	7.57	7.05	6.58

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

GERMANY

GENERAL INFORMATION

Network length of distribution networks	1,807,895 km
Number of metering points in distribution network	50,467,615
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	No
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	No
Are non-technical losses included in published losses and losses regulation?	No
Method for determining losses	Any method to derive the amount of losses is allowed. This includes estimation, free valuation, and calculation.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

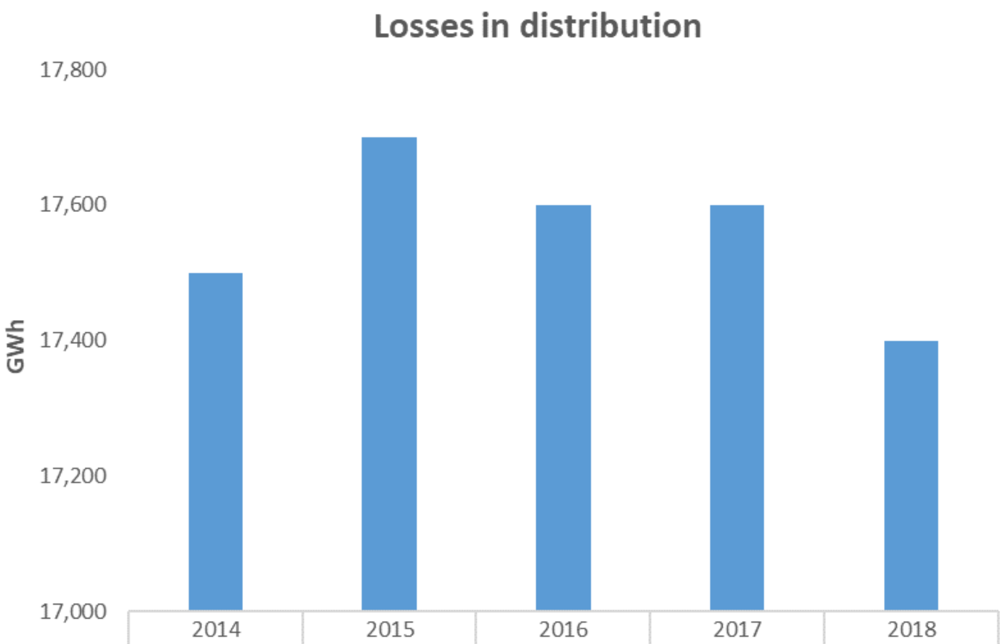
Party responsible for procurement of power losses	DSO and TSO (each in their own network)
Party responsible for forecasting power losses	DSO and TSO (each in their own network)

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

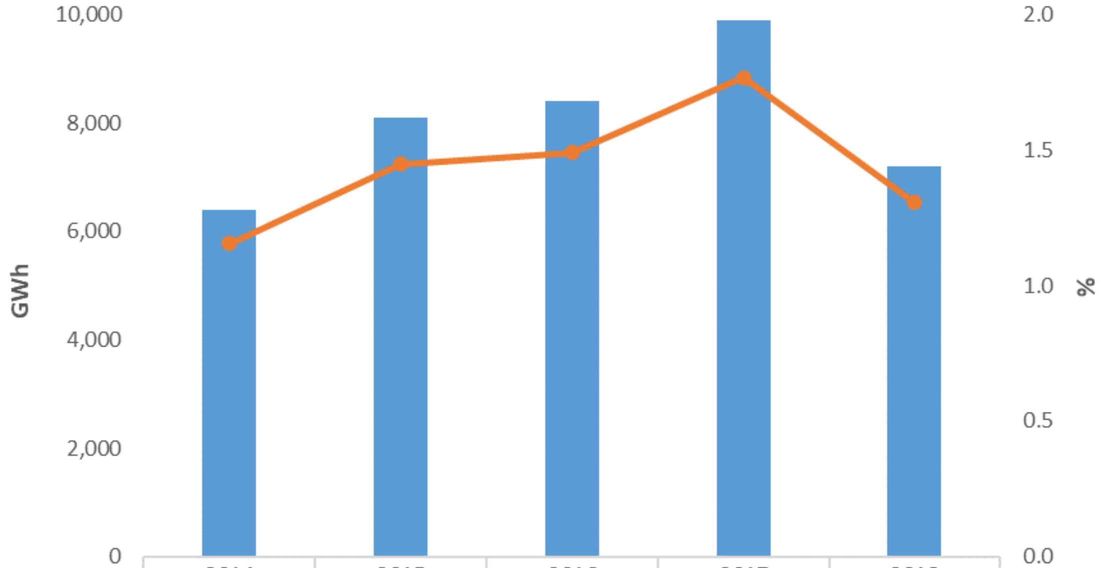
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



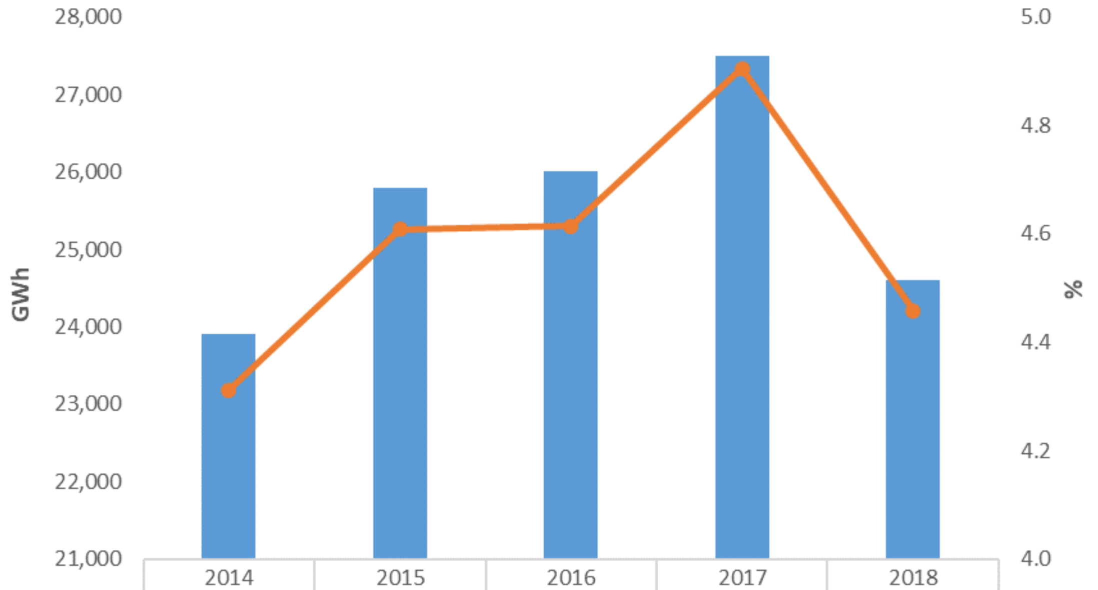
	2014	2015	2016	2017	2018
(GWh)	17,500	17,700	17,600	17,600	17,400

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	6,400	8,100	8,400	9,900	7,200
(%)	1.15	1.45	1.49	1.77	1.31

Total losses*



	2014	2015	2016	2017	2018
(GWh)	23,900	25,800	26,000	27,500	24,600
(%)	4.31	4.61	4.61	4.91	4.46

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

GREAT BRITAIN

GENERAL INFORMATION

Network length of distribution networks	800,479 km
Number of metering points in distribution network	29,773,856
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	No
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No (measured on EHV level, both measured and estimated on other voltage levels)

PROCUREMENT OF LOSSES

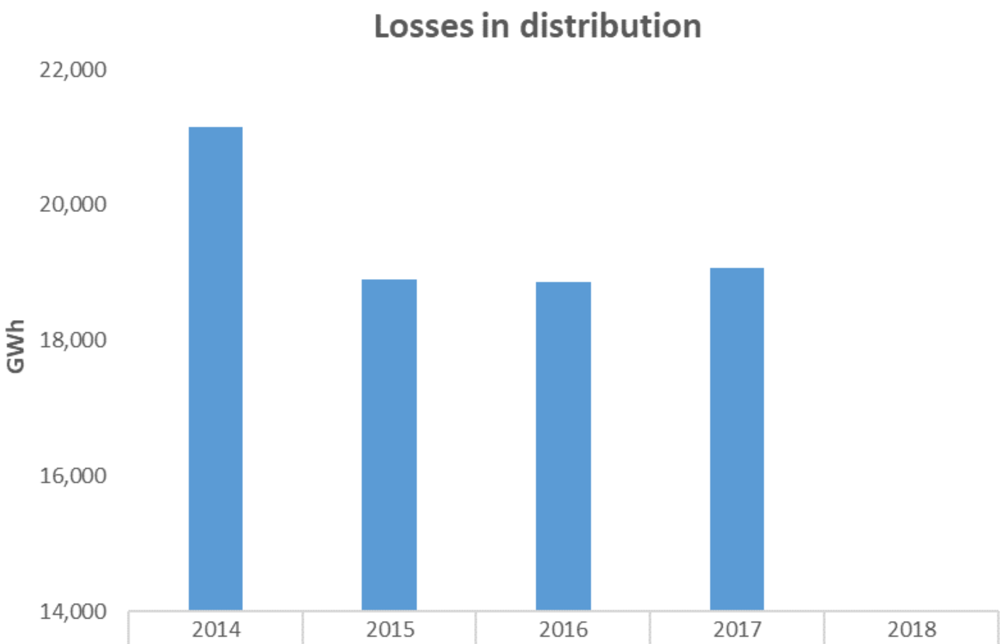
Party responsible for procurement of power losses	Suppliers
Party responsible for forecasting power losses	No specific requirement to forecast losses.

How are costs of procuring losses covered?	NA

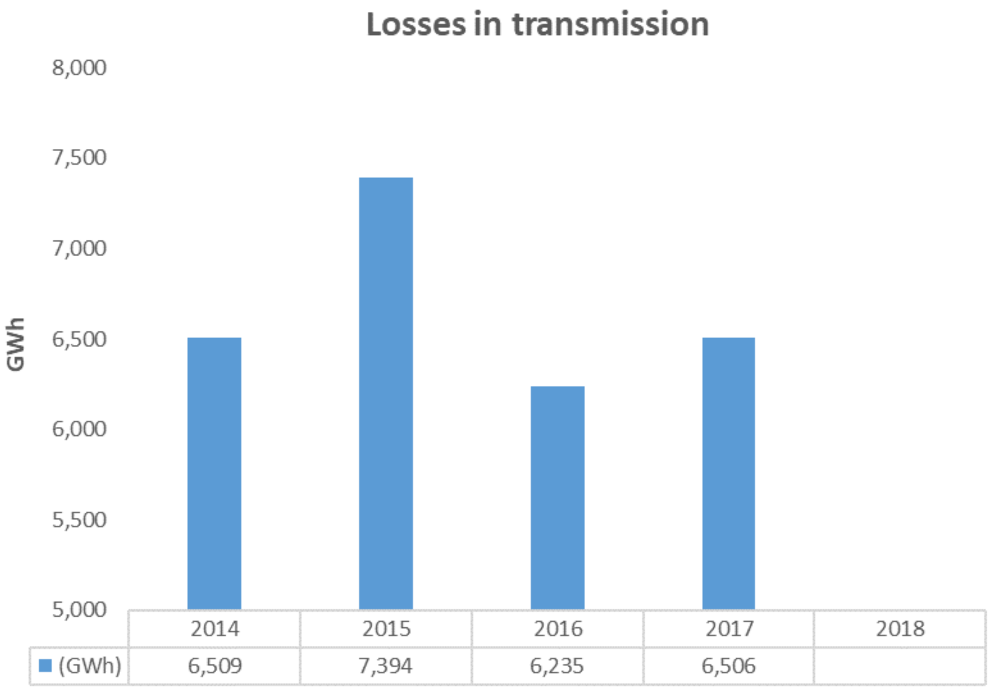
REGULATORY FRAMEWORK

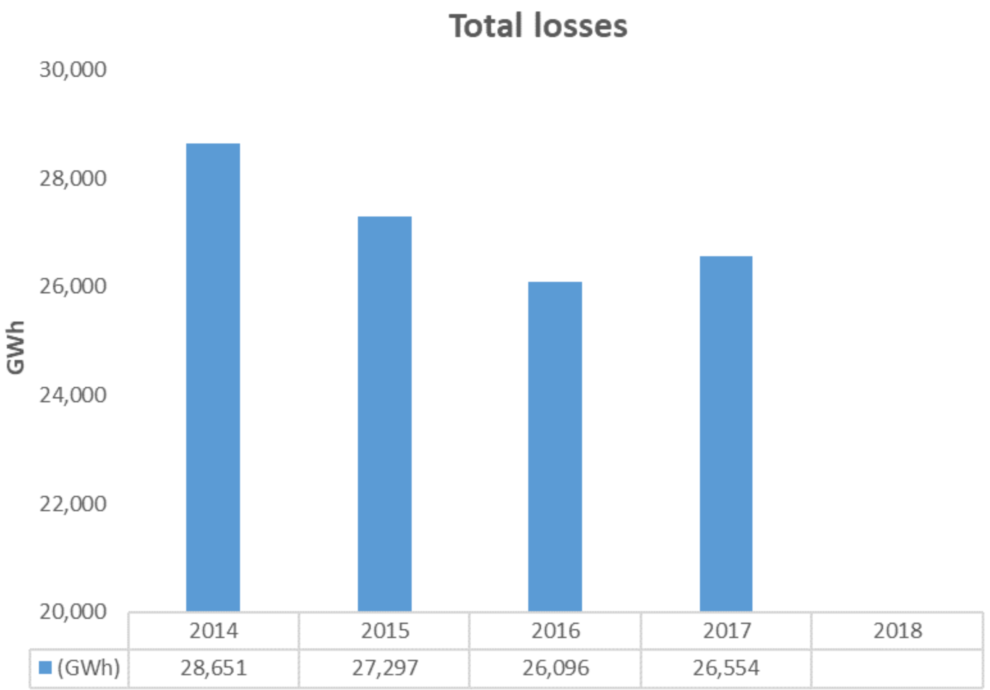
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes (for transmission)

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	21,141	18,906	18,866	19,065	


Losses in transmission
GWh
8,000
7,500
7,000
6,500
6,000
5,500
5,000
2014
2015
2016
2017
2018
(GWh)
6,509
7,394
6,235
6,506


Total losses
GWh
30,000
28,000
26,000
24,000
22,000
20,000
2014
2015
2016
2017
2018
(GWh)
28,651
27,297
26,096
26,554

GREECE

GENERAL INFORMATION

Network length of distribution networks	239,232 km
Number of metering points in distribution network	7,486,139
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

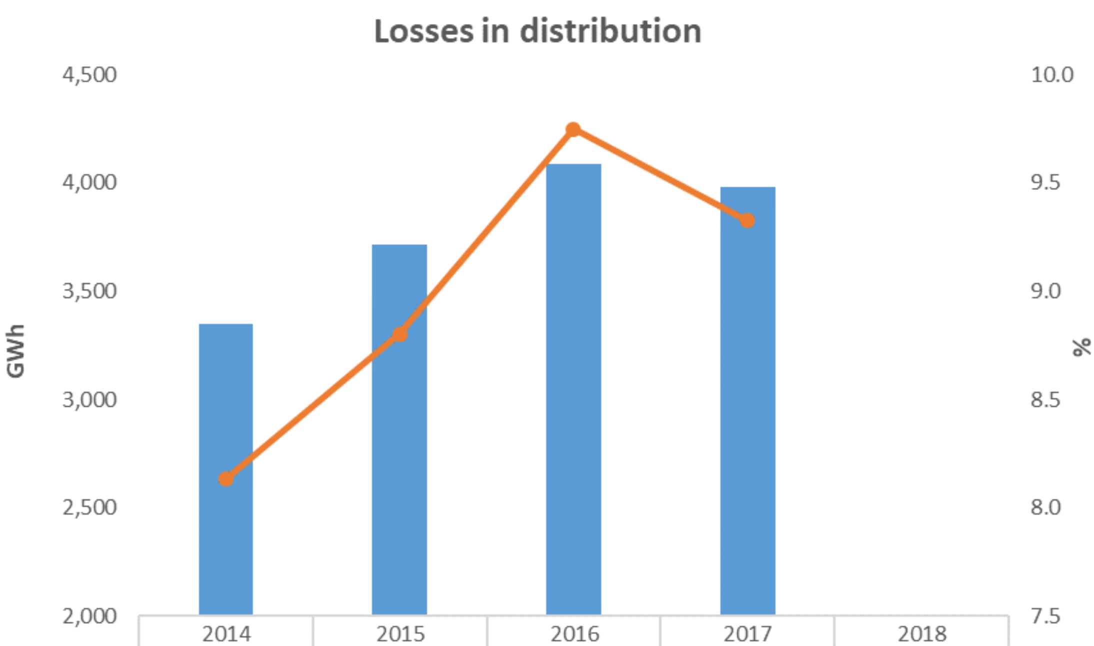
Party responsible for procurement of power losses	Market participants
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Market participants active in competitive activities bear the cost of network losses.

REGULATORY FRAMEWORK

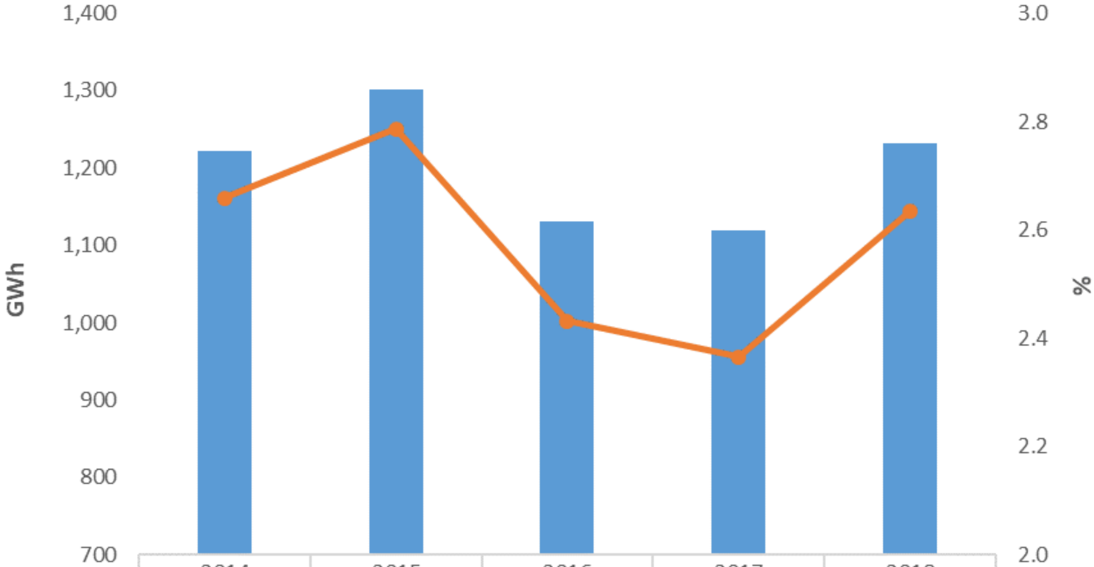
Regulatory incentives to reduce losses or costs related to losses in distribution?	Distribution Network Code includes provisions for a penalty/reward scheme to incentivise DSO to control network losses, but the scheme has not been activated yet.
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



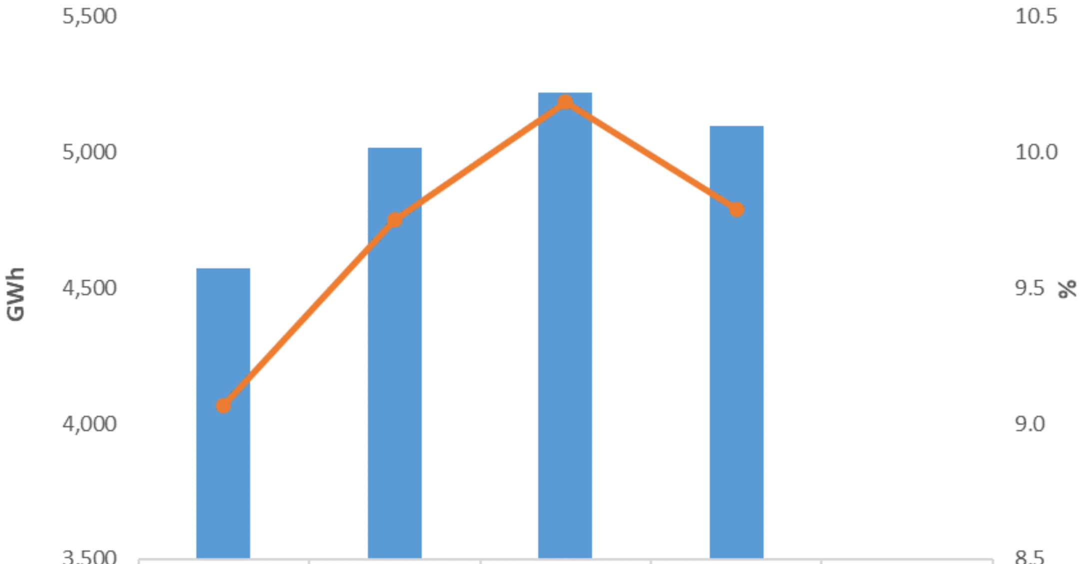
	2014	2015	2016	2017	2018
(GWh)	3,349	3,713	4,088	3,979	
(%)	8.13	8.80	9.75	9.33	

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	1,222	1,302	1,131	1,119	1,232
(%)	2.66	2.79	2.43	2.37	2.64

Total losses



	2014	2015	2016	2017	2018
(GWh)	4,571	5,015	5,219	5,098	
(%)	9.07	9.75	10.18	9.79	

HUNGARY

GENERAL INFORMATION

Network length of distribution networks	162,666 km
Number of metering points in distribution network	7,313,408
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- "hidden" non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Calculation and estimation.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

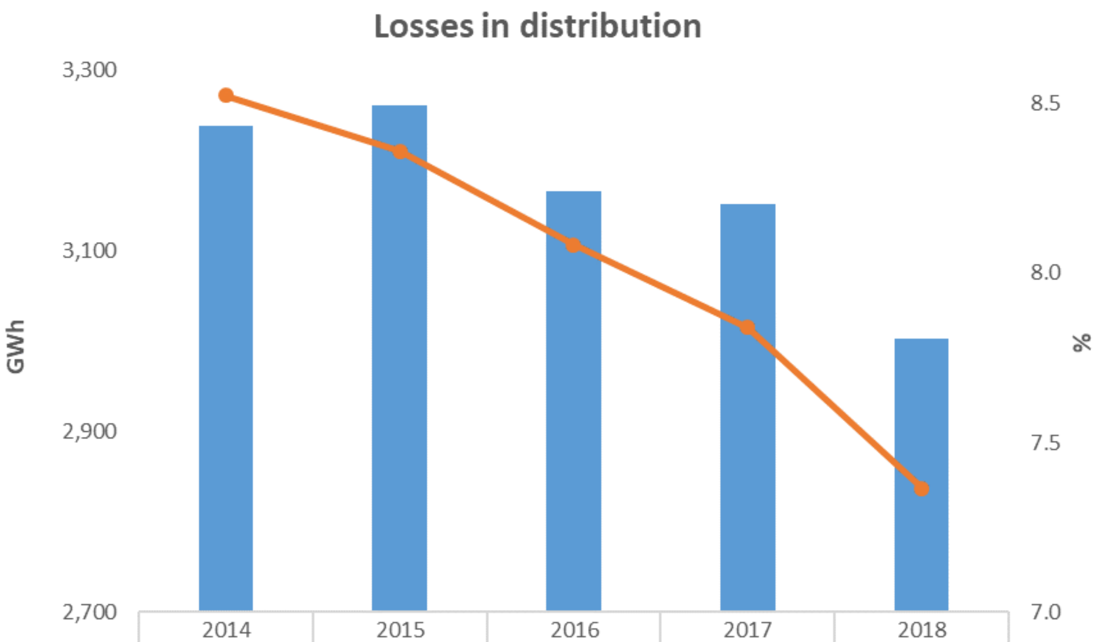
Party responsible for procurement of power losses	DSOs and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

