PROGRAMME FUNDED BY THE EU

ENERGY COOPERATION BETWEEN THE EU, THE LITTORAL STATES OF THE BLACK & CASPIAN SEAS AND THEIR NEIGHBOURING COUNTRIES

Ad Hoc Expert Facility

under the INOGATE project

“Support to Energy Market Integration and Sustainable Energy in the NIS” (SEMISE)

EU practice in treatment of technical losses in the high voltage electricity grid

TABLE OF CONTENTS

1. Introduction

This report focuses on the EU experience and existing practices in dealing with transmission losses. The major information source used out in this report comes from a benchmarking effort carried out by the European Regulators' Group for Electricity and Gas (ERGEG) in 2008 when a relevant Position Paper on Treatment of Losses was launched for consultation. France, UK, and Italy are given a special analysis as case studies.

2. Treatment of losses in the EU

Until to-date there have been no formal attempts to harmonise the treatment of network losses at a pan-European level; analyses have been carried out within the scope of benchmarking studies of electricity transmission tariffs by the European Commission, the European Transmission System Operators (ENTSO-E) and the Council of European Energy Regulators (CEER/ERGEG).

2.1 Current practices

Definition of losses

ERGEG reports that there is no common definition of losses within the EU. Admittedly this leads to a situation where different definitions in the Member States exist. While this broad statement is generally true considering both the losses in the Transmission and Distribution sector, it is worthwhile to be mentioned that the source of differentiation across EU jurisdictions is largely accounted to the distribution side where non-metered, non-billed and illegally off-taken energy may also be accounted as part of the general losses definition. On the other hand, in respect to the lack of harmonisation of losses definition, the boundary points of the transmission grid, should be clearly defined i.e. interconnection nodes and boundary points between the transmission system assets and the transmission users' assets. In principle, in the EU this boundary point refers to the HV bushings side of the transmission systems' user transformer.

Having the technical (or "physical) and non-technical losses duly discriminated the former can in turn be broken down to fixed and variable components. National Grid, the UK TSO, in their "National Electricity Transmission System Seven Year Statement" defines transmission losses as:

> The losses incurred on the system between the power station generating unit and the grid supply points and are made up of:

- Variable' (I^2R) transmission heating losses in the overhead lines, underground cables and other equipment on our transmission system but excluding grid supply transformers at the Grid Supply Points (GSPs);
- 'Fixed' losses made up of corona losses on outdoor transmission equipment and iron losses in transformers;
- 'Variable' (I^2R) heating losses (copper losses) in grid supply transformers at the GSPs; and,
- 'Variable' (I^2R) heating losses (copper losses) in generator transformers.

The above comprise a relatively robust definition of technical losses with the remark that even the "fixed" part of the losses may be subjected to short variations from time to time if cases of network configuration alterations (switching on or off lines and/or transformers) or weather influence on corona effect are to be accounted.

A summary of the above considerations with regards to the definition of losses as identified by ERGEG's consultation of 2008 is clearly illustrated in Figure 1 below:

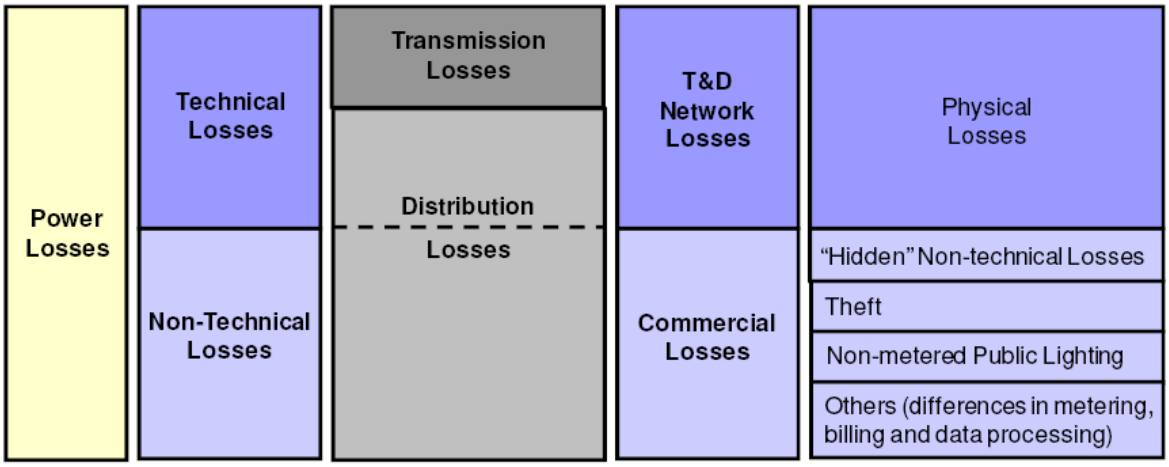

Figure 1*. Categorisation of Losses*

Source: Treatment of