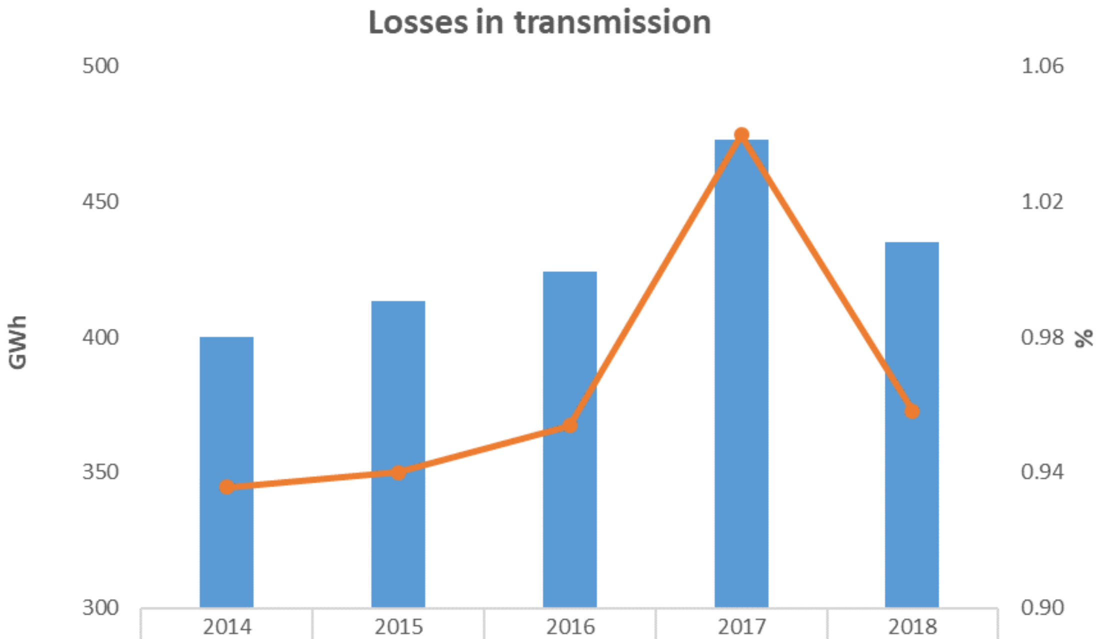
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

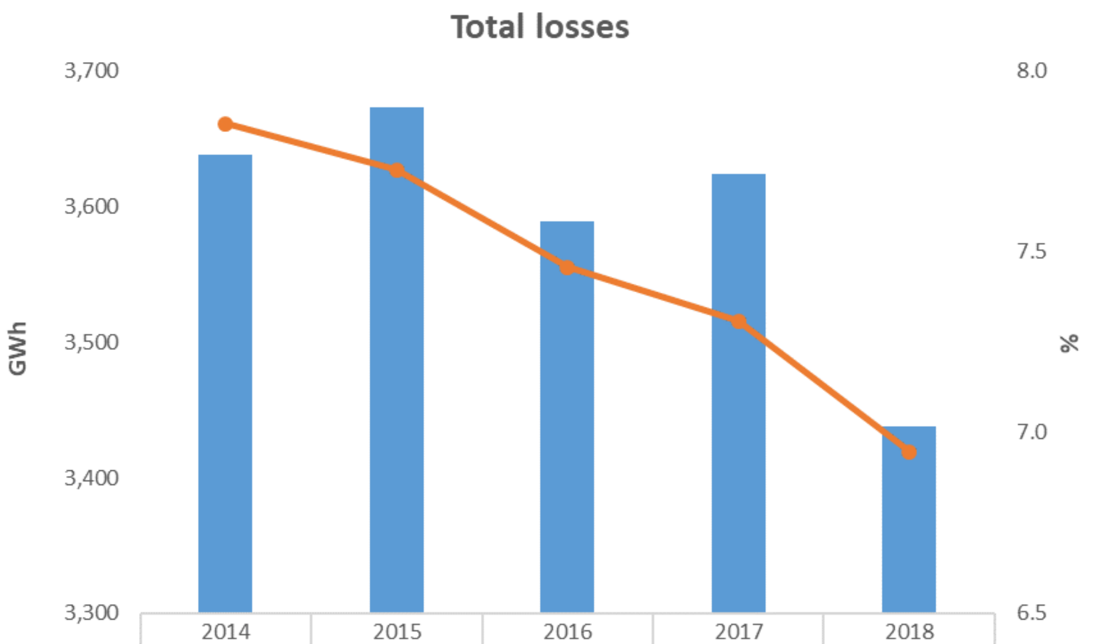
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	3,238	3,260	3,165	3,151	3,003
(%)	8.52	8.36	8.08	7.84	7.36



	2014	2015	2016	2017	2018
(GWh)	400	413	424	473	435
(%)	0.94	0.94	0.95	1.04	0.96



	2014	2015	2016	2017	2018
(GWh)	3,638	3,673	3,589	3,624	3,438
(%)	7.85	7.73	7.46	7.31	6.95

IRELAND

GENERAL INFORMATION

Network length of distribution networks	172,843 km
Number of metering points in distribution network	2,344,445
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses are measured for distribution and transmission systems. The apportionment by voltage level is estimated based on calculation.

PROCUREMENT OF LOSSES

Party responsible for procurement of power losses	Suppliers
Party responsible for forecasting power losses	System operators

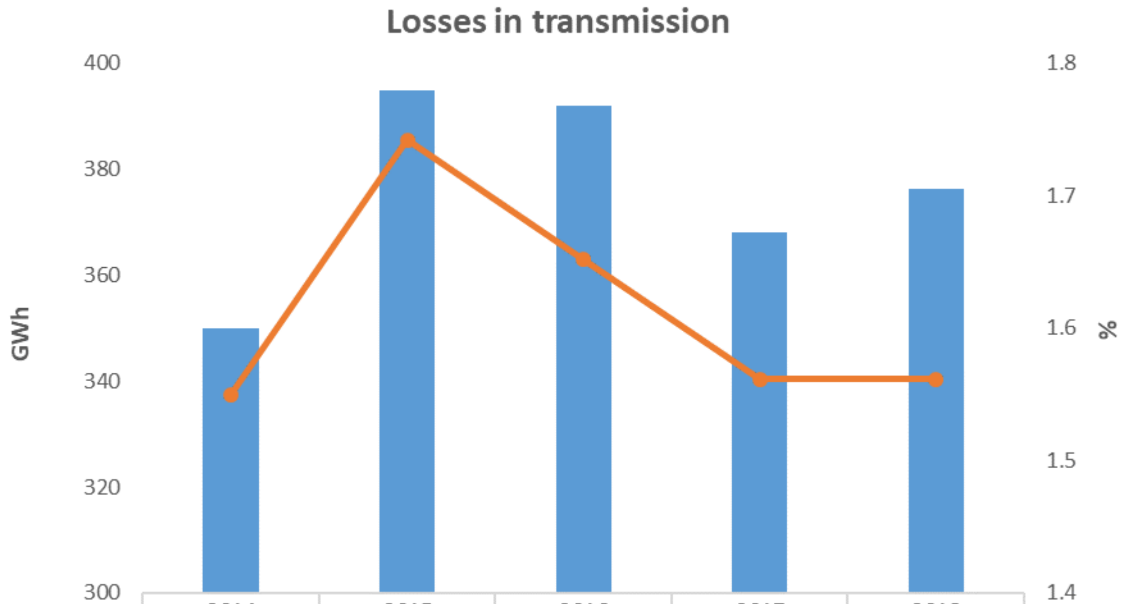
How are costs of procuring losses covered?	Through the market

REGULATORY FRAMEWORK

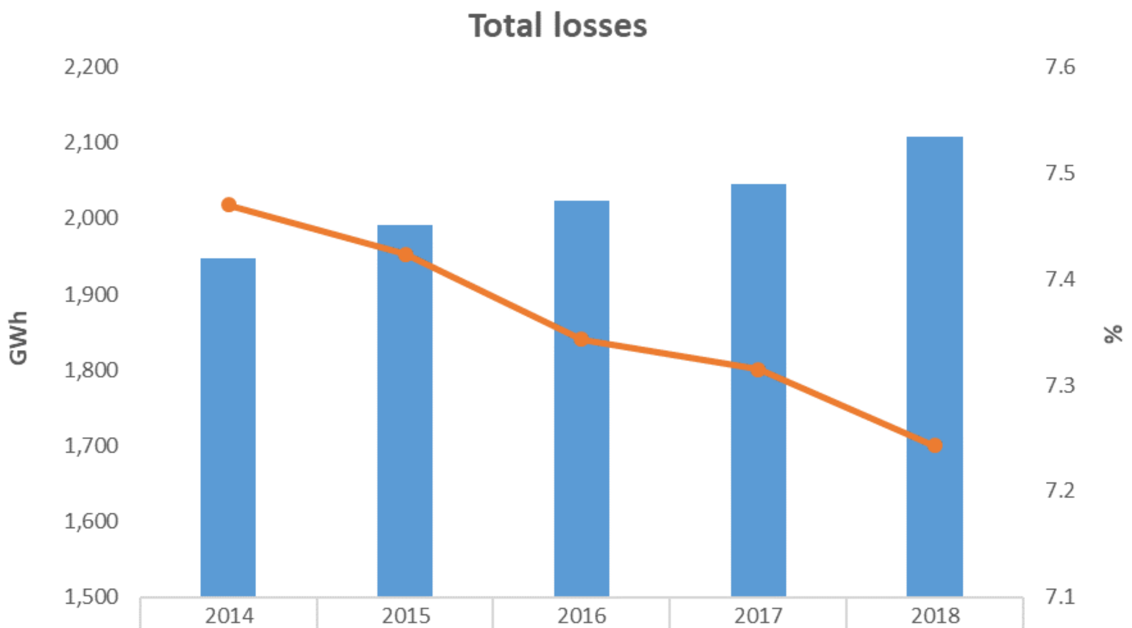
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

VALUES OF LOSSES

	2014	2015	2016	2017	2018
(GWh)	1,597	1,597	1,632	1,677	1,732
(%)	6.73	6.62	6.62	6.70	6.70



	2014	2015	2016	2017	2018
(GWh)	350	395	392	368	376
(%)	1.55	1.74	1.65	1.56	1.56



	2014	2015	2016	2017	2018
(GWh)	1,947	1,992	2,024	2,045	2,109
(%)	7.47	7.42	7.34	7.31	7.24

ITALY

GENERAL INFORMATION

Network length of distribution networks	1,256,567 km
Number of metering points in distribution network	36,756,395
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

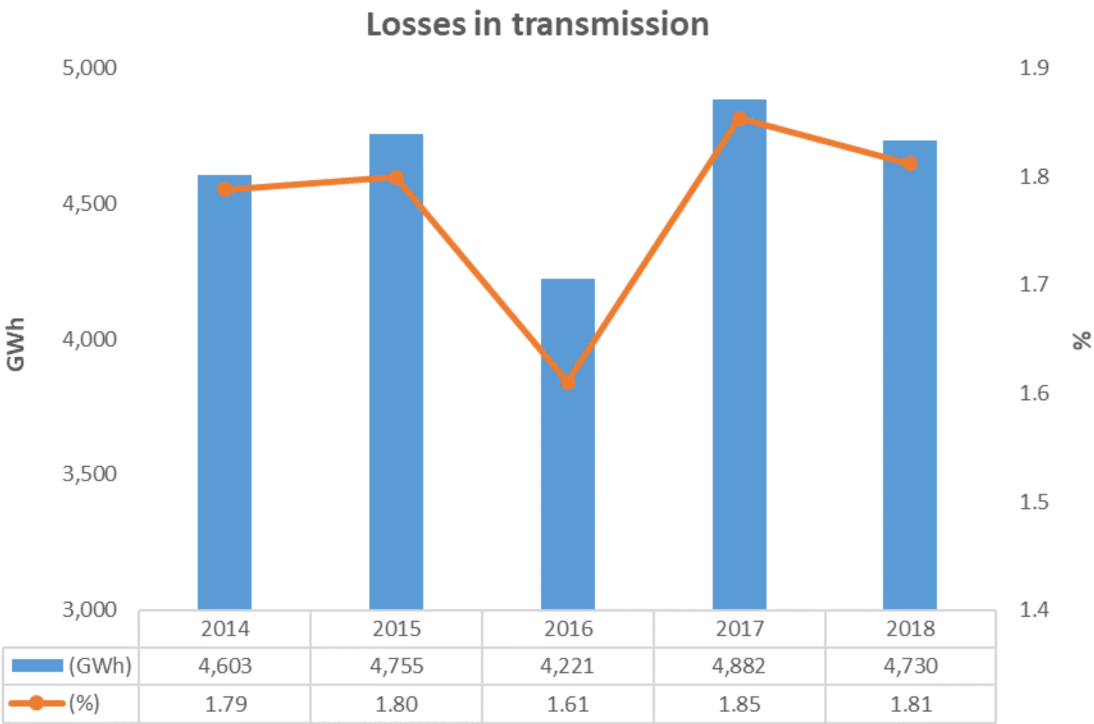
Party responsible for procurement of power losses	Standard losses: BRPs. Difference between actual and standard losses: TSO (transmission), single buyer (distribution)
Party responsible for forecasting power losses	TSO

How are costs of procuring losses covered?	Standard losses: BRPs in the wholesale market and the cost is then transferred to their clients. Difference between actual and standard losses: BRPs (transmission), DSOs (distribution)

REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No (although they could be indicated on the bill)
Different prices of losses for different network users?	No

VALUES OF LOSSES



*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

KOSOVO*

GENERAL INFORMATION

Network length of distribution networks	27,725.3 km
Number of metering points in distribution network	579,963
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

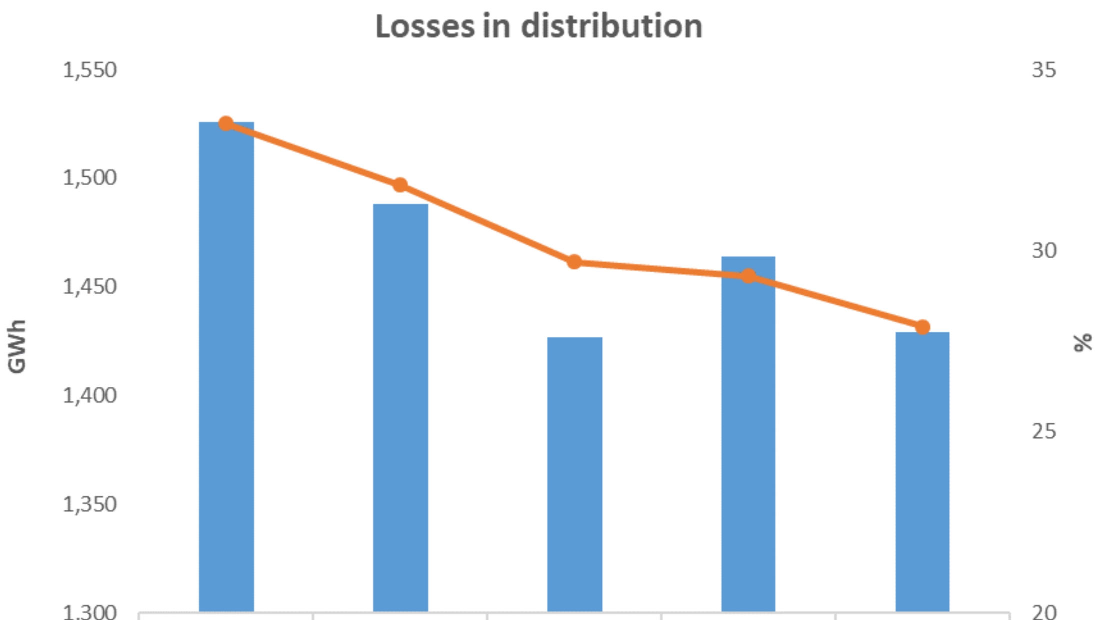
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

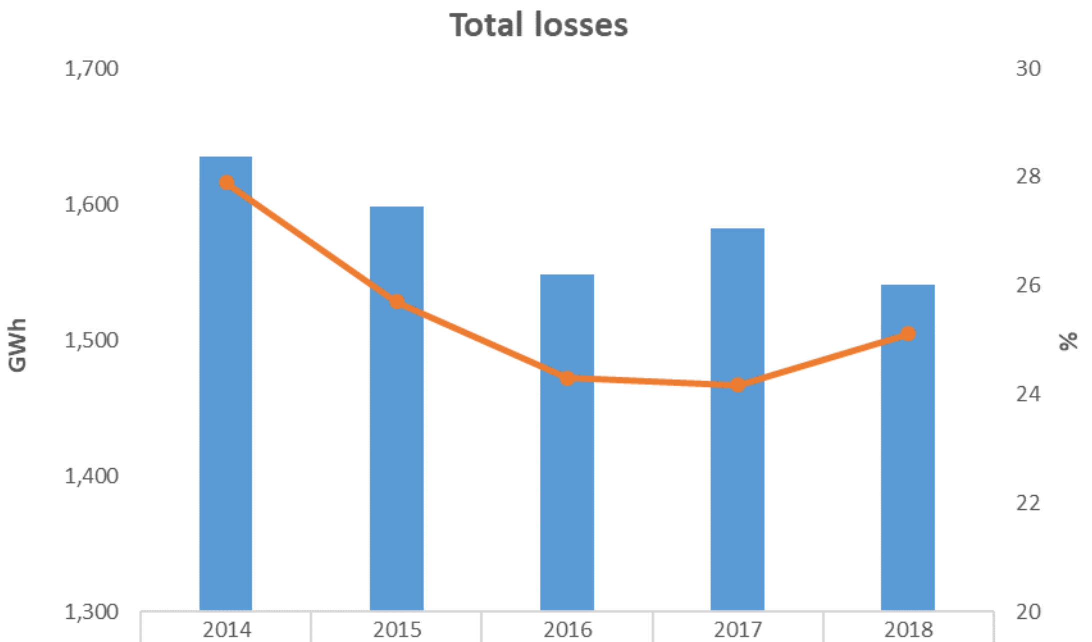
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	1,526	1,488	1,427	1,464	1,429
(%)	33.50	31.82	29.69	29.30	27.91

	2014	2015	2016	2017	2018
(GWh)	109	110	120	118	111
(%)	1.88	1.78	1.90	1.82	1.83



	2014	2015	2016	2017	2018
(GWh)	1,635	1,598	1,548	1,582	1,541
(%)	27.90	25.70	24.30	24.18	25.11

LATVIA

GENERAL INFORMATION

Network length of distribution networks	93,175 km
Number of metering points in distribution network	1,105,763
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

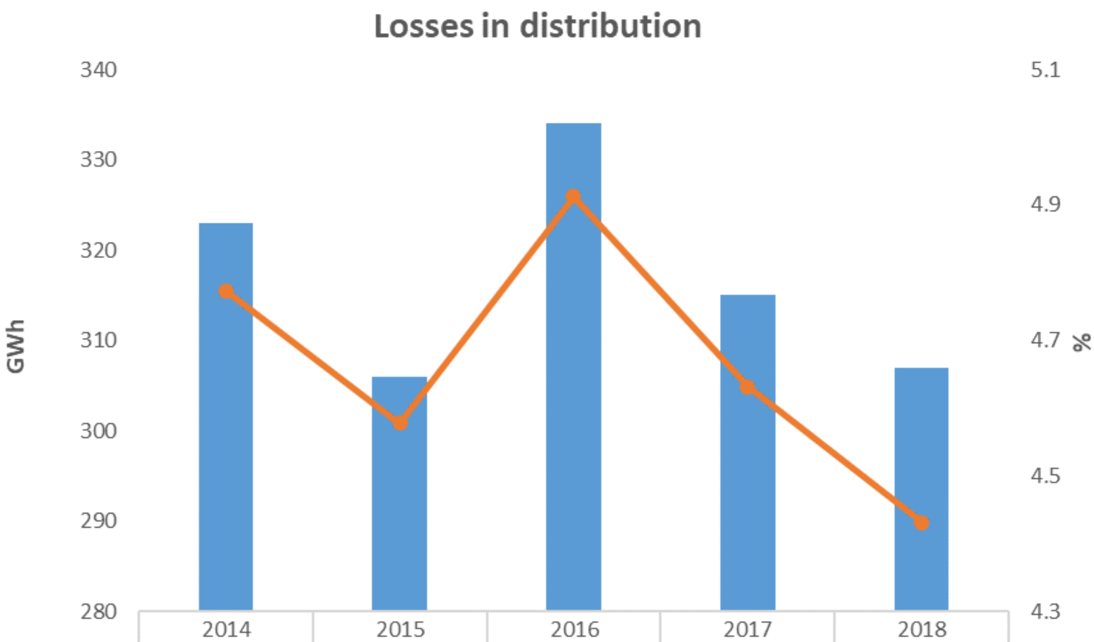
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

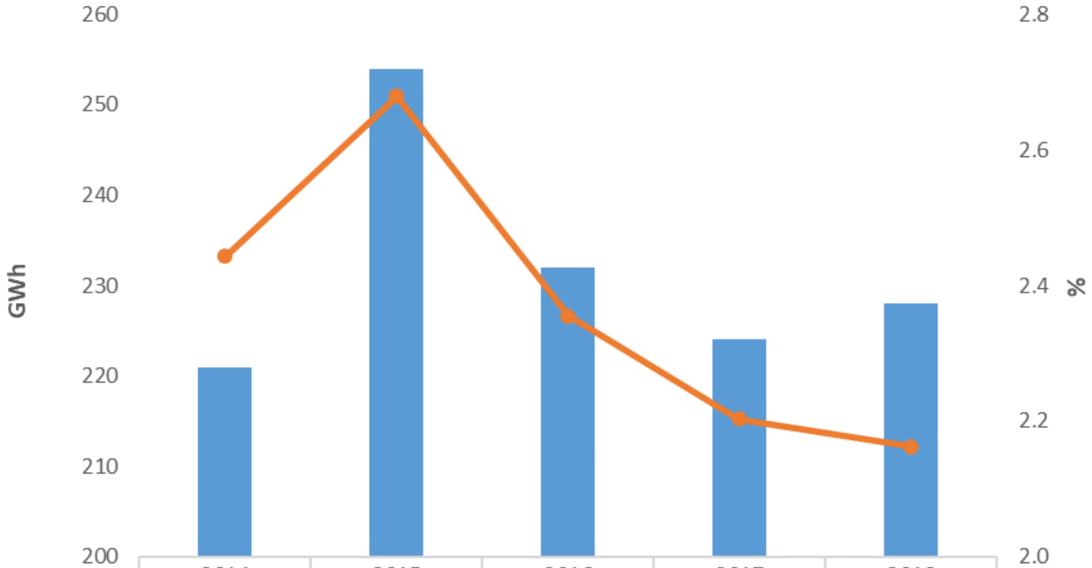
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



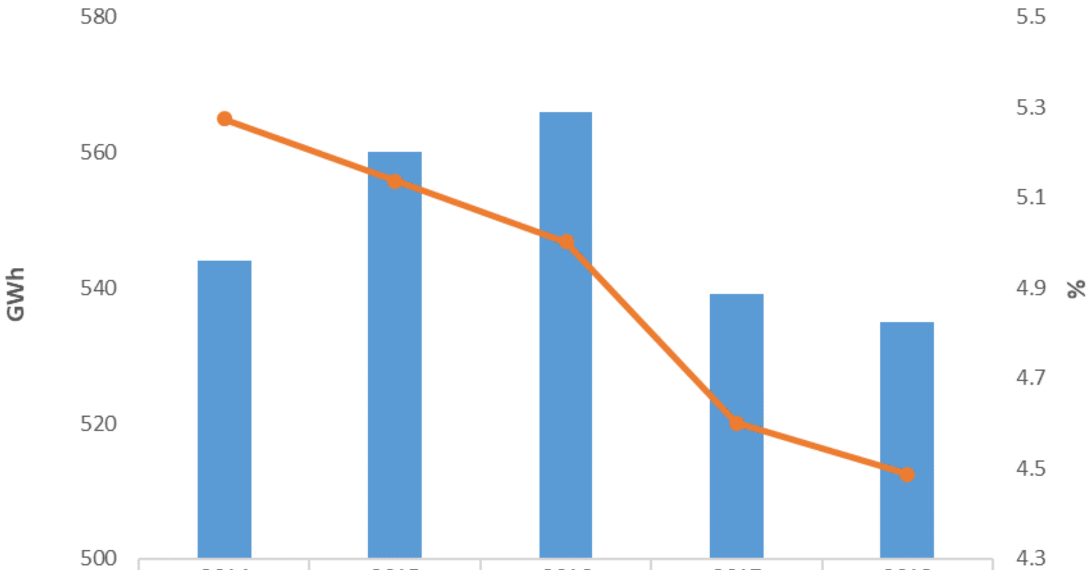
	2014	2015	2016	2017	2018
(GWh)	323	306	334	315	307
(%)	4.77	4.58	4.91	4.63	4.43

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	221	254	232	224	228
(%)	2.44	2.68	2.36	2.20	2.16

Total losses



	2014	2015	2016	2017	2018
(GWh)	544	560	566	539	535
(%)	5.27	5.14	5.00	4.60	4.49

LITHUANIA

GENERAL INFORMATION

Network length of distribution networks	125,000 km
Number of metering points in distribution network	1,795,153
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	NA

PROCUREMENT OF LOSSES

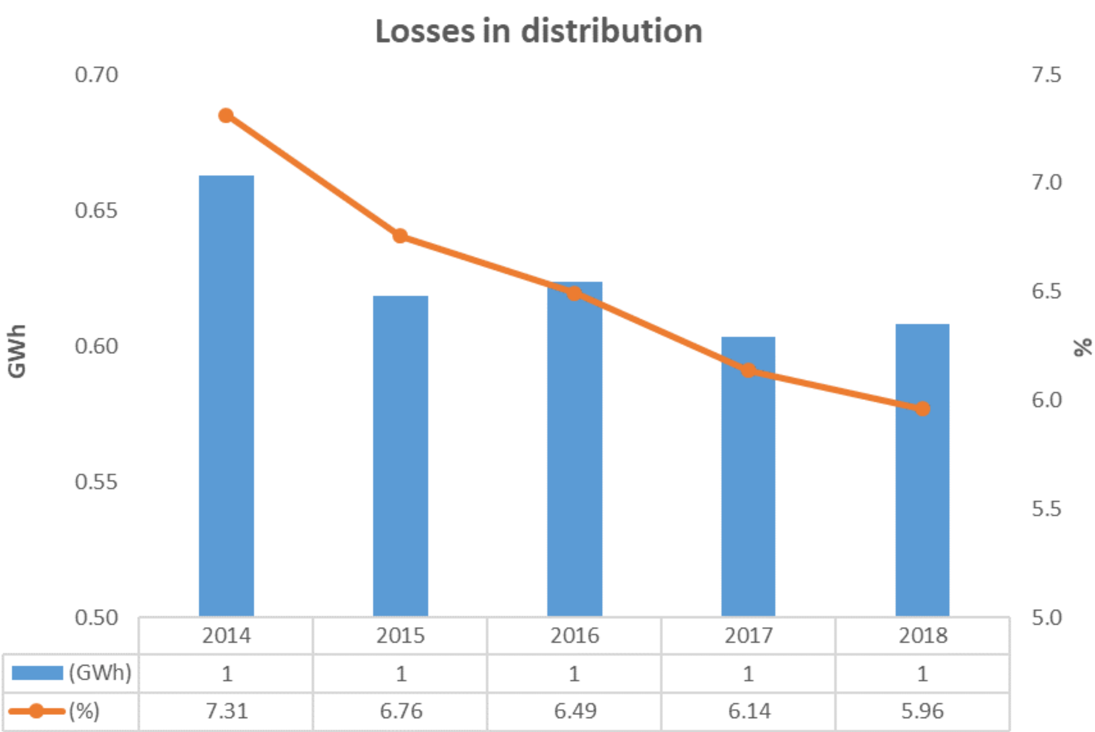
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

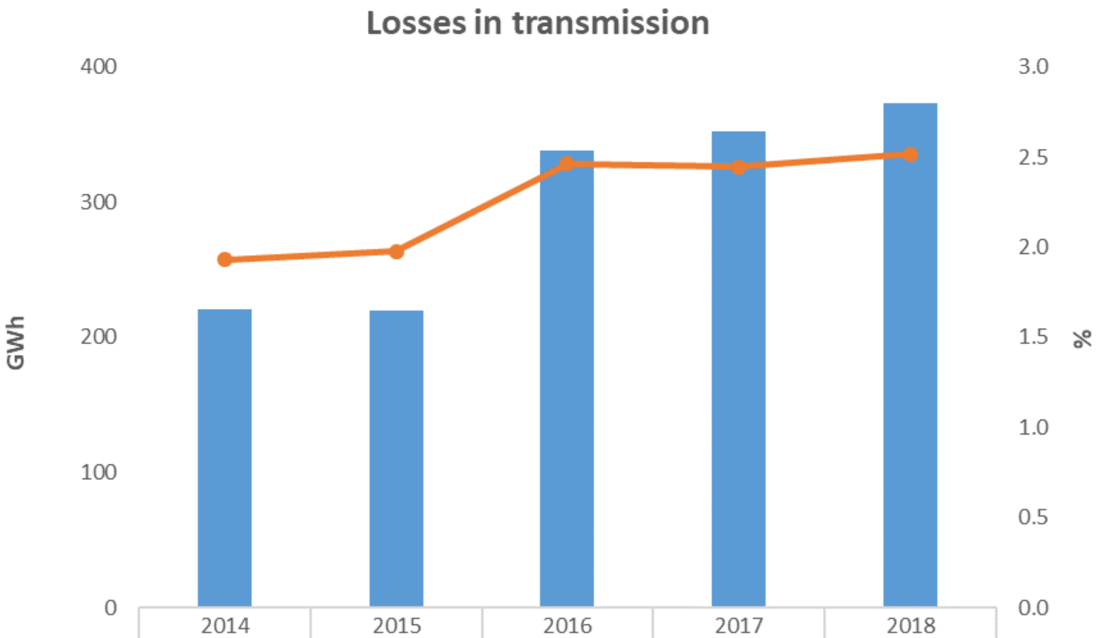
How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

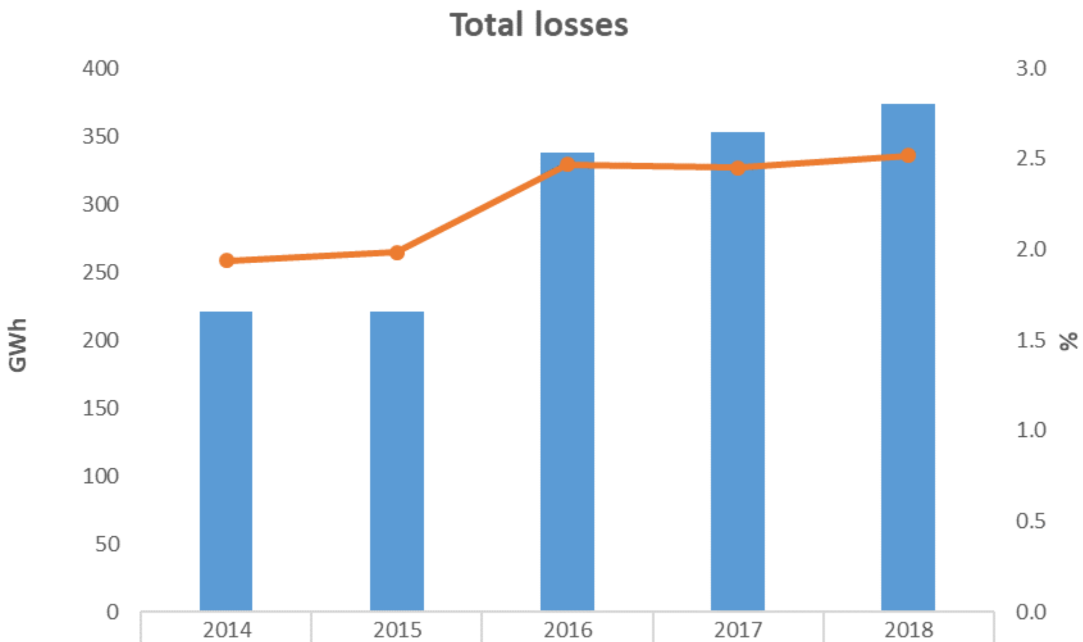
Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

VALUES OF LOSSES





	2014	2015	2016	2017	2018
(GWh)	220	220	338	352	373
(%)	1.93	1.98	2.46	2.45	2.51



	2014	2015	2016	2017	2018
(GWh)	221	220	338	353	373
(%)	1.94	1.98	2.47	2.45	2.52

LUXEMBOURG

GENERAL INFORMATION

Network length of distribution networks	11,374 km
Number of metering points in distribution network	307,154
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	No
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	No
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

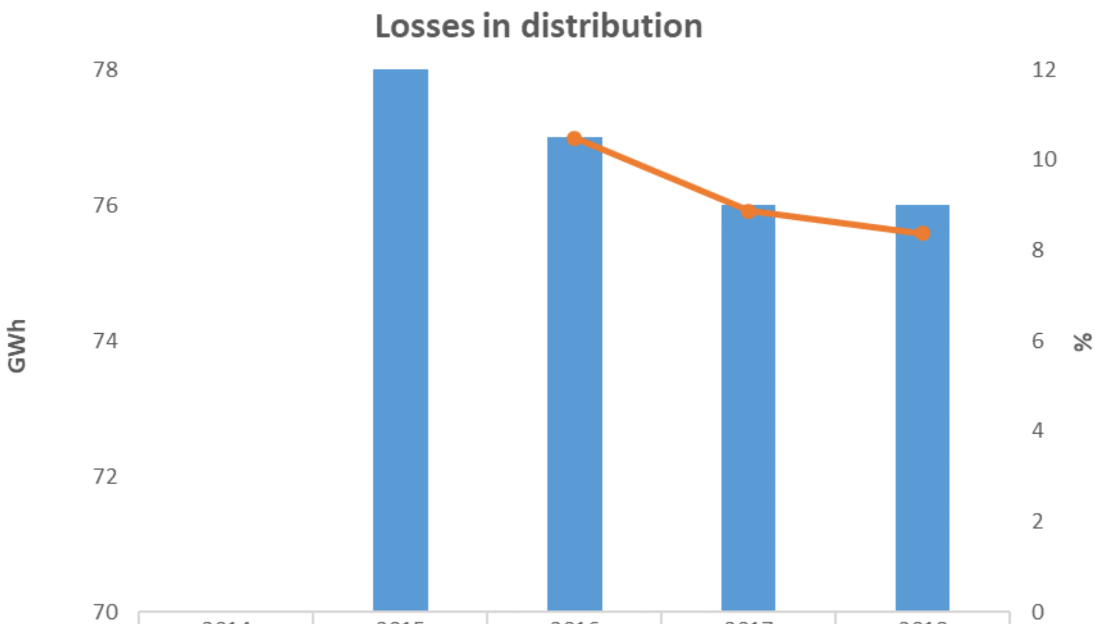
Party responsible for procurement of power losses	DSO
Party responsible for forecasting power losses	DSO

How are costs of procuring losses covered?	Tariffs (DSO)

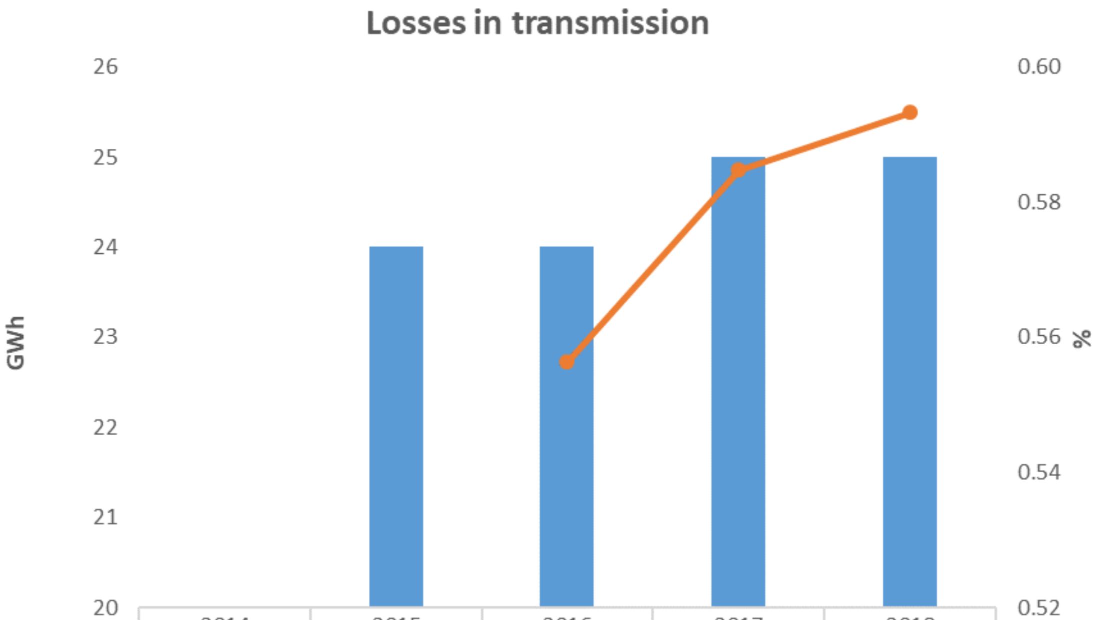
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

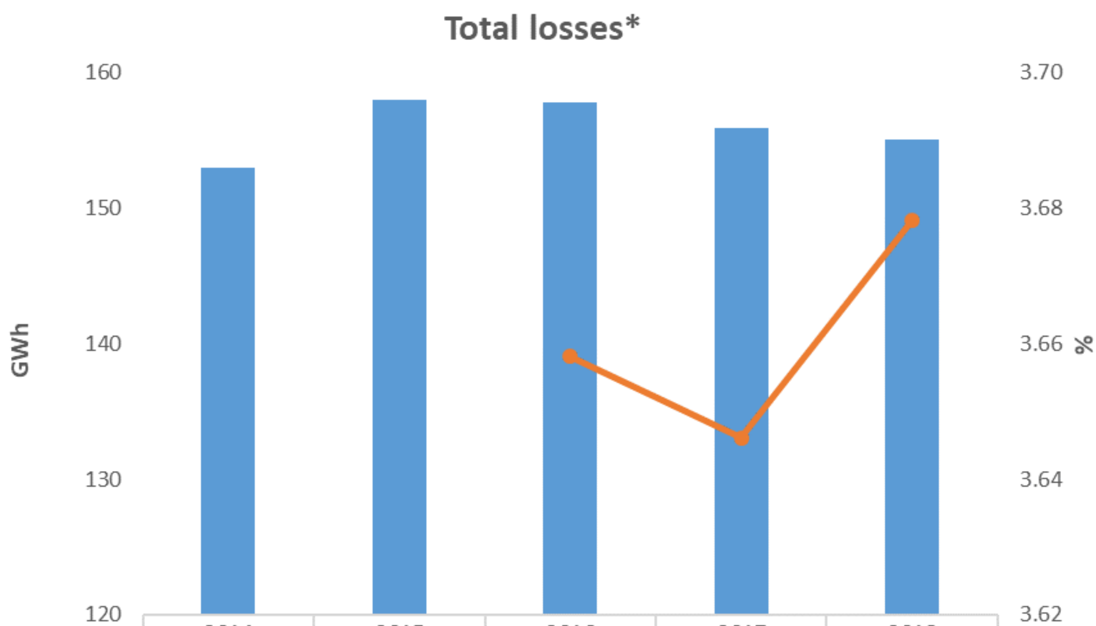
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)		78	77	76	76
(%)			10.48	8.87	8.37



	2014	2015	2016	2017	2018
(GWh)		24	24	25	25
(%)			0.56	0.58	0.59



	2014	2015	2016	2017	2018
(GWh)	153	158	158	156	155
(%)			3.66	3.65	3.68

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

MALTA

GENERAL INFORMATION

Network length of distribution networks	5,179.1 km
Number of metering points in distribution network	308,601
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Technical losses are evaluated every few years by calculation (where SCADA readings are available) and by sampling and extrapolation (where no readings are available). Non-technical losses are calculated as the difference between technical losses and total losses.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

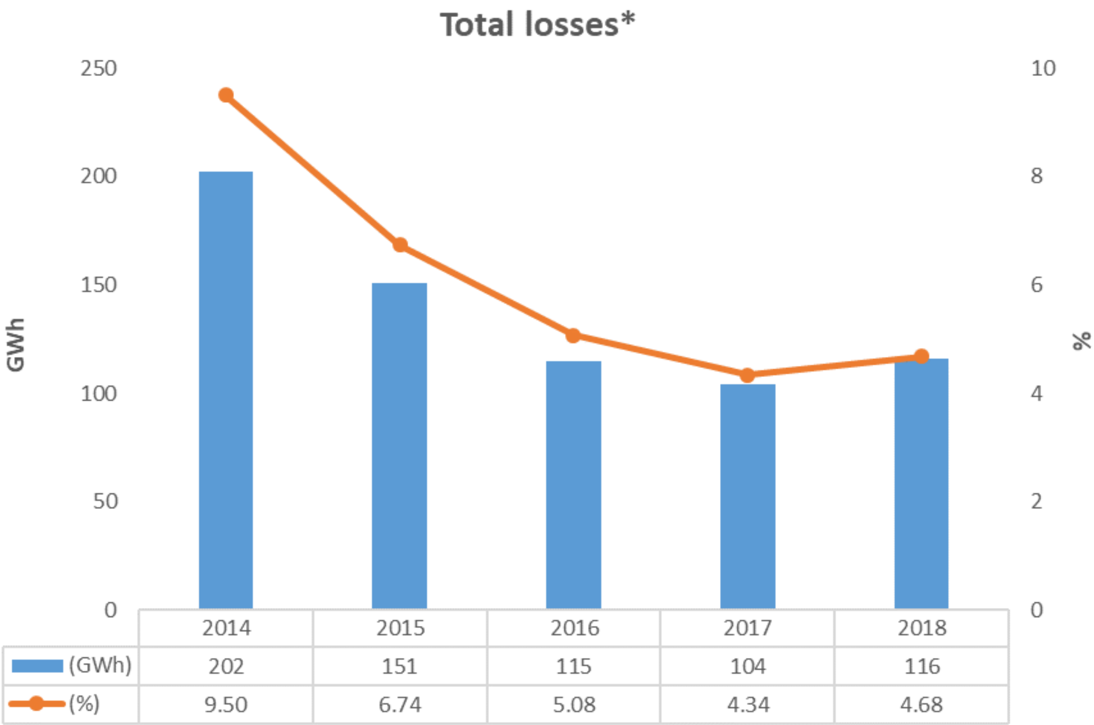
Party responsible for procurement of power losses	DSO

Party responsible for forecasting power losses	DSO
How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No transmission in Malta
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



*Total losses = distribution losses as Malta has no transmission grid

MOLDOVA

GENERAL INFORMATION

Network length of distribution networks	57,722.7 km
Number of metering points in distribution network	1,195,011
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	No
Components included in definition of non-technical losses	
- "hidden" non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	No
Method for determining losses	By using methodology approved by the NRA. System operators calculate losses from values obtained by meters.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

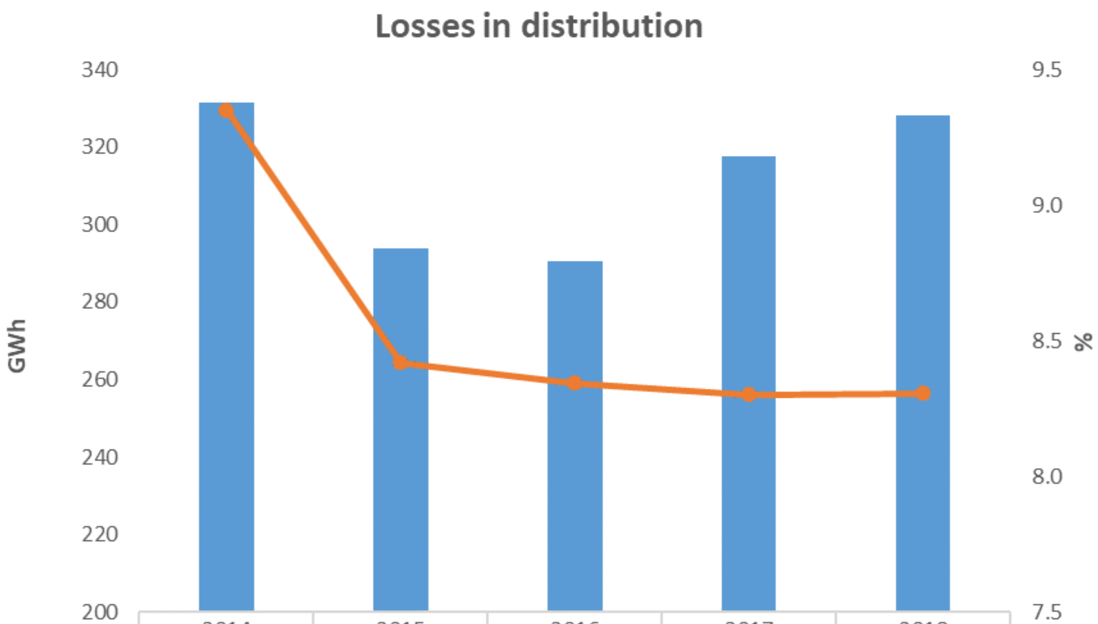
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

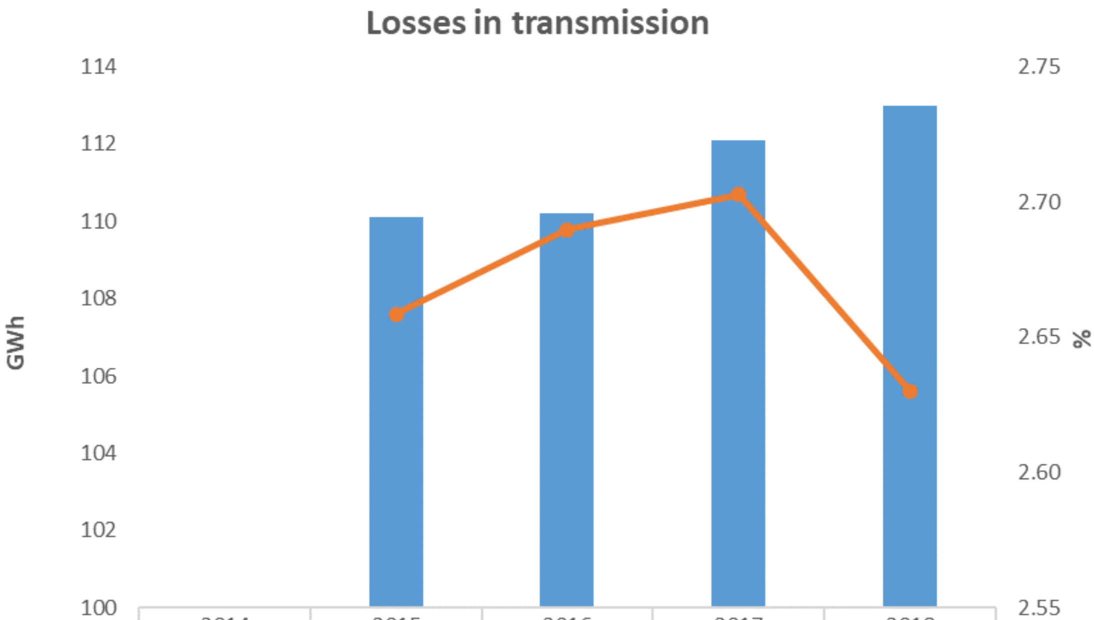
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

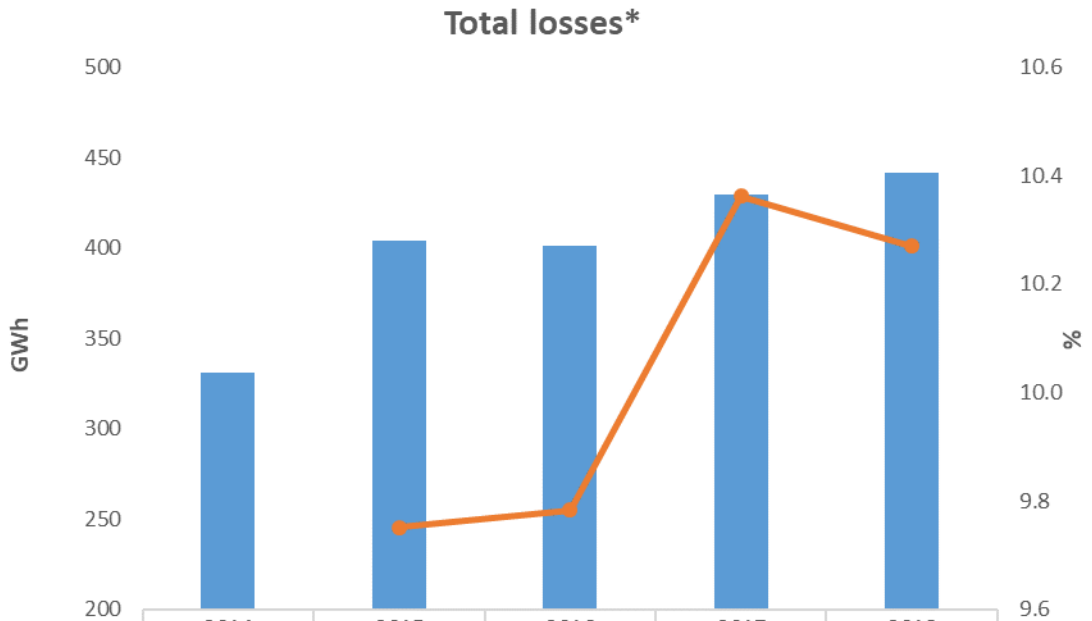
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	331	294	291	318	328
(%)	9.35	8.42	8.34	8.30	8.31



	2014	2015	2016	2017	2018
(GWh)		110	110	112	113
(%)		2.66	2.69	2.70	2.63



	2014	2015	2016	2017	2018
(GWh)	331	404	401	430	441
(%)		9.75	9.78	10.36	10.27

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

MONTENEGRO

GENERAL INFORMATION

Network length of distribution networks	19,425.08 km
Number of metering points in distribution network	376,727
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

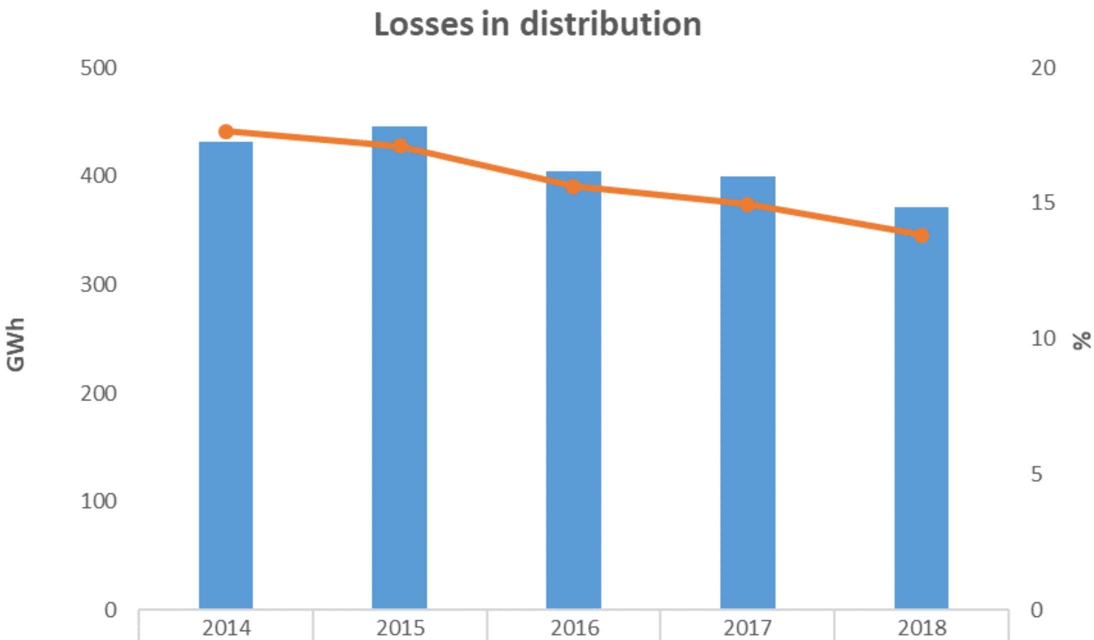
Party responsible for procurement of power losses	System operators procure energy for losses in their system.

Party responsible for forecasting power losses	System operators procure energy for losses in their system.
How are costs of procuring losses covered?	Through network tariffs. Customers have to pay only for technical losses.

REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Rate of return on planned investments that deals with reduction of technical losses. Non-technical losses are not recognized as part of network tariffs, so DSOs are motivated to reduce them.
Regulatory incentives to reduce losses or costs related to losses in transmission?	Rate of return on planned investments that deal with reduction of technical losses.
Legal obligation to separately indicate the cost of losses on electricity bills?	Yes
Different prices of losses for different network users?	Yes

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	432	446	404	400	372
(%)	17.65	17.11	15.61	14.96	13.83

	2014	2015	2016	2017	2018
(GWh)	122	135	119	127	142
(%)	1.77	2.28	2.03	2.26	2.21

	2014	2015	2016	2017	2018
(GWh)	554	581	523	526	514
(%)	8.00	9.75	8.82	9.26	7.87

THE NETHERLANDS

GENERAL INFORMATION

Network length of distribution networks	257,670.5 km
Number of metering points in distribution network	8,331,243
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	No

PROCUREMENT OF LOSSES

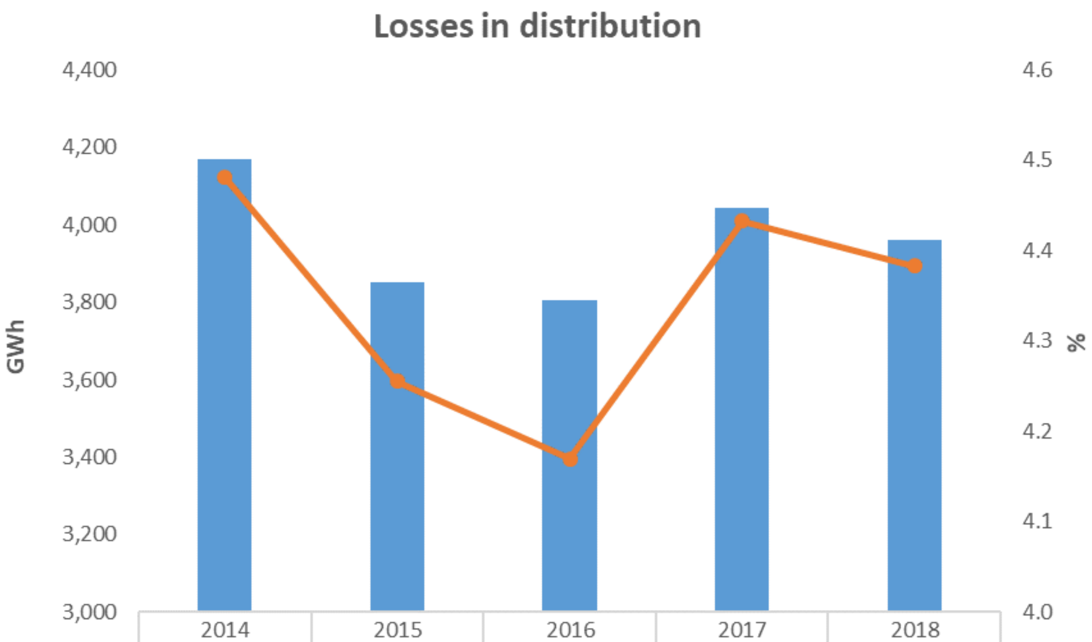
Party responsible for procurement of power losses	Every system operator (DSO and TSO) is responsible for procurement of losses for its own network.
Party responsible for forecasting power losses	TSO

How are costs of procuring losses covered?	No dedicated tariff for DSOs. For DSOs, costs are based on previous years and are included in total costs of system operators. For TSO, see below.

REGULATORY FRAMEWORK

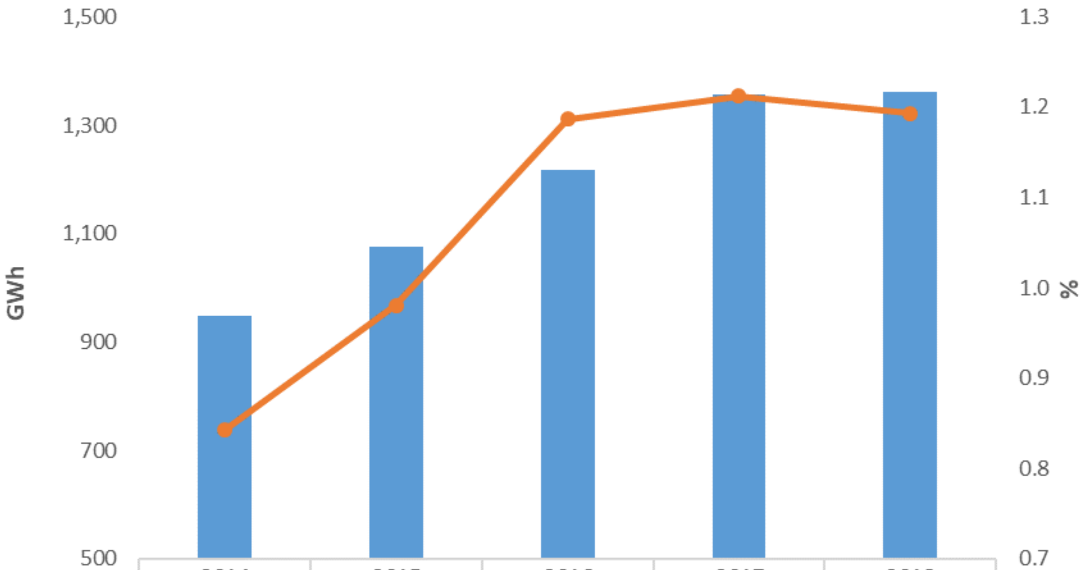
Regulatory incentives to reduce losses or costs related to losses in distribution?	Costs of procuring energy for losses are included in total DSO costs. Yardstick regulation is used for total costs of DSOs.
Regulatory incentives to reduce losses or costs related to losses in transmission?	TSO is incentivised to procure energy more efficiently by being partially reimbursed for the difference between realized costs (in year t-2) and estimated purchasing costs (for the current year).
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



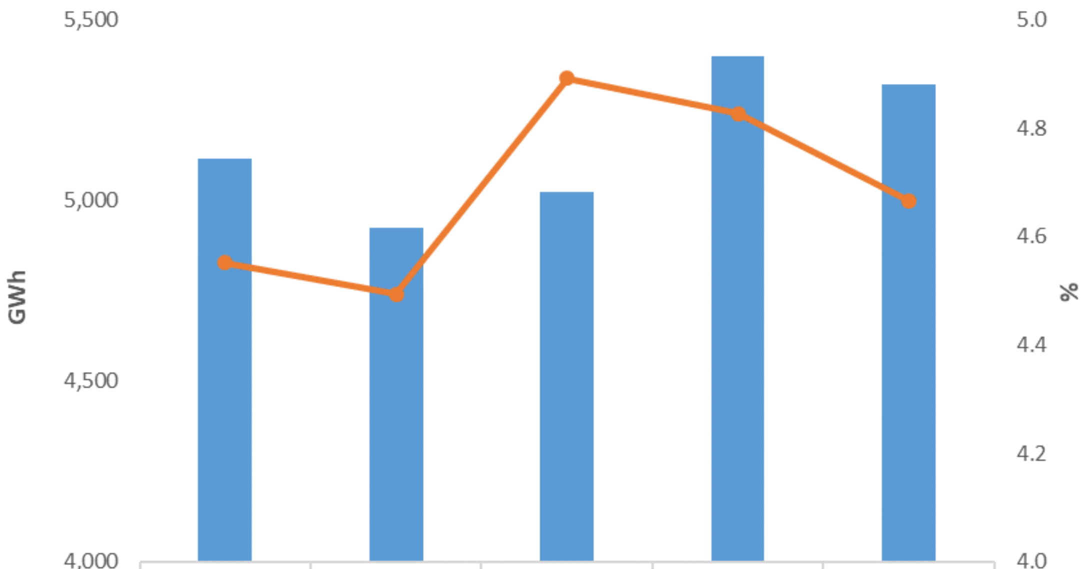
	2014	2015	2016	2017	2018
(GWh)	4,169	3,850	3,804	4,043	3,961
(%)	4.48	4.26	4.17	4.43	4.38

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	947	1,075	1,218	1,356	1,361
(%)	0.84	0.98	1.19	1.21	1.19

Total losses*



	2014	2015	2016	2017	2018
(GWh)	5,116	4,925	5,022	5,399	5,322
(%)	4.55	4.49	4.89	4.83	4.67

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

NORTH MACEDONIA

GENERAL INFORMATION

Network length of distribution networks	28,128 km
Number of metering points in distribution network	741,867
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- "hidden" non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	No
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level.

PROCUREMENT OF LOSSES

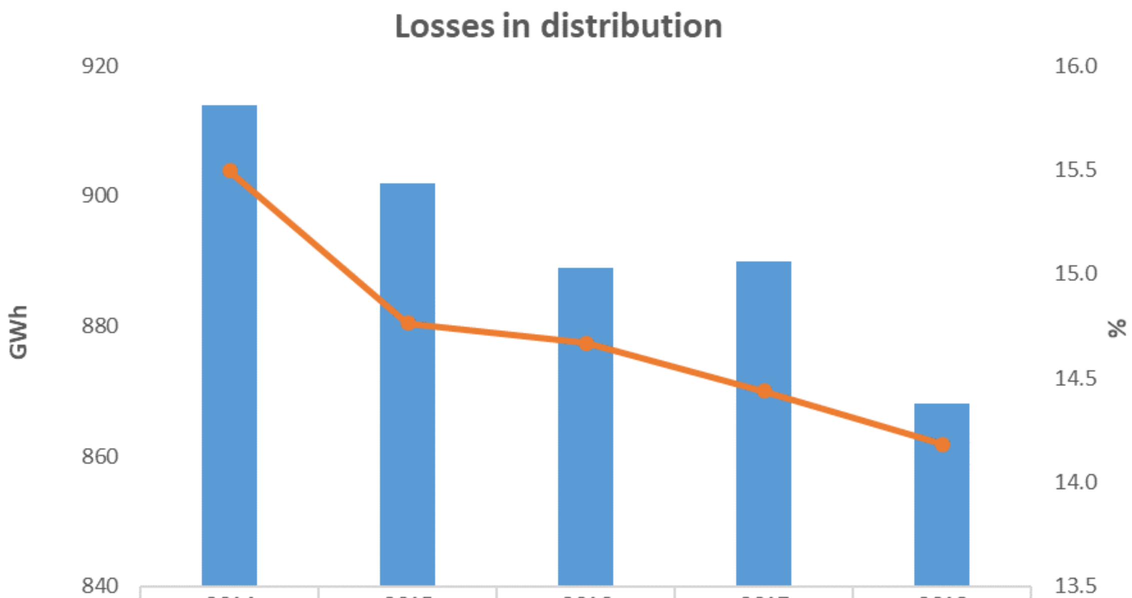
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	By transmission tariff (losses in transmission network) and by distribution tariff (losses in distribution network).

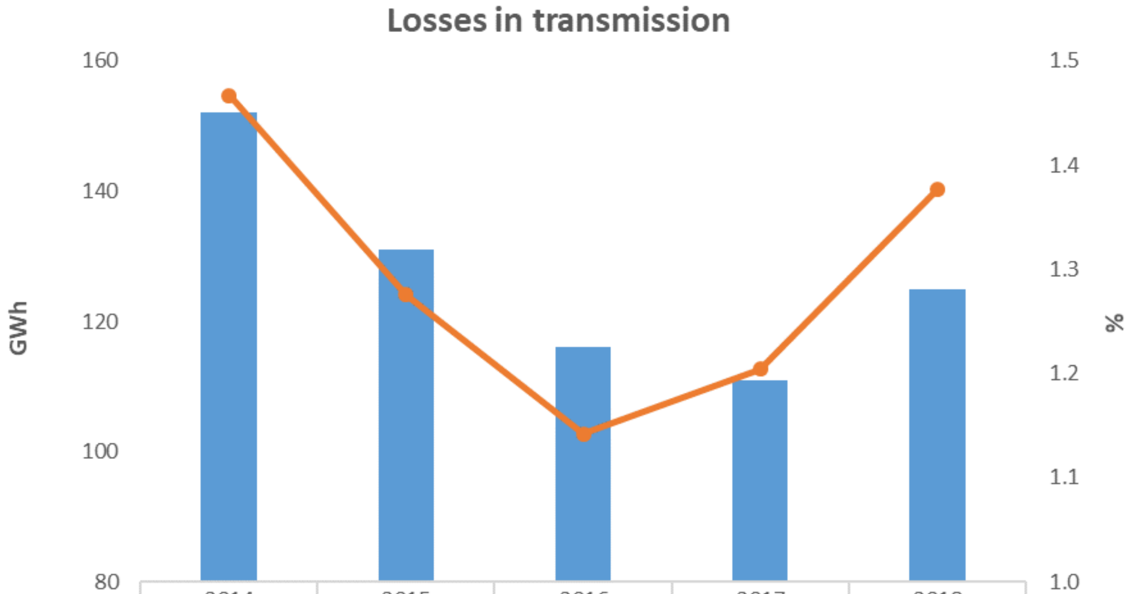
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	No
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

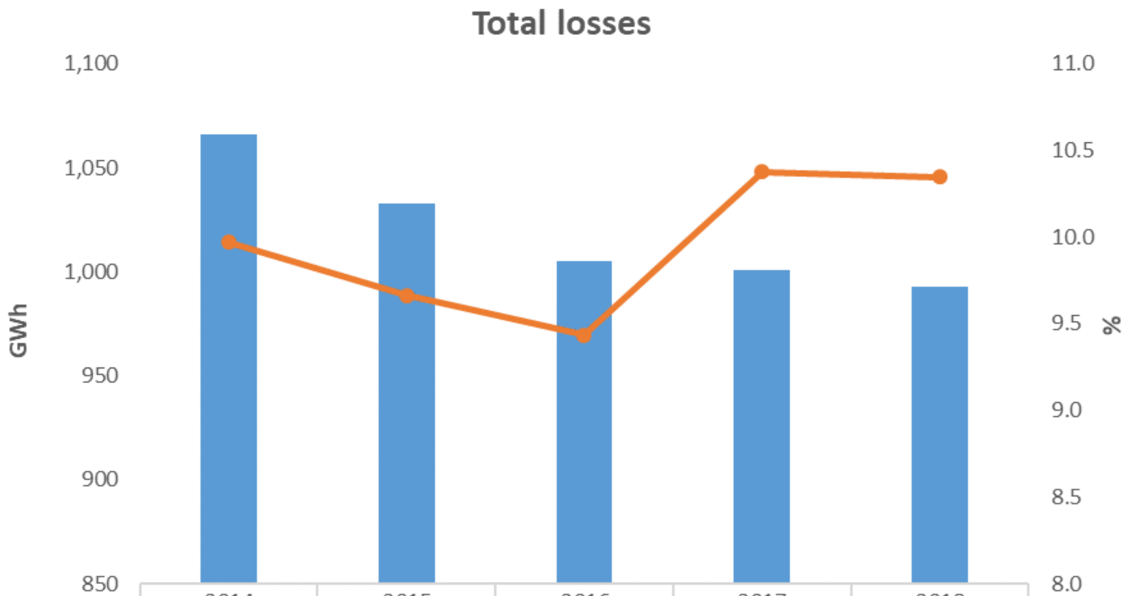
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	914	902	889	890	868
(%)	15.50	14.76	14.67	14.44	14.18



	2014	2015	2016	2017	2018
(GWh)	152	131	116	111	125
(%)	1.47	1.28	1.14	1.20	1.38



	2014	2015	2016	2017	2018
(GWh)	1,066	1,033	1,005	1,001	993
(%)	9.97	9.66	9.43	10.38	10.35

NORWAY

GENERAL INFORMATION

Network length of distribution networks	333,444 km
Number of metering points in distribution network	3,079,199
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	No
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

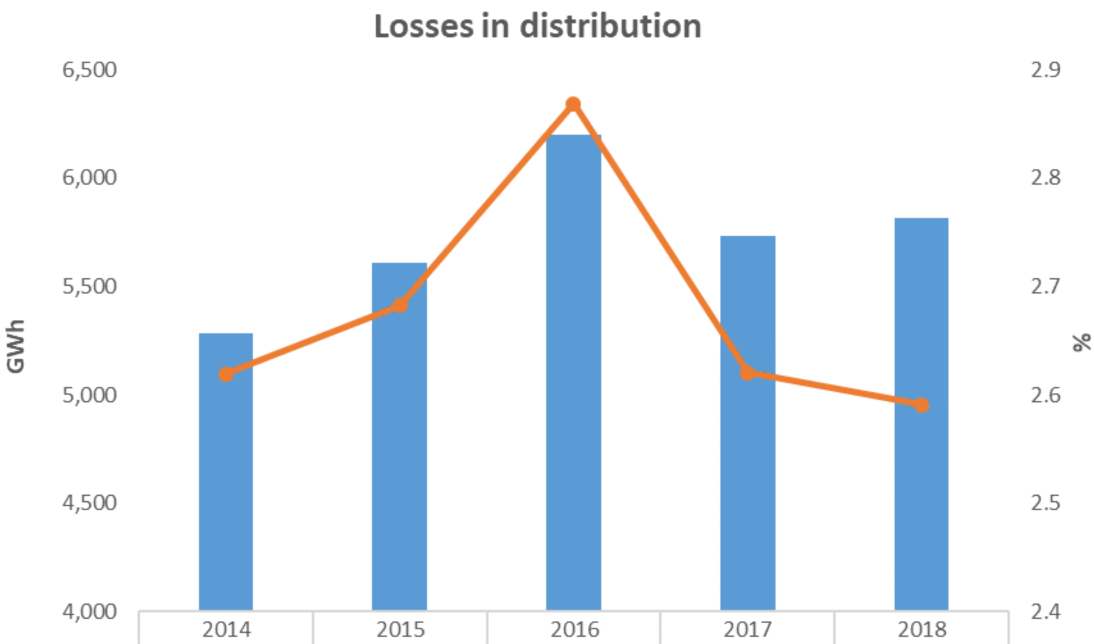
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

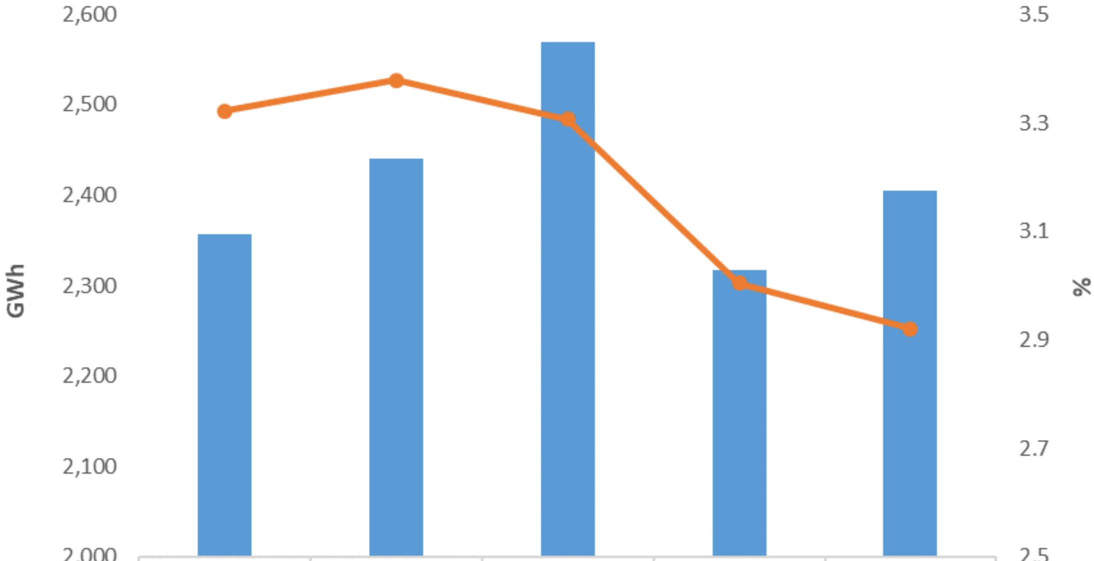
Regulatory incentives to reduce losses or costs related to losses in distribution?	Incentives are not directly aimed at reducing losses but at reducing the overall cost of which losses are a part of.
Regulatory incentives to reduce losses or costs related to losses in transmission?	Incentives are not directly aimed at reducing losses but at reducing the overall cost of which losses are a part of.
Legal obligation to separately indicate the cost of losses on electricity bills?	Yes
Different prices of losses for different network users?	No

VALUES OF LOSSES



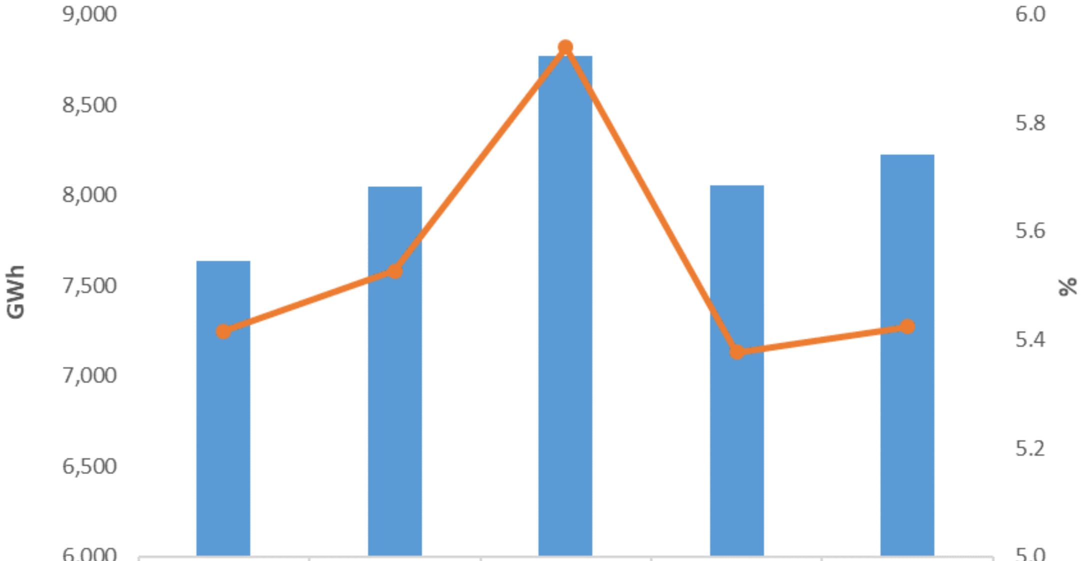
	2014	2015	2016	2017	2018
(GWh)	5,281	5,606	6,200	5,733	5,818
(%)	2.62	2.68	2.87	2.62	2.59

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	2,356	2,440	2,569	2,317	2,405
(%)	3.32	3.38	3.31	3.00	2.92

Total losses



	2014	2015	2016	2017	2018
(GWh)	7,637	8,046	8,769	8,051	8,223
(%)	5.42	5.53	5.94	5.38	5.42

POLAND

GENERAL INFORMATION

Network length of distribution networks	758,256 km
Number of metering points in distribution network	17,742,407
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes (except for purposes of regulation)

PROCUREMENT OF LOSSES

Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	NRA

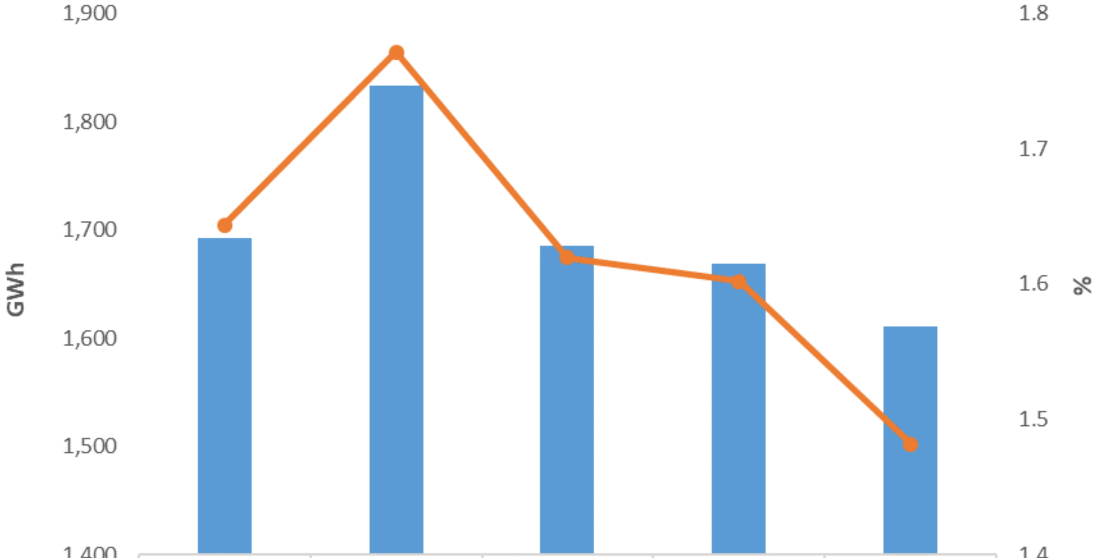
How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

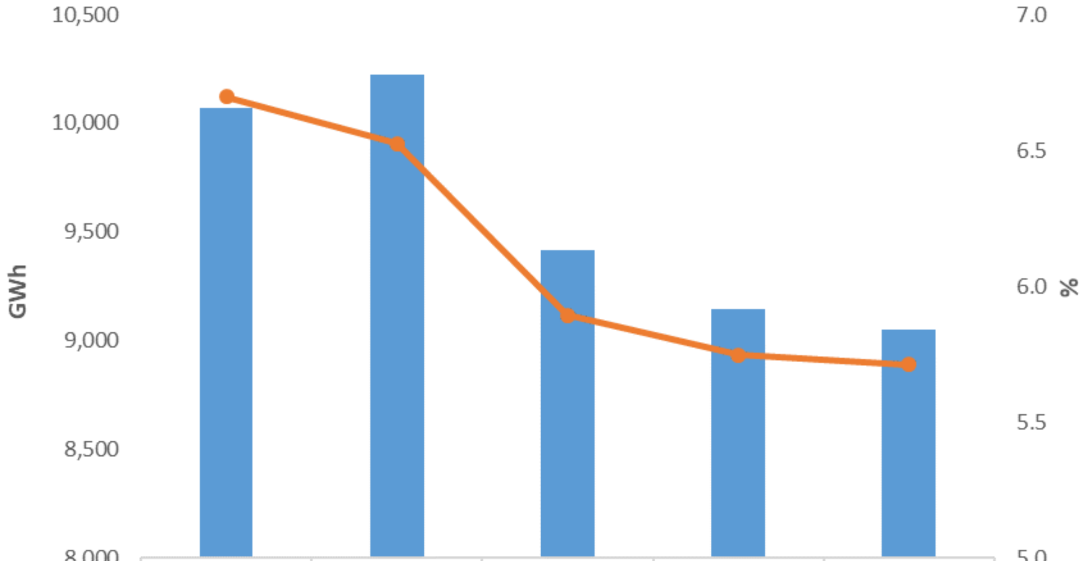
VALUES OF LOSSES

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	1,693	1,833	1,685	1,669	1,611
(%)	1.64	1.77	1.62	1.60	1.48

Total losses



	2014	2015	2016	2017	2018
(GWh)	10,072	10,222	9,417	9,143	9,048
(%)	6.70	6.53	5.89	5.75	5.71

PORTUGAL

GENERAL INFORMATION

Network length of distribution networks	225,529 km
Number of metering points in distribution network	6,068,857
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No (in-house consumption is charged through tariffs as regular consumption)
- Non-metered consumption (e.g. public lighting)	No (public lighting not treated as a loss but as regular consumption)
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between network injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

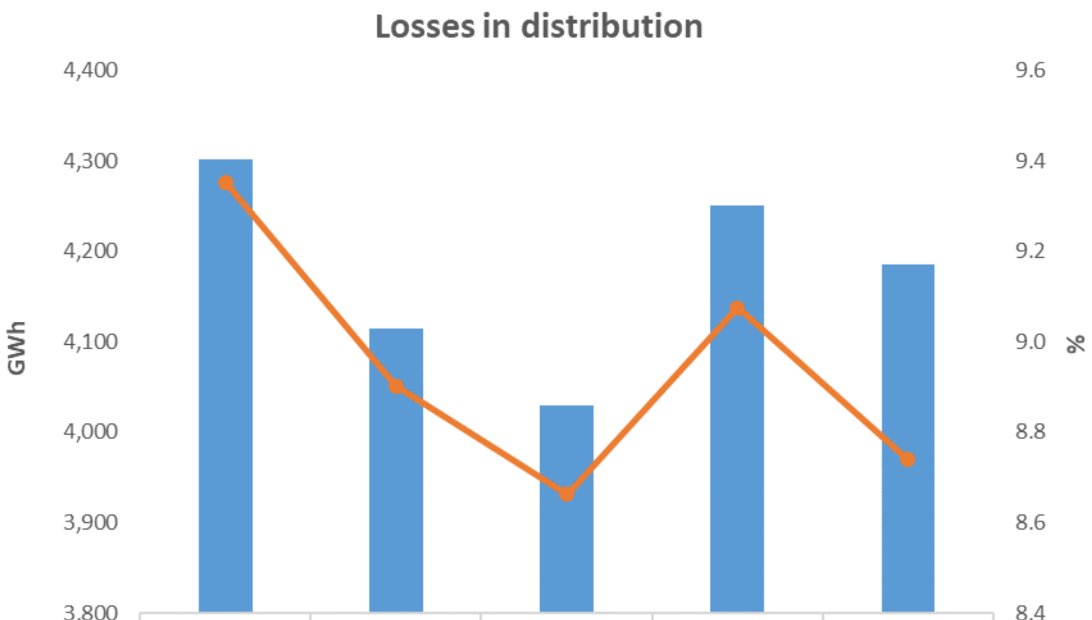
Party responsible for procurement of power losses	Supplier
Party responsible for forecasting power losses	NRA

How are costs of procuring losses covered?	Paid by suppliers

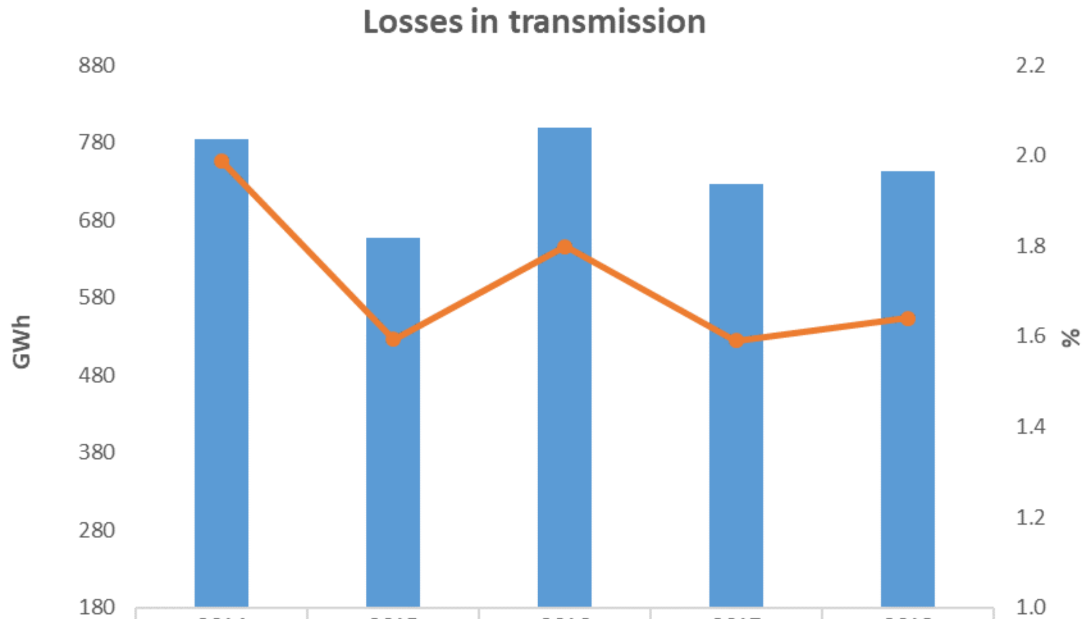
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	The incentive mechanism allows the DSO to be rewarded/penalised in case of achieving global distribution losses below/above a reference value set by the NRA, on a yearly basis.
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

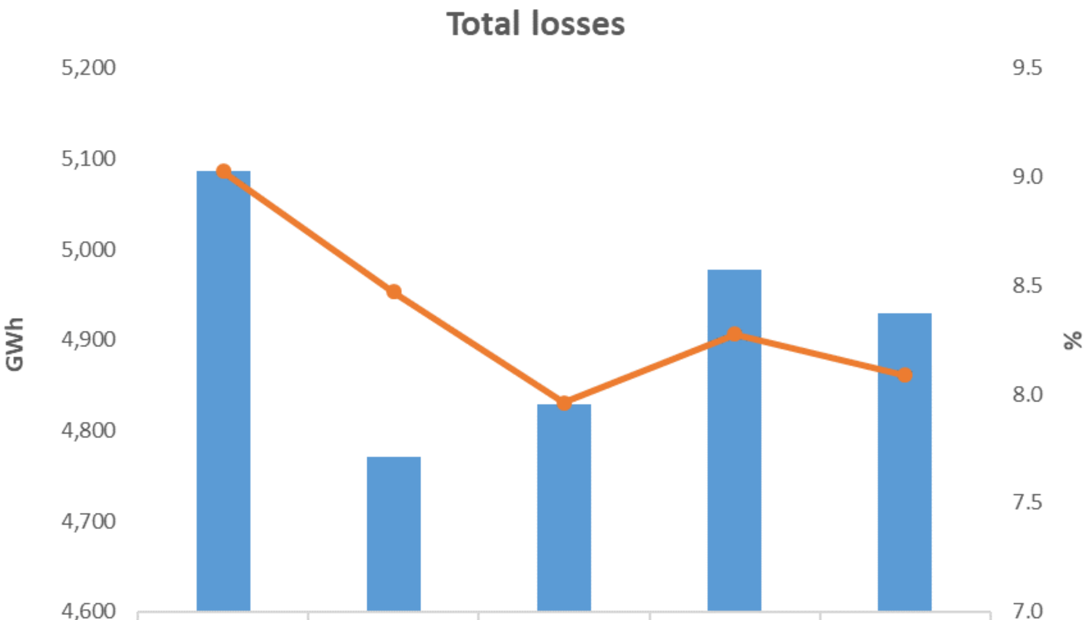
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	4,302	4,114	4,029	4,251	4,186
(%)	9.35	8.90	8.66	9.08	8.74



	2014	2015	2016	2017	2018
(GWh)	785	657	800	726	744
(%)	1.99	1.59	1.80	1.59	1.64



	2014	2015	2016	2017	2018
(GWh)	5,087	4,771	4,829	4,977	4,930
(%)	9.02	8.47	7.96	8.28	8.09

SERBIA

GENERAL INFORMATION

Network length of distribution networks	169,184 km
Number of metering points in distribution network	3,651,169
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between network injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level. TSO determines them for transmission, DSO for distribution.

PROCUREMENT OF LOSSES

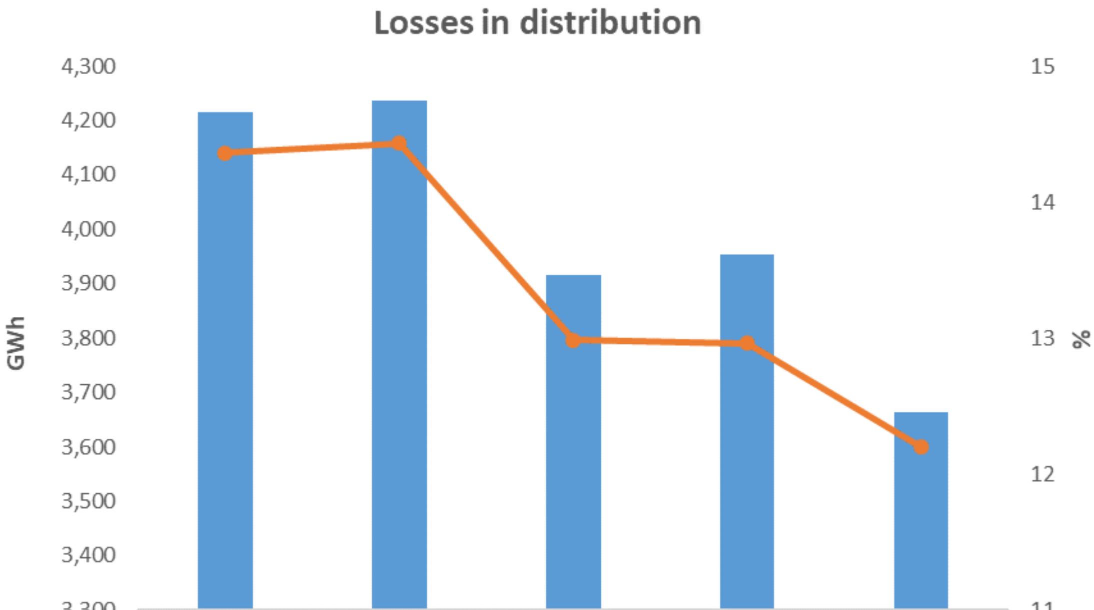
Party responsible for procurement of power losses	DSO and TSO

Party responsible for forecasting power losses	DSO and TSO
How are costs of procuring losses covered?	Tariffs

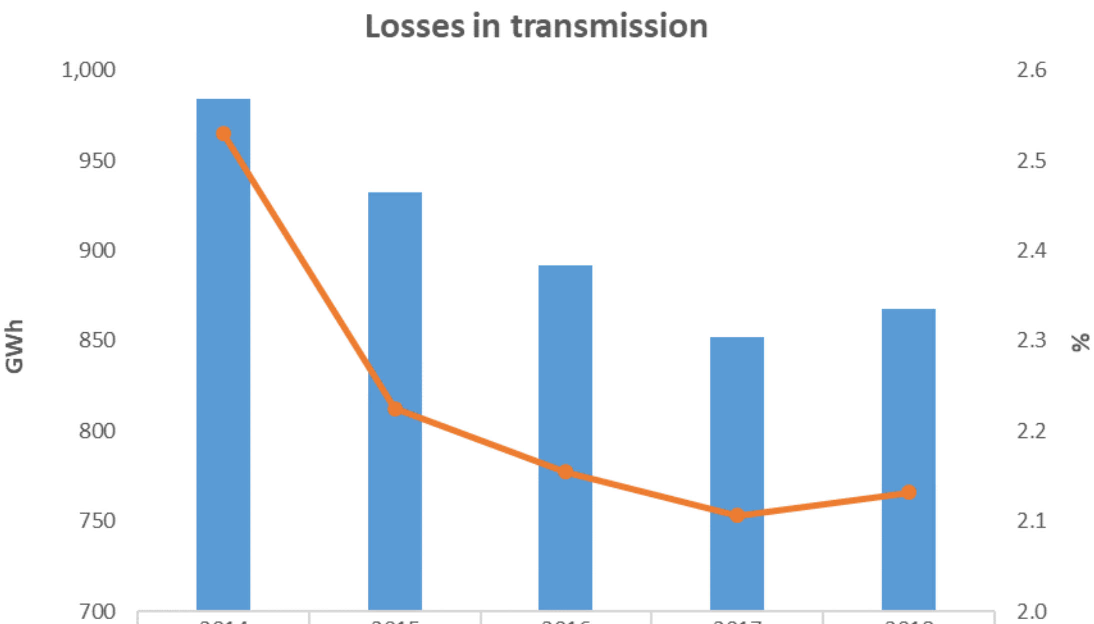
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

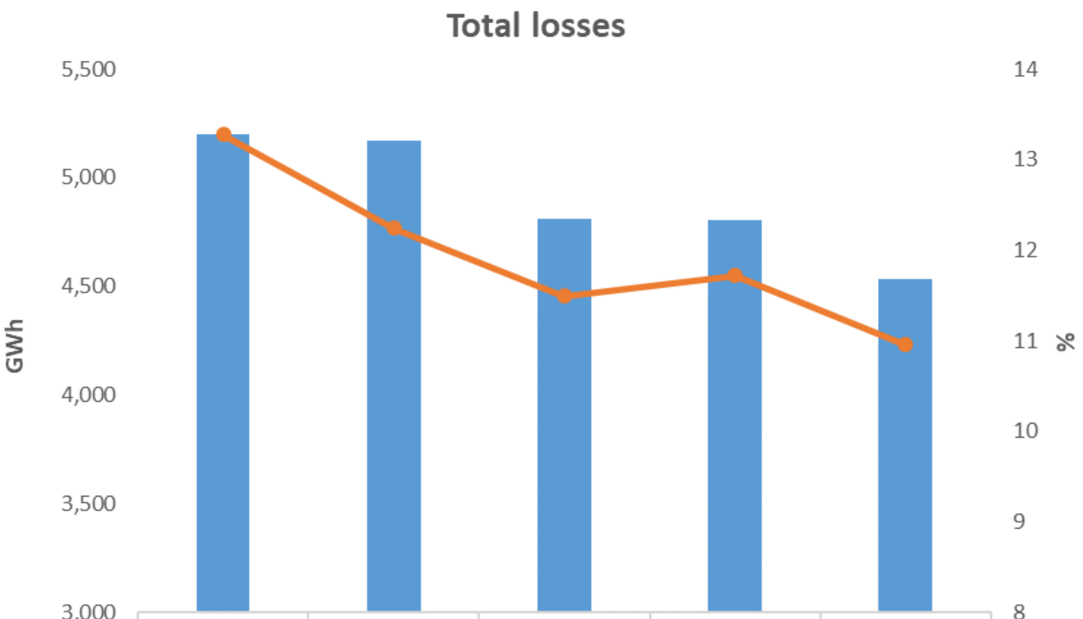
VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	4,215	4,236	3,917	3,953	3,664
(%)	14.36	14.43	12.99	12.96	12.20



	2014	2015	2016	2017	2018
(GWh)	984	932	892	852	868
(%)	2.53	2.22	2.15	2.11	2.13



	2014	2015	2016	2017	2018
(GWh)	5,199	5,168	4,809	4,805	4,532
(%)	13.28	12.24	11.49	11.72	10.96

SLOVAKIA

GENERAL INFORMATION

Network length of distribution networks	95,283 km
Number of metering points in distribution network	2,548,081
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- “hidden” non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

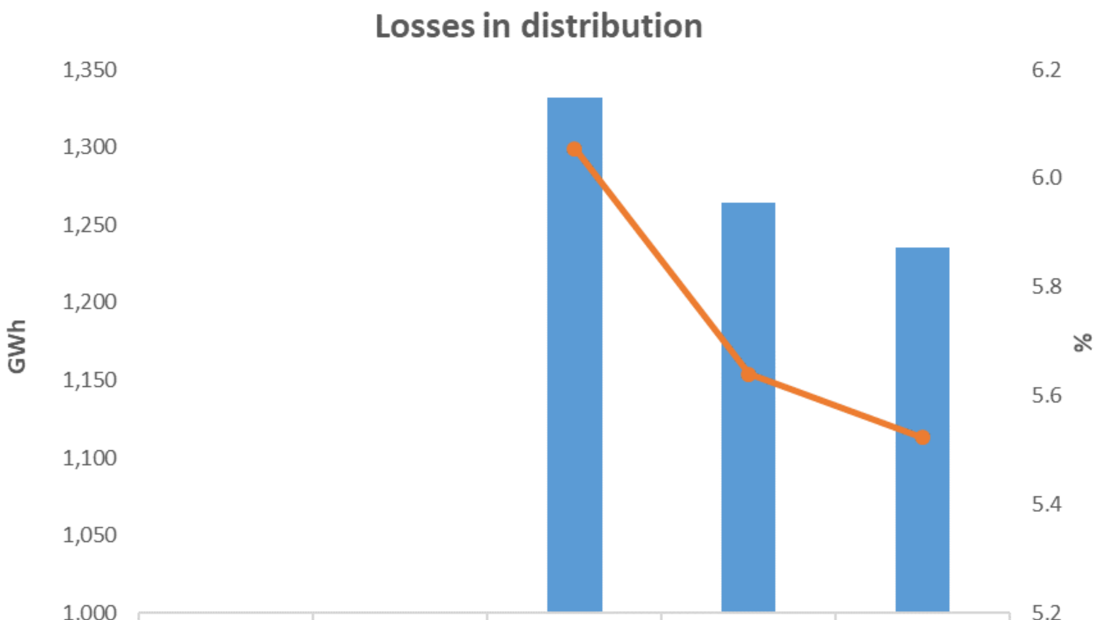
Party responsible for procurement of power losses	DSO
Party responsible for forecasting power losses	DSO

How are costs of procuring losses covered?	Tariffs

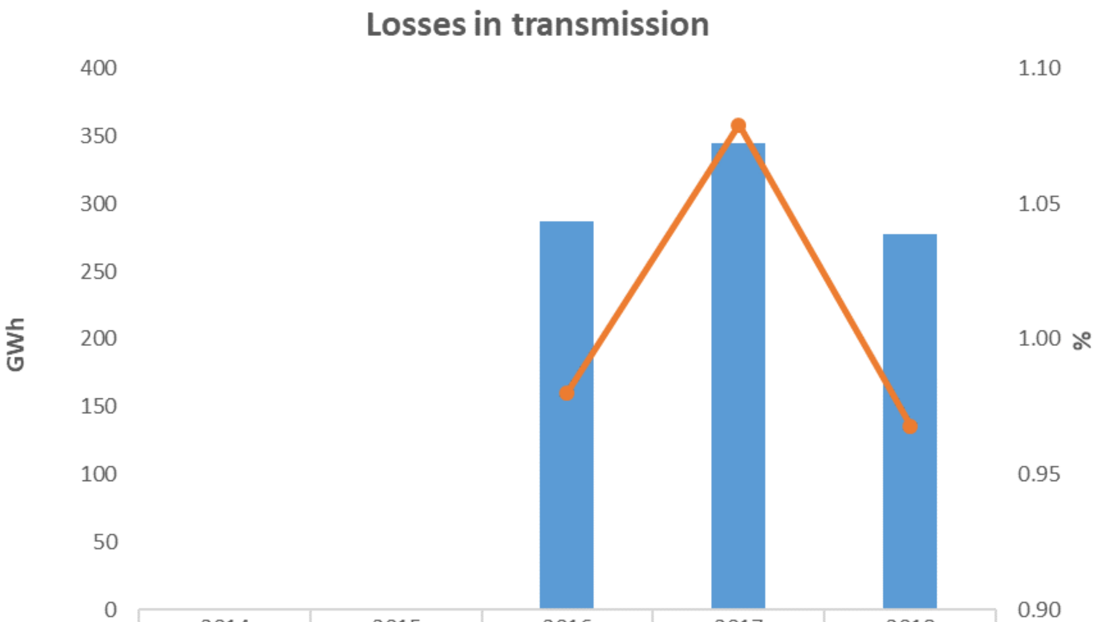
REGULATORY FRAMEWORK

Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	Yes
Different prices of losses for different network users?	Yes

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)			1,332	1,264	1,235
(%)			6.05	5.64	5.52



	2014	2015	2016	2017	2018
(GWh)			287	345	277
(%)			0.98	1.08	0.97

	2014	2015	2016	2017	2018
(GWh)			1,619	1,609	1,512
(%)			4.45	4.08	4.27

SLOVENIA

GENERAL INFORMATION

Network length of distribution networks	65,386 km
Number of metering points in distribution network	956,590
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level. They are separately determined for transmission and distribution.

PROCUREMENT OF LOSSES

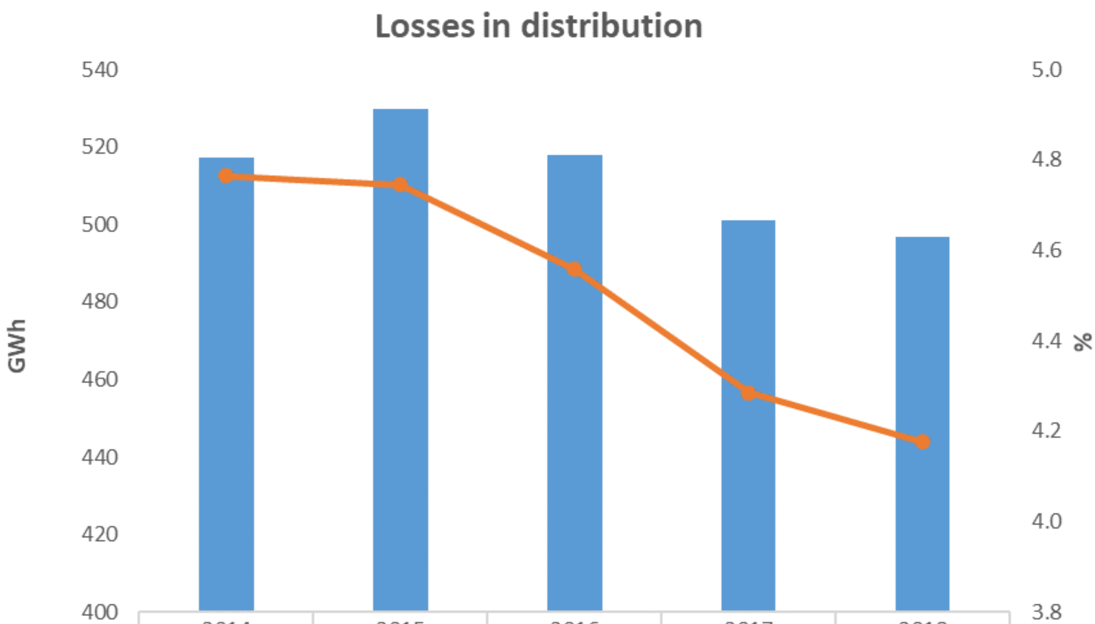
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	NRA

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

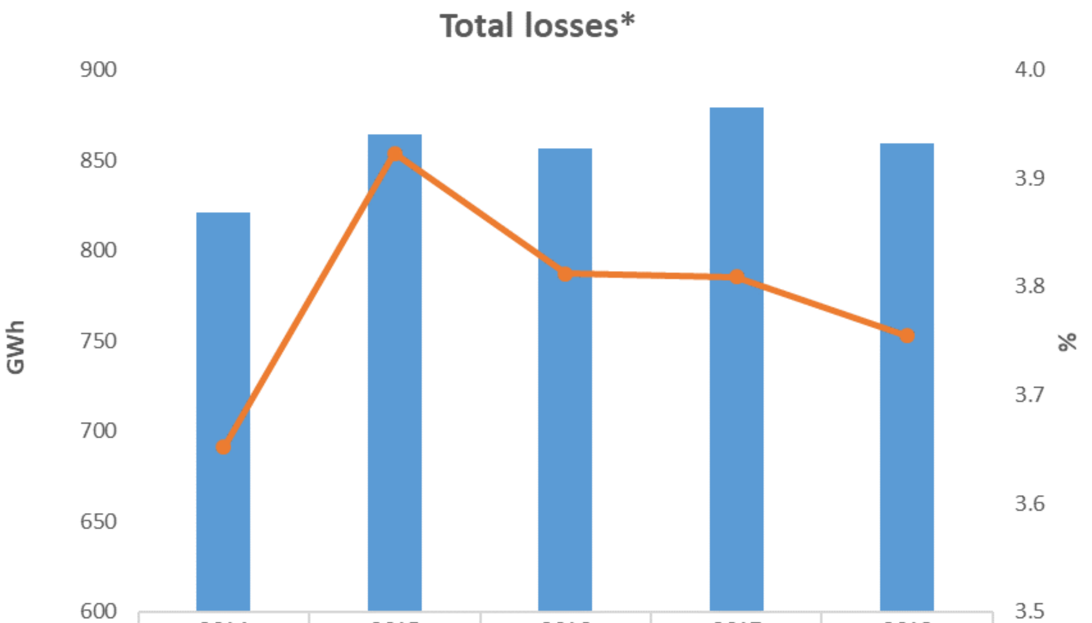
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes (set in the new methodology for the regulatory period 2019-2021)
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes (set in the new methodology for the regulatory period 2019-2021)
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	517	530	518	501	497
(%)	4.76	4.74	4.56	4.28	4.18

	2014	2015	2016	2017	2018
(GWh)	303	334	339	378	362
(%)	1.35	1.52	1.51	1.64	1.58



	2014	2015	2016	2017	2018
(GWh)	821	864	857	879	859
(%)	3.65	3.92	3.81	3.81	3.75

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

SPAIN

GENERAL INFORMATION

Network length of distribution networks	804,250.054 km
Number of metering points in distribution network	29,900,000
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- “hidden” non-technical losses	Yes, in distribution
- Non-metered consumption (e.g. public lighting)	Yes, in distribution
- Theft	Yes, in distribution
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, in distribution
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level.

PROCUREMENT OF LOSSES

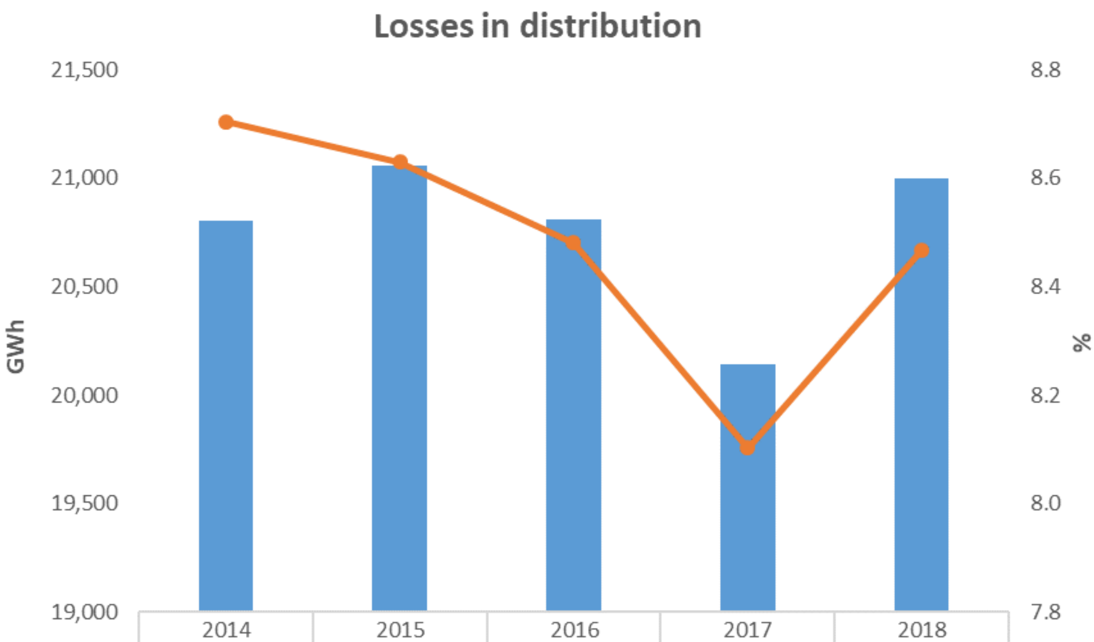
Party responsible for procurement of power losses	Supplier
Party responsible for forecasting power losses	TSO

How are costs of procuring losses covered?	Since energy is procured by suppliers, estimated losses are priced at the same level as the wholesale market price to supply the consumption.

REGULATORY FRAMEWORK

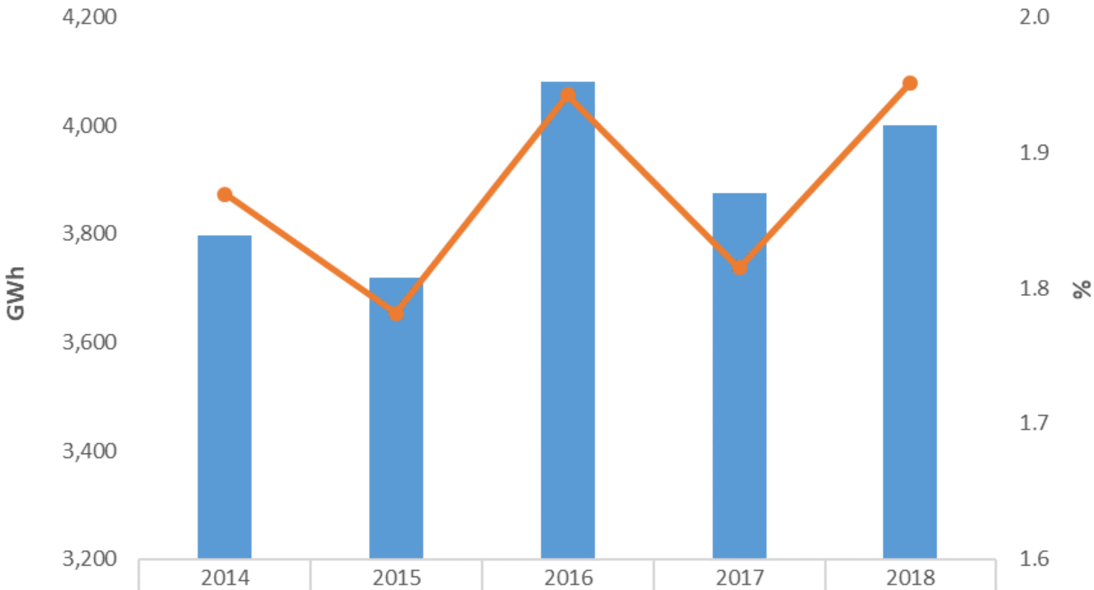
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	No
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	Yes

VALUES OF LOSSES



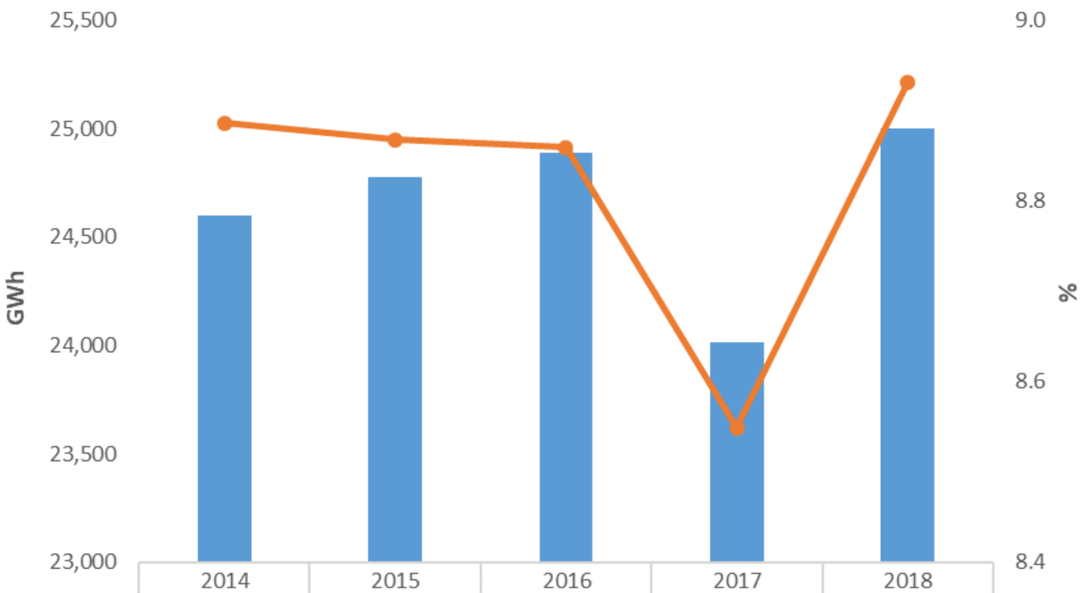
	2014	2015	2016	2017	2018
(GWh)	20,801	21,058	20,811	20,140	21,000
(%)	8.70	8.63	8.48	8.10	8.47

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	3,797	3,720	4,079	3,876	4,000
(%)	1.87	1.78	1.94	1.82	1.95

Total losses



	2014	2015	2016	2017	2018
(GWh)	24,597	24,778	24,890	24,015	25,000
(%)	8.89	8.87	8.86	8.55	8.93

SWEDEN

GENERAL INFORMATION

Network length of distribution networks	553,715 km
Number of metering points in distribution network	5,500,000
Year	2017

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, both distribution and transmission
Components included in definition of non-technical losses	
- "hidden" non-technical losses	Yes, both distribution and transmission
- Non-metered consumption (e.g. public lighting)	Yes, both distribution and transmission
- Theft	Yes, both distribution and transmission
- Others (e.g. metering errors, differences in metering, billing and data processing)	Yes, both distribution and transmission
Are non-technical losses included in published losses and losses regulation?	Yes
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Losses not determined per voltage level. They are determined per system operator.

PROCUREMENT OF LOSSES

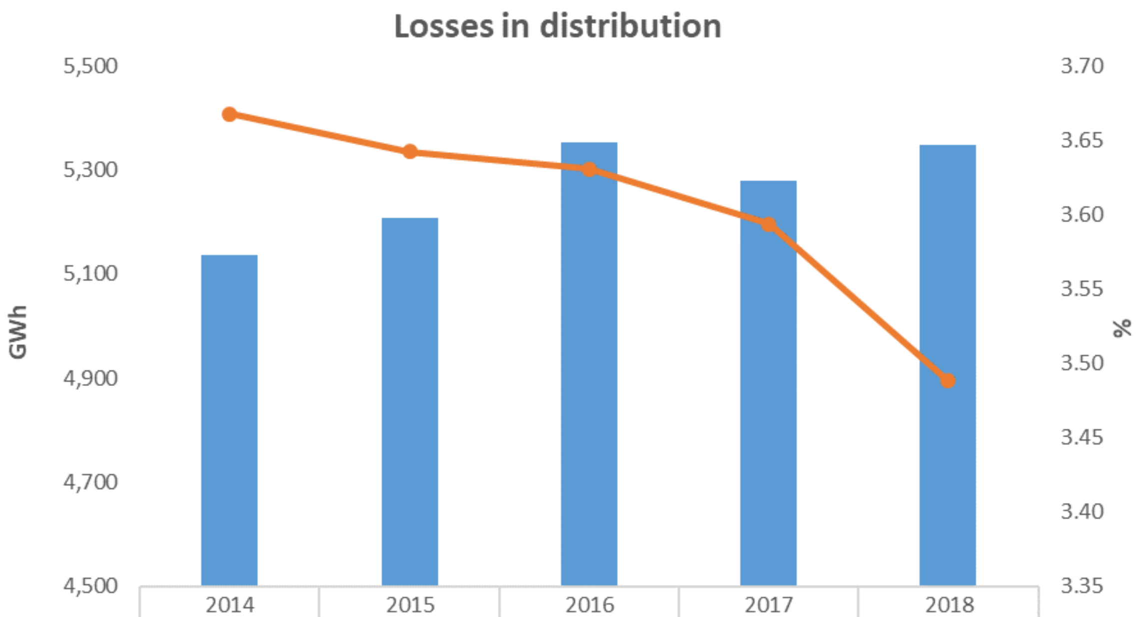
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO and TSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

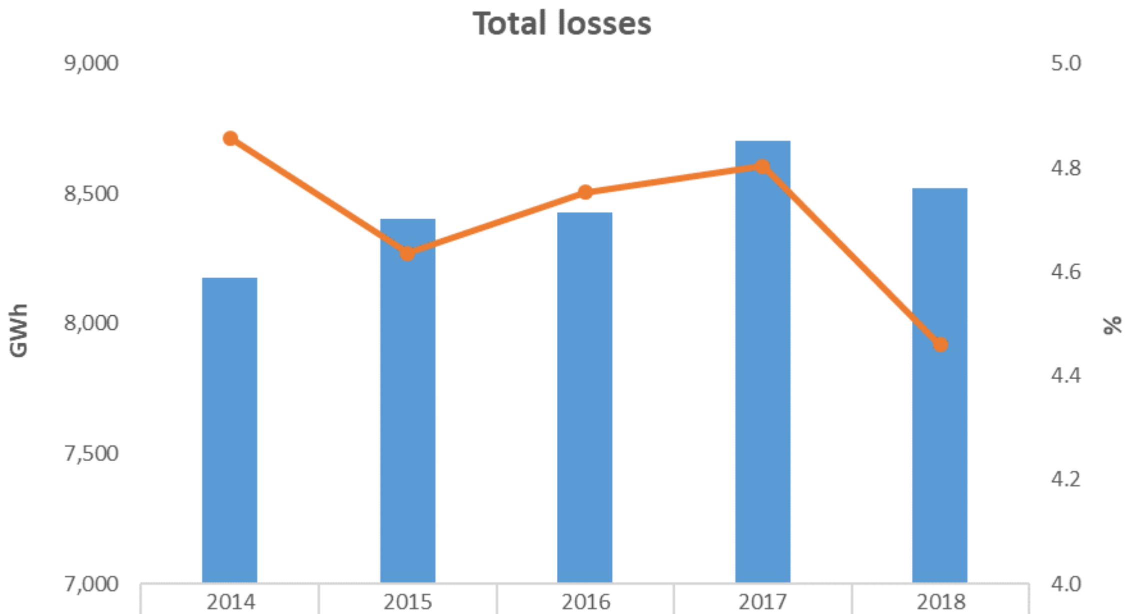
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	Yes
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



	2014	2015	2016	2017	2018
(GWh)	5,137	5,208	5,352	5,280	5,347
(%)	3.67	3.64	3.63	3.59	3.49

	2014	2015	2016	2017	2018
(GWh)	3,041	3,195	3,076	3,423	3,173
(%)	2.61	2.71	2.61	2.80	2.55



	2014	2015	2016	2017	2018
(GWh)	8,178	8,403	8,428	8,703	8,520
(%)	4.86	4.64	4.75	4.80	4.46

UKRAINE

GENERAL INFORMATION

Network length of distribution networks	826,710 km
Number of metering points in distribution network	18,236,738
Year	2018

DEFINITION AND DETERMINATION OF LOSSES

Are non-technical losses included in values submitted for this report?	Yes, in distribution
Components included in definition of non-technical losses	
- "hidden" non-technical losses	No
- Non-metered consumption (e.g. public lighting)	No
- Theft	No
- Others (e.g. metering errors, differences in metering, billing and data processing)	No
Are non-technical losses included in published losses and losses regulation?	Some components (hidden, theft, metering errors, differences in metering) are included in technical losses. Otherwise, non-technical losses are not defined in Ukraine.
Method for determining losses	Difference between injections and withdrawals.
Is the same method used to determine losses on every voltage level?	Yes

PROCUREMENT OF LOSSES

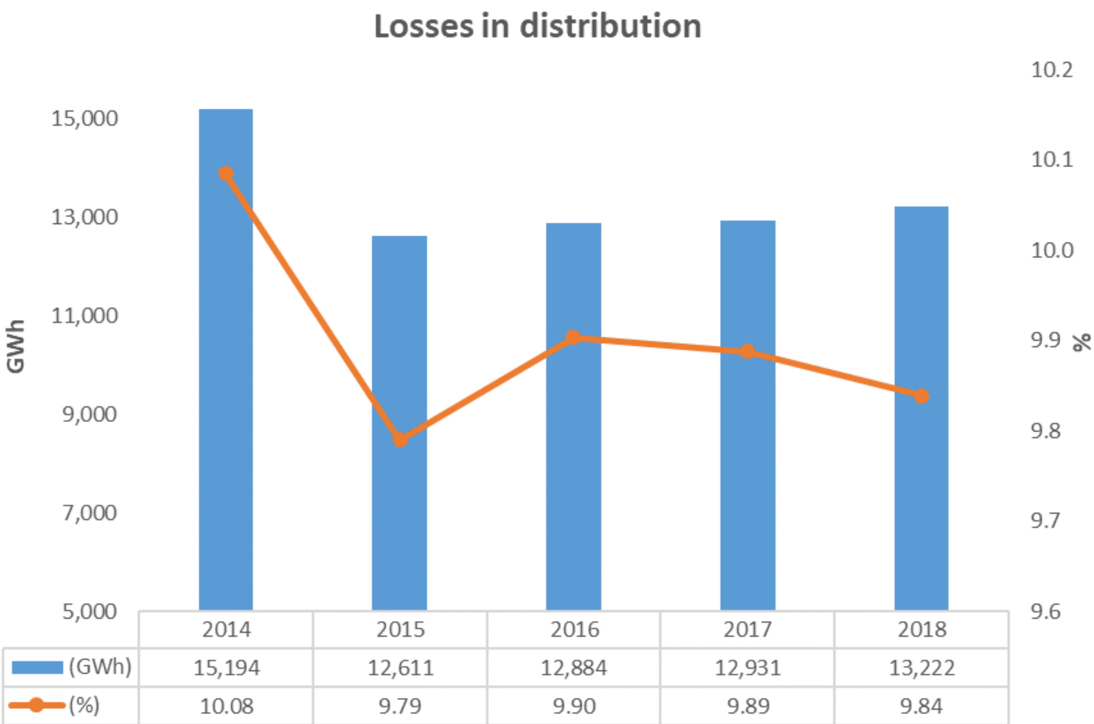
Party responsible for procurement of power losses	DSO and TSO
Party responsible for forecasting power losses	DSO

How are costs of procuring losses covered?	Tariffs

REGULATORY FRAMEWORK

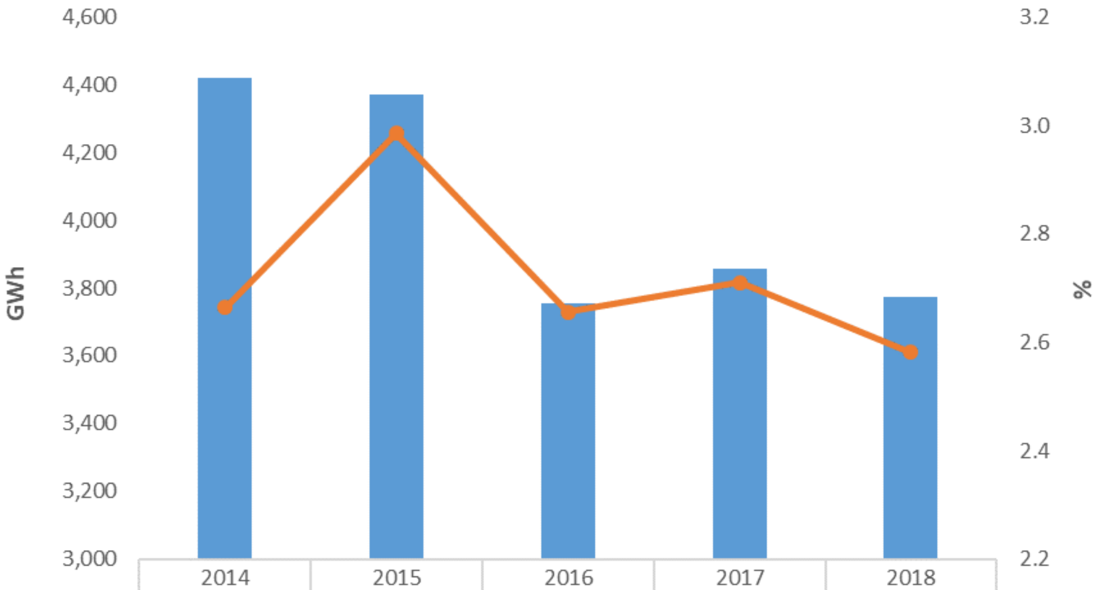
Regulatory incentives to reduce losses or costs related to losses in distribution?	Yes
Regulatory incentives to reduce losses or costs related to losses in transmission?	No (but they are planned)
Legal obligation to separately indicate the cost of losses on electricity bills?	No
Different prices of losses for different network users?	No

VALUES OF LOSSES



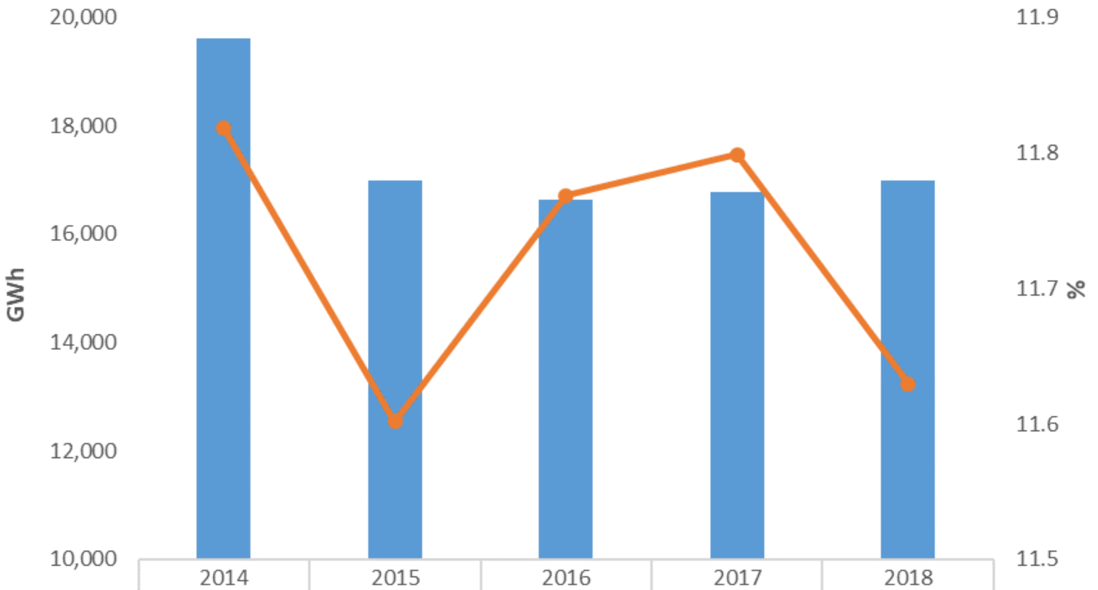
	2014	2015	2016	2017	2018
(GWh)	15,194	12,611	12,884	12,931	13,222
(%)	10.08	9.79	9.90	9.89	9.84

Losses in transmission



	2014	2015	2016	2017	2018
(GWh)	4,421	4,369	3,754	3,855	3,773
(%)	2.66	2.99	2.66	2.71	2.58

Total losses*



	2014	2015	2016	2017	2018
(GWh)	19,615	16,980	16,638	16,786	16,995
(%)	11.82	11.60	11.77	11.80	11.63

*Data about injections by generators connected directly to distribution is not available and is therefore set to zero. Hence, the value of total losses as percentage of total injections appears to be higher than it is in reality.

Annex 4 – Data

Injections in transmission (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	37,693	40,348	42,759	43,732	44,558	46,802	45,666	50,206	47,825
BA	18,713	17,885	16,752	18,937	17,682	17,860	19,070	17,996	20,326
BE	89,100	84,300	78,600	79,600	74,600	71,500	76,500	75,800	70,600
CY	4,968	4,761	4,499	4,000	3,989	4,126	4,487	4,591	4,606
CZ	58,836	63,037	64,405	63,254	64,261	66,577	63,877	68,654	66,964
DE	367,400	514,100	543,800	566,100	554,200	559,800	563,400	560,600	551,700
DK					35,852	36,054	37,339	36,419	36,613
EE	12,855	12,678	12,802	13,826	14,402	14,115	13,690	13,238	13,710
EL	52,366	51,872	50,558	46,505	45,953	46,717	46,510	47,313	46,751
ES	216,465	211,871	214,845	202,223	203,135	208,794	210,028	213,516	205,000
FI	69,332	65,369	65,284	65,753	68,243	69,080	69,621	67,247	69,657
FR	512,142	502,732	497,486	505,704	494,450	495,137	478,733	472,080	485,719
GB									
GE	10,141	10,383	10,087	10,345	11,006	11,292	11,844	12,813	13,456
HR	25,156	23,641	22,590	23,854	22,547	22,449	22,828	22,098	23,830
HU	42,566	42,626	42,294	42,184	42,745	43,937	44,478	45,460	45,418
IE			23,260	22,934	22,587	22,673	23,731	23,567	24,093
IT	303,895	297,275	283,714	266,998	257,480	264,305	262,169	263,404	261,105
KS*	5,814	5,952	5,908	6,340	5,810	6,184	6,318	6,500	6,078
LT	12,758	11,679	11,647	11,441	11,414	11,115	13,712	14,411	14,824
LU							4,314	4,276	4,214
LV	9,917	9,318	10,075	9,933	9,046	9,481	9,849	10,168	10,544
MD						4,141	4,097	4,148	4,297
ME	6,440	6,139	6,283	6,779	6,893	5,916	5,857	5,617	6,424
MK	11,791	10,374	9,982	9,458	10,364	10,269	10,159	9,216	9,079
MT									
NL	95,122	92,905	96,829	109,810	112,383	109,608	102,649	111,846	114,051
NO				81,269	70,931	72,217	77,704	77,127	82,345
PL	93,375	96,978	100,101	99,320	102,970	103,464	104,038	104,197	108,701
PT	41,224	40,961	39,461	39,337	39,480	41,242	44,481	45,634	45,318
RS	41,352	42,661	40,197	41,463	38,891	41,891	41,401	40,453	40,715
SE	110,300	113,498	123,538	119,328	116,725	117,837	118,046	122,338	124,421
SI	23,126	21,173	21,145	21,515	22,475	22,030	22,476	23,085	22,884
SK	23,436	28,342	30,876	28,277	29,604	31,272	29,277	31,975	28,619
UA	170,985	176,614	176,331	176,331	165,974	146,358	141,378	142,272	146,139

Table 11: Injections in transmission in GWh

Withdrawals from transmission (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	37,218	39,830	42,144	43,137	43,957	46,164	45,031	49,446	47,149
BA	18,713	17,885	16,752	18,937	17,682	17,860	19,070	17,996	20,326
BE	87,600	82,900	77,200	78,200	73,200	70,100	75,100	74,400	69,300
CY	4,881	4,679	4,424	3,926	3,916	4,049	4,404	4,525	4,544
CZ	58,163	62,254	63,572	62,462	63,430	65,570	62,914	67,442	65,825
DE	35,400	44,800	42,100	41,000	37,200	38,300	38,200	40,300	24,800
DK					35,229	35,398	36,683	35,739	35,918
EE	12,475	12,323	12,450	13,477	14,021	13,712	13,281	12,912	13,330
EL	50,863	50,583	49,237	45,333	44,731	45,415	45,379	46,194	45,519
ES	212,160	208,029	211,157	198,493	199,339	205,075	205,949	209,641	201,000
FI	68,148	64,186	64,131	64,786	67,154	67,869	68,496	66,173	68,577
FR	469,467	434,634	441,705	445,788	416,418	420,247	425,739	420,477	411,423
GB									
GE	9,966	10,187	9,908	10,141	10,774	11,042	11,586	12,561	13,198
HR	24,623	23,127	22,128	23,371	22,117	21,942	22,318	21,681	23,296
HU	42,192	42,243	41,905	41,779	42,345	43,524	44,054	44,987	44,983
IE			22,984	22,618	22,237	22,278	23,339	23,199	23,717
IT	299,514	293,144	278,890	262,479	252,876	259,549	257,948	258,521	256,375
KS*	5,685	5,816	5,800	6,220	5,715	6,055	6,146	6,405	6,178
LT	12,519	11,456	11,434	11,229	11,223	10,925	13,407	14,089	14,484
LU							99	158	113
LV	9,657	9,090	9,837	9,695	8,825	9,227	9,617	9,944	10,316
MD						4,031	3,987	4,036	4,184
ME	6,275	5,980	6,130	6,636	6,771	5,781	5,738	5,490	6,282
MK	11,587	10,173	9,795	9,299	10,212	10,138	10,043	9,105	8,999
MT									
NL	94,102	92,079	96,006	108,979	111,436	108,533	101,431	110,490	112,690
NO				79,029	68,575	69,776	75,135	74,810	79,939
PL	91,628	95,294	98,413	97,626	101,277	101,631	102,353	102,528	107,089
PT	40,445	40,214	38,819	38,619	38,695	40,585	43,681	44,908	44,574
RS	40,287	41,565	39,173	40,450	37,943	40,959	40,511	39,602	39,846
SE	108,000	110,711	120,045	116,506	113,683	114,642	114,971	118,915	121,248
SI	22,805	12,599	12,508	12,551	12,415	12,797	12,963	13,315	13,510
SK	23,204	28,048	30,546	28,001	29,309	30,966	28,990	31,630	28,343
UA	166,629	172,299	172,057	172,057	161,553	141,989	137,623	138,417	142,366

Table 12: Withdrawals from transmission in GWh

Injections in distribution (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	56,606	64,612	72,471	74,114	73,431	74,622	76,908	78,112	76,853
BA	9,484	9,495	9,571	9,679	9,529	9,909	10,086	10,275	10,265
BE	59,500	57,300	56,800	56,700	54,400	55,000	55,200	54,500	53,900
CY								4,510	4,557
CZ	58,584	57,612	57,305	57,376	56,836	57,877	59,354	60,028	60,004
DE	163,700								
DK					35,983	36,780	37,078	38,166	38,751
EE	7,346	7,172	7,409	7,192	7,215	7,171	7,416	7,623	7,739
EL	44,541	43,788	43,714	41,782	41,178	42,176	41,938	42,663	
ES	256,029	250,864	247,700	241,864	238,981	244,034	245,411	248,539	248,000
FI	86,473	81,232	82,133	79,968	78,385	80,322	81,161	81,822	82,331
FR						381,075	387,418	387,126	387,624
GB									
GE		6,767	7,271	7,286	7,733	7,861	8,279	8,817	9,234
HR	17,152	16,927	16,755	16,601	15,441	16,076	16,160	16,695	16,758
HU	37,278	37,559	37,266	37,482	37,986	39,000	39,151	40,194	40,775
IE			23,994	23,982	23,749	24,116	24,652	25,020	25,852
IT									
KS*	4,559	4,682	4,767	4,794	4,555	4,677	4,807	4,997	5,120
LT	9	9	9	9	9	9	10	10	10
LU							735	857	908
LV	6,840	6,646	6,900	6,808	6,767	6,684	6,799	6,800	6,927
MD				3,471	3,543	3,489	3,483	3,827	3,951
ME	2,516	2,564	2,596	2,531	2,448	2,607	2,588	2,670	2,686
MK	6,260	6,548	6,368	6,031	5,898	6,110	6,061	6,164	6,120
MT	1,994	2,056	2,164	2,133	2,126	2,240	2,266	2,399	2,479
NL	92,853	95,321	95,197	94,395	93,042	90,485	91,229	91,213	90,369
NO				198,476	201,611	208,987	216,143	218,788	224,547
PL	155,642	155,024	157,209	153,785	153,610	157,608	163,448	163,862	167,299
PT	50,603	48,197	46,657	46,450	45,997	46,218	46,513	46,846	47,898
RS	30,454	30,607	30,259	30,068	29,351	29,351	30,162	30,503	30,040
SE	147,471	137,912	142,259	141,455	140,057	142,990	147,418	146,924	153,284
SI	11,166	11,124	10,965	10,968	10,858	11,169	11,364	11,696	11,894
SK							21,999	22,413	22,359
UA	162,641	165,804	166,186	161,640	150,664	128,810	130,094	130,780	134,382

Table 13: Injections in distribution in GWh

Withdrawals from distribution (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	54,387	62,184	69,979	71,631	71,039	72,220	74,604	75,805	74,640
BA	9,484	9,495	9,571	9,679	9,529	9,909	10,086	10,275	10,265
BE	56,800	54,800	54,200	54,200	52,100	52,600	52,800	52,100	51,600
CY								4,378	4,461
CZ	54,867	54,067	54,029	54,152	53,821	54,817	56,236	56,865	56,873
DE	455,100	461,300	469,900	469,600	460,600	449,700	449,900	445,200	443,000
DK					34,599	35,320	35,561	36,680	38,512
EE	6,852	6,747	6,981	6,807	6,807	6,810	7,088	7,247	7,387
EL	42,142	40,763	40,611	39,325	37,829	38,463	37,850	38,684	
ES	236,813	231,938	227,059	220,887	218,181	222,976	224,600	228,399	227,000
FI	84,612	79,129	79,998	77,922	76,384	78,183	78,789	79,150	79,598
FR						358,236	364,265	363,827	364,322
GB									
GE		6,069	6,644	6,715	7,163	7,251	7,640	8,165	8,606
HR	15,728	15,602	15,353	15,142	14,184	14,781	14,925	15,352	15,470
HU	33,904	34,249	34,005	34,224	34,747	35,740	35,987	37,042	37,772
IE			22,352	22,359	22,152	22,520	23,020	23,344	24,120
IT									
KS*	2,680	2,890	3,019	3,090	3,029	3,188	3,379	3,532	3,691
LT	8	8	8	8	8	9	9	9	10
LU							4,791	4,819	4,854
LV	6,393	6,211	6,468	6,447	6,421	6,263	6,465	6,464	6,600
MD				3,108	3,212	3,195	3,192	3,509	3,623
ME	2,013	2,072	2,055	2,051	2,016	2,161	2,184	2,271	2,315
MK	5,185	5,362	5,261	5,040	4,983	5,208	5,172	5,273	5,251
MT	1,759	1,813	1,871	1,854	1,924	2,089	2,151	2,295	2,363
NL	84,939	84,783	85,049	84,346	83,106	80,228	81,607	81,546	80,538
NO				193,028	196,331	203,381	209,943	213,055	218,729
PL	145,437	146,018	148,092	144,938	145,146	149,216	152,221	156,387	159,862
PT	46,824	44,734	42,753	41,763	41,695	42,104	42,484	42,595	43,693
RS	25,497	25,859	25,673	25,584	25,136	25,894	26,246	26,549	26,376
SE	141,291	132,354	136,774	136,129	134,920	137,782	142,066	141,644	147,938
SI	10,515	10,574	10,390	10,426	10,340	10,639	10,846	11,195	11,398
SK							20,666	21,149	21,123
UA	144,737	148,034	148,205	144,771	135,080	115,592	116,874	117,527	120,836

Table 14: Withdrawals from distribution in GWh

Energy injected by generators connected to distribution grid (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	29,109	30,753	32,948	31,309	30,630	32,299	35,079	37,420	35,227
BA	515	355	399	591	558	482	620	598	716
BE	3,800	4,400	5,100	5,400	5,600	6,900	7,100	7,400	8,000
CY									
CZ	20,278	20,752	20,507	20,643	19,686	20,450	19,104	18,707	17,555
DE									
DK					12,680	14,037	13,527	15,474	15,726
EE	213	193	193	197	204	223	237	231	196
EL	1,224	1,361	2,352	4,217	4,463	4,716	4,736	4,765	
ES	71,319	67,830	70,473	80,600	73,658	70,615	70,930	67,389	74,896
FI	18,269	17,313	16,291	15,092	14,131	14,701			
FR						38,888	40,056	43,664	49,905
GB									
GE									
HR	471	370	498	209	544	715	900	877	1,055
HU	6,319	4,927	4,550	3,971	3,576	3,605	3,649	4,126	4,076
IE			2,786	3,193	3,460	4,160	3,832	4,385	5,021
IT									
KS*	42	31	31	44	50	34	52	43	58
LT				1	1	1	1	1	1
LU									
LV	521	627	883	1,112	1,270	1,421	1,466	1,547	1,377
MD									
ME	29	16	22	30	32	46	76	67	102
MK	311	242	235	291	327	422	493	430	518
MT									
NL	92,853	95,321	95,197	94,395	93,042	90,485	91,229	91,213	90,369
NO				62,855	70,091	73,363	69,948	72,591	69,246
PL	48,585	50,578	49,395	50,727	47,419	53,179	55,747	54,900	49,681
PT		14,438	14,012	16,723	16,890	15,075	16,174	14,509	15,624
RS	61	46	72	104	267	321	448	538	642
SE	41,463	43,166	44,969	47,185	51,641	63,440	59,268	58,881	66,628
SI									
SK							7,067	7,475	6,806
UA									

Table 15: Energy injected into distribution grid in GWh

Total losses (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	2,693.9	2,946.8	3,107.1	3,077.8	2,993.7	3,040.5	2,939.6	3,066.7	2,889.5
BA	1,602.0	1,449.0	1,496.0	1,448.3	1,322.3	1,394.5	1,358.1	1,347.4	1,348.8
BE	4,200.0	3,900.0	4,100.0	3,900.0	3,700.0	3,800.0	3,800.0	3,800.0	3,600.0
CY	256.0	298.0	200.0	243.0	226.0	286.0		271.0	211.0
CZ	4,389.9	4,328.8	4,108.0	4,015.5	3,846.7	4,067.0	4,080.1	4,374.7	4,269.4
DE	21,000.0	21,400.0	23,400.0	26,200.0	23,900.0	25,800.0	26,000.0	27,500.0	24,600.0
DK				2,273.0	2,239.0	2,347.0	2,307.0	2,311.0	2,344.0
EE	875.0	781.0	780.0	734.0	789.0	763.0	736.0	702.0	732.0
EL	3,902.0	4,314.0	4,424.0	3,629.0	4,571.0	5,015.0	5,219.0	5,098.0	
ES	23,522.4	22,767.5	24,328.7	24,706.1	24,597.2	24,777.7	24,890.4	24,015.1	25,000.0
FI	3,045.4	3,285.7	3,288.0	3,013.7	3,089.4	3,349.8	3,497.8	3,745.5	3,813.1
FR	37,027.0	34,572.0	34,542.0	35,929.0	32,934.0	33,588.0	34,307.0	34,432.0	34,329.0
GB	27,036.0	28,129.0	28,905.0	27,666.0	28,651.0	27,297.0	26,096.0	26,554.0	
GE		893.6	805.7	775.4	802.3	860.4	896.5	903.8	886.0
HR	1,957.0	1,839.0	1,864.0	1,942.0	1,687.0	1,802.0	1,745.0	1,760.0	1,822.0
HU	3,748.0	3,693.0	3,650.0	3,664.0	3,638.0	3,673.0	3,589.3	3,623.6	3,438.2
IE			1,918.0	1,938.8	1,946.9	1,991.9	2,024.1	2,044.6	2,108.6
IT	20,570.0	20,847.5	21,000.3	21,187.5	19,451.0	19,716.9	18,752.6	18,667.7	
KS*	2,010.0	1,901.0	1,858.0	1,814.0	1,635.0	1,598.0	1,548.0	1,582.0	1,541.0
LT	269.8	256.7	248.7	244.6	221.1	220.4	338.2	353.0	373.3
LU	134.0	166.0	154.0	153.0	153.0	158.0	157.8	155.9	155.0
LV	695.0	651.0	646.0	575.0	544.0	560.0	566.0	539.0	535.0
MD				363.1	331.3	403.9	400.9	429.8	441.2
ME	667.3	651.4	694.8	622.4	554.1	581.2	523.0	526.5	513.8
MK	1,278.0	1,387.0	1,294.0	1,149.0	1,066.0	1,033.0	1,005.0	1,001.0	993.0
MT	235.0	243.0	293.0	279.0	202.0	151.0	115.0	104.0	116.0
NL	5,637.9	5,197.9	5,073.9	5,318.2	5,115.8	4,925.1	5,021.7	5,399.2	5,321.8
NO				7,688.0	7,637.0	8,046.0	8,769.0	8,051.0	8,223.0
PL	11,959.2	10,583.2	10,720.3	10,474.9	10,072.1	10,222.2	9,417.0	9,143.0	9,048.0
PT	4,556.3	4,209.8	4,545.4	5,405.0	5,086.6	4,771.3	4,829.2	4,977.4	4,929.5
RS	6,023.0	5,843.0	5,610.0	5,495.0	5,199.0	5,168.0	4,809.0	4,805.0	4,532.0
SE	8,480.0	8,345.0	8,978.0	8,148.0	8,178.0	8,403.0	8,428.0	8,703.0	8,520.0
SI	971.7	821.0	876.7	848.7	820.8	864.3	856.7	879.3	859.3
SK							1,619.0	1,609.0	1,512.0
UA	21,808.0	21,620.0	21,982.0	20,713.0	19,615.0	16,980.0	16,638.0	16,786.0	16,995.0

Table 16: Total losses in GWh

Losses in transmission (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	475.2	518.4	615.3	595.0	601.6	638.4	635.6	759.7	676.7
BA	338.0	324.2	308.1	343.1	304.5	359.4	333.3	341.5	398.8
BE	1,500.0	1,400.0	1,500.0	1,400.0	1,400.0	1,400.0	1,400.0	1,400.0	1,300.0
CY	87.0	82.0	75.0	74.0	73.0	77.0	83.0	66.0	62.0
CZ	672.4	783.6	832.6	791.3	831.2	1,007.1	962.6	1,212.1	1,139.0
DE	3,700.0	3,300.0	6,200.0	6,300.0	6,400.0	8,100.0	8,400.0	9,900.0	7,200.0
DK				871.0	886.0	962.0	962.0	1,020.0	975.0
EE	381.0	356.0	352.0	349.0	381.0	402.0	408.0	325.0	380.0
EL	1,503.0	1,289.0	1,321.0	1,172.0	1,222.0	1,302.0	1,131.0	1,119.0	1,232.0
ES	4,305.7	3,841.7	3,688.0	3,729.8	3,796.7	3,719.7	4,079.2	3,875.5	4,000.0
FI	1,184.0	1,183.0	1,152.5	967.2	1,089.0	1,210.6	1,125.6	1,073.6	1,080.1
FR	11,927.0	10,972.0	10,442.0	11,229.0	10,434.0	10,749.0	11,154.0	11,133.0	11,027.0
GB	5,975.0	6,467.0	6,757.0	6,351.0	6,509.0	7,394.0	6,235.0	6,506.0	
GE	175.0	195.9	179.0	204.1	231.9	250.0	258.0	251.9	258.1
HR	533.0	514.0	462.0	483.0	430.0	507.0	510.0	417.0	534.0
HU	374.0	383.0	389.0	405.0	400.0	413.0	424.3	472.6	435.2
IE			275.7	316.2	349.6	395.4	392.2	368.0	376.2
IT	4,380.8	4,131.5	4,824.4	4,518.4	4,603.4	4,755.3	4,221.2	4,882.2	4,730.0
KS*	131.0	115.0	109.0	110.0	109.0	110.0	120.0	118.0	111.0
LT	269.0	256.0	248.0	243.9	220.4	219.8	337.6	352.4	372.7
LU						24.0	24.0	25.0	25.0
LV	260.0	228.0	238.0	238.0	221.0	254.0	232.0	224.0	228.0
MD						110.1	110.2	112.1	113.0
ME	164.4	159.5	153.8	142.4	122.1	135.2	119.0	126.9	142.2
MK	204.0	201.0	187.0	159.0	152.0	131.0	116.0	111.0	125.0
MT									
NL	1,020.0	826.0	823.0	831.3	947.0	1,075.0	1,218.0	1,356.0	1,360.8
NO				2,240.0	2,356.0	2,440.0	2,569.0	2,317.0	2,405.0
PL	1,747.1	1,684.8	1,687.7	1,694.0	1,692.5	1,832.9	1,685.0	1,669.0	1,611.0
PT	778.2	746.3	641.2	718.1	784.6	657.0	800.0	726.0	743.5
RS	1,065.0	1,096.0	1,024.0	1,013.0	984.0	932.0	892.0	852.0	868.0
SE	2,300.0	2,787.0	3,493.0	2,822.0	3,041.0	3,195.0	3,076.0	3,423.0	3,173.0
SI	320.5	271.9	301.6	306.6	303.5	334.3	338.7	378.1	362.5
SK							287.0	345.0	277.0
UA	4,355.0	4,314.0	4,459.0	4,273.0	4,421.0	4,369.0	3,754.0	3,855.0	3,773.0

Table 17: Losses in transmission in GWh

Losses in distribution (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	2,218.7	2,428.4	2,491.8	2,482.8	2,392.0	2,402.1	2,304.0	2,307.0	2,212.7
BA	1,264.0	1,124.8	1,187.9	1,105.2	1,017.8	1,035.1	1,024.8	1,005.9	950.0
BE	2,700.0	2,500.0	2,600.0	2,500.0	2,300.0	2,400.0	2,400.0	2,400.0	2,300.0
CY	109.0	139.0	81.0	109.0	99.0	135.0		132.0	96.0
CZ	3,717.5	3,545.2	3,275.4	3,224.2	3,015.5	3,059.9	3,117.6	3,162.7	3,130.4
DE	17,300.0	18,100.0	17,200.0	19,900.0	17,500.0	17,700.0	17,600.0	17,600.0	17,400.0
DK	1,353.0	1,257.0	1,248.0	1,402.0	1,353.0	1,385.0	1,345.0	1,291.0	1,369.0
EE	494.0	425.0	428.0	385.0	408.0	361.0	328.0	377.0	352.0
EL	2,399.0	3,025.0	3,103.0	2,457.0	3,349.0	3,713.0	4,088.0	3,979.0	
ES	19,216.7	18,925.8	20,640.7	20,976.2	20,800.6	21,058.0	20,811.2	20,139.6	21,000.0
FI	1,861.4	2,102.7	2,135.6	2,046.5	2,000.4	2,139.2	2,372.2	2,671.9	2,733.0
FR	25,100.0	23,600.0	24,100.0	24,700.0	22,500.0	22,839.0	23,153.0	23,299.0	23,302.0
GB	19,986.0	20,622.0	21,120.0	20,339.0	21,141.0	18,906.0	18,866.0	19,065.0	
GE		697.7	626.7	571.3	570.4	610.4	638.5	651.9	627.9
HR	1,424.0	1,325.0	1,402.0	1,459.0	1,257.0	1,295.0	1,235.0	1,343.0	1,288.0
HU	3,374.0	3,310.0	3,261.0	3,259.0	3,238.0	3,260.0	3,165.0	3,151.0	3,003.0
IE			1,642.3	1,622.6	1,597.3	1,596.5	1,632.0	1,676.6	1,732.4
IT	16,189.2	16,715.0	16,176.3	16,669.5	14,848.7	14,961.9	14,531.6	13,758.5	
KS*	1,879.0	1,786.0	1,749.0	1,704.0	1,526.0	1,488.0	1,427.0	1,464.0	1,429.0
LT	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
LU						78.0	77.0	76.0	76.0
LV	435.0	423.0	408.0	337.0	323.0	306.0	334.0	315.0	307.0
MD				363.1	331.3	293.8	290.7	317.7	328.2
ME	502.9	491.9	541.0	480.0	432.0	446.0	404.0	399.6	371.6
MK	1,074.0	1,186.0	1,107.0	990.0	914.0	902.0	889.0	890.0	868.0
MT	235.0	243.0	293.0	279.0	202.0	151.0	115.0	104.0	116.0
NL	4,617.9	4,371.9	4,250.9	4,486.9	4,168.8	3,850.1	3,803.7	4,043.2	3,961.0
NO				5,548.0	5,281.0	5,606.0	6,200.0	5,733.0	5,818.0
PL	10,212.1	8,898.4	9,032.6	8,780.9	8,379.6	8,389.4	7,732.0	7,474.0	7,437.0
PT	3,778.1	3,463.5	3,904.2	4,686.9	4,302.0	4,114.3	4,029.2	4,251.4	4,186.0
RS	4,958.0	4,747.0	4,586.0	4,482.0	4,215.0	4,236.0	3,917.0	3,953.0	3,664.0
SE	6,180.0	5,558.0	5,485.0	5,326.0	5,137.0	5,208.0	5,352.0	5,280.0	5,347.0
SI	651.2	549.1	575.1	542.1	517.3	529.9	518.0	501.1	496.8
SK							1,332.0	1,264.0	1,235.0
UA	17,453.0	17,306.0	17,523.0	16,440.0	15,194.0	12,611.0	12,884.0	12,931.0	13,222.0

Table 18: Losses in distribution in GWh

Low voltage losses (GWh)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT									
BA	-	-	-	-	-	-	-	-	-
BE									
CY	60.0	77.0	44.0	60.0	54.0	74.0		73.0	53.0
CZ	1,647.1	1,612.6	1,458.4	1,462.8	1,333.0	1,402.4	1,387.6	1,418.4	1,416.1
DE	8,600.0	8,700.0	9,000.0	9,700.0	8,600.0	8,700.0	8,800.0	8,600.0	8,500.0
DK									
EE									
EL		1,682.0	1,751.0	1,482.0	2,060.0	2,340.0	2,578.0	2,494.0	
ES									
FI									
FR									
GB									
GE									
HR									
HU			1,753.0	1,741.0	1,710.0	1,711.0	1,606.0	1,507.0	1,338.0
IE			530.9	524.5	487.8	480.9	509.8	545.0	556.5
IT									
KS*				498.0	466.0	478.0	386.0	364.0	396.0
LT									
LU						56.0	56.0	55.0	54.0
LV	401.0	390.0	198.0	148.0	134.0	118.0	123.0	130.0	128.0
MD									
ME									
MK									
MT									
NL									
NO									
PL	4,291.1	3,495.3	3,628.7	3,444.3	3,289.2	3,099.1	2,711.0	2,646.0	2,613.0
PT									
RS									
SE									
SI									
SK							716.0	664.0	644.0
UA									

Table 19: Low voltage losses in GWh

Total losses in %

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	4.03	4.14	4.10	4.10	3.98	3.84	3.64	3.50	3.48
BA	8.33	7.94	8.72	7.42	7.25	7.60	6.90	7.25	6.41
BE	4.52	4.40	4.90	4.59	4.61	4.85	4.55	4.57	4.58
CY	5.15	6.26	4.45	6.08	5.67	6.93	-	5.90	4.58
CZ	5.55	5.17	4.84	4.79	4.58	4.67	4.92	5.01	5.05
DE	5.72	4.16	4.30	4.63	4.31	4.61	4.61	4.91	4.46
DK					4.61	4.69	4.54	4.45	4.48
EE	6.70	6.07	6.00	5.23	5.40	5.32	5.28	5.21	5.26
EL	7.28	8.10	8.36	7.15	9.07	9.75	10.18	9.79	
ES	8.17	8.14	8.53	8.74	8.89	8.87	8.86	8.55	8.93
FI	3.48	3.97	4.03	3.73	3.75	4.00			
FR						6.29	6.61	6.68	6.41
GB									
GE	-	8.61	7.99	7.50	7.29	7.62	7.57	7.05	6.58
HR	7.64	7.66	8.07	8.07	7.31	7.78	7.35	7.66	7.32
HU	7.67	7.77	7.79	7.94	7.85	7.73	7.46	7.31	6.95
IE			7.36	7.42	7.47	7.42	7.34	7.31	7.24
IT	6.77	7.01	7.40	7.94	7.55	7.46	7.15	7.09	-
KS*	34.32	31.77	31.28	28.41	27.90	25.70	24.30	24.18	25.11
LT				2.14	1.94	1.98	2.47	2.45	2.52
LU							3.66	3.65	3.68
LV	6.66	6.55	5.90	5.21	5.27	5.14	5.00	4.60	4.49
MD						9.75	9.78	10.36	10.27
ME	10.32	10.58	11.02	9.14	8.00	9.75	8.82	9.26	7.87
MK	10.56	13.07	12.67	11.79	9.97	9.66	9.43	10.38	10.35
MT									
NL	3.00	2.76	2.64	2.60	2.49	2.46	2.59	2.66	2.60
NO				5.33	5.42	5.53	5.94	5.38	5.42
PL	8.42	7.17	7.17	6.98	6.70	6.53	5.89	5.75	5.71
PT		7.60	8.50	9.64	9.02	8.47	7.96	8.28	8.09
RS	14.54	13.68	13.93	13.22	13.28	12.24	11.49	11.72	10.96
SE	5.59	5.33	5.33	4.89	4.86	4.64	4.75	4.80	4.46
SI	4.20	3.88	4.15	3.94	3.65	3.92	3.81	3.81	3.75
SK							4.45	4.08	4.27
UA	12.75	12.24	12.47	11.75	11.82	11.60	11.77	11.80	11.63

Table 20: Total losses in %

Losses in transmission in %

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	1.26	1.28	1.44	1.36	1.35	1.36	1.39	1.51	1.42
BA	1.81	1.81	1.84	1.81	1.72	2.01	1.75	1.90	1.96
BE	1.68	1.66	1.91	1.76	1.88	1.96	1.83	1.85	1.84
CY	1.75	1.72	1.67	1.85	1.83	1.87	1.85	1.44	1.35
CZ	1.14	1.24	1.29	1.25	1.29	1.51	1.51	1.77	1.70
DE	1.01	0.64	1.14	1.11	1.15	1.45	1.49	1.77	1.31
DK	-	-	-	-	2.47	2.67	2.58	2.80	2.66
EE	2.96	2.81	2.75	2.52	2.65	2.85	2.98	2.46	2.77
EL	2.87	2.48	2.61	2.52	2.66	2.79	2.43	2.37	2.64
ES	1.99	1.81	1.72	1.84	1.87	1.78	1.94	1.82	1.95
FI	1.71	1.81	1.77	1.47	1.60	1.75	1.62	1.60	1.55
FR	2.33	2.18	2.10	2.22	2.11	2.17	2.33	2.36	2.27
GB	-	-	-	-	-	-	-	-	-
GE	1.73	1.89	1.77	1.97	2.11	2.21	2.18	1.97	1.92
HR	2.12	2.17	2.05	2.02	1.91	2.26	2.23	1.89	2.24
HU	0.88	0.90	0.92	0.96	0.94	0.94	0.95	1.04	0.96
IE			1.19	1.38	1.55	1.74	1.65	1.56	1.56
IT	1.44	1.39	1.70	1.69	1.79	1.80	1.61	1.85	1.81
KS*	2.25	1.93	1.84	1.74	1.88	1.78	1.90	1.82	1.83
LT	2.11	2.19	2.13	2.13	1.93	1.98	2.46	2.45	2.51
LU	-	-	-	-	-	-	0.56	0.58	0.59
LV	2.62	2.45	2.36	2.40	2.44	2.68	2.36	2.20	2.16
MD	-	-	-	-	-	2.66	2.69	2.70	2.63
ME	2.55	2.60	2.45	2.10	1.77	2.28	2.03	2.26	2.21
MK	1.73	1.94	1.87	1.68	1.47	1.28	1.14	1.20	1.38
MT	-	-	-	-	-	-	-	-	-
NL	1.07	0.89	0.85	0.76	0.84	0.98	1.19	1.21	1.19
NO	-	-	-	2.76	3.32	3.38	3.31	3.00	2.92
PL	1.87	1.74	1.69	1.71	1.64	1.77	1.62	1.60	1.48
PT	1.89	1.82	1.62	1.83	1.99	1.59	1.80	1.59	1.64
RS	2.58	2.57	2.55	2.44	2.53	2.22	2.15	2.11	2.13
SE	2.09	2.46	2.83	2.36	2.61	2.71	2.61	2.80	2.55
SI	1.39	1.28	1.43	1.43	1.35	1.52	1.51	1.64	1.58
SK	-	-	-	-	-	-	0.98	1.08	0.97
UA	2.55	2.44	2.53	2.42	2.66	2.99	2.66	2.71	2.58

Table 21: Losses in transmission in %

Losses in distribution in %

	2010	2011	2012	2013	2014	2015	2016	2017	2018
AT	3.92	3.76	3.44	3.35	3.26	3.22	3.00	2.95	2.88
BA	13.33	11.85	12.41	11.42	10.68	10.45	10.16	9.79	9.26
BE	4.54	4.36	4.58	4.41	4.23	4.36	4.35	4.40	4.27
CY	-	-	-	-	-	-	-	2.93	2.11
CZ	6.35	6.15	5.72	5.62	5.31	5.29	5.25	5.27	5.22
DE	10.57	-	-	-	-	-	-	-	-
DK	-	-	-	-	3.76	3.77	3.63	3.38	3.53
EE	6.72	5.93	5.78	5.35	5.65	5.03	4.42	4.95	4.55
EL	5.39	6.91	7.10	5.88	8.13	8.80	9.75	9.33	-
ES	7.51	7.54	8.33	8.67	8.70	8.63	8.48	8.10	8.47
FI	2.15	2.59	2.60	2.56	2.55	2.66	2.92	3.27	3.32
FR	-	-	-	-	-	5.99	5.98	6.02	6.01
GB	-	-	-	-	-	-	-	-	-
GE	-	10.31	8.62	7.84	7.38	7.76	7.71	7.39	6.80
HR	8.30	7.83	8.37	8.79	8.14	8.06	7.64	8.04	7.69
HU	9.05	8.81	8.75	8.69	8.52	8.36	8.08	7.84	7.36
IE	-	-	6.84	6.77	6.73	6.62	6.62	6.70	6.70
IT	-	-	-	-	-	-	-	-	-
KS*	41.22	38.15	36.69	35.54	33.50	31.82	29.69	29.30	27.91
LT	9.06	8.17	7.76	7.42	7.31	6.76	6.49	6.14	5.96
LU	-	-	-	-	-	-	10.48	8.87	8.37
LV	6.36	6.36	5.91	4.95	4.77	4.58	4.91	4.63	4.43
MD	-	-	-	10.46	9.35	8.42	8.34	8.30	8.31
ME	19.99	19.19	20.84	18.96	17.65	17.11	15.61	14.96	13.83
MK	17.16	18.11	17.38	16.42	15.50	14.76	14.67	14.44	14.18
MT	11.79	11.82	13.54	13.08	9.50	6.74	5.08	4.34	4.68
NL	4.97	4.59	4.47	4.75	4.48	4.26	4.17	4.43	4.38
NO	-	-	-	2.80	2.62	2.68	2.87	2.62	2.59
PL	6.56	5.74	5.75	5.71	5.46	5.32	4.73	4.56	4.45
PT	7.47	7.19	8.37	10.09	9.35	8.90	8.66	9.08	8.74
RS	16.28	15.51	15.16	14.91	14.36	14.43	12.99	12.96	12.20
SE	4.19	4.03	3.86	3.77	3.67	3.64	3.63	3.59	3.49
SI	5.83	4.94	5.25	4.94	4.76	4.74	4.56	4.28	4.18
SK	-	-	-	-	-	-	6.05	5.64	5.52
UA	10.73	10.44	10.54	10.17	10.08	9.79	9.90	9.89	9.84

Table 22: Losses in distribution in %

Annex 5 – About CEER

The Council of European Energy Regulators (CEER) is the voice of Europe's national energy regulators. CEER's members and observers comprise 39 national energy regulatory authorities (NRAs) from across Europe.

CEER is legally established as a not-for-profit association under Belgian law, with a small Secretariat based in Brussels to assist the organisation.

CEER supports its NRA members/observers in their responsibilities, sharing experience and developing regulatory capacity and best practices. It does so by facilitating expert working group meetings, hosting workshops and events, supporting the development and publication of regulatory papers, and through an in-house Training Academy. Through CEER, European NRAs cooperate and develop common position papers, advice and forward-thinking recommendations to improve the electricity and gas markets for the benefit of consumers and businesses.

In terms of policy, CEER actively promotes an investment friendly, harmonised regulatory environment and the consistent application of existing EU legislation. A key objective of CEER is to facilitate the creation of a single, competitive, efficient and sustainable Internal Energy Market in Europe that works in the consumer interest.

Specifically, CEER deals with a range of energy regulatory issues including wholesale and retail markets; consumer issues; distribution networks; smart grids; flexibility; sustainability; and international cooperation.

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More information is available at www.ceer.eu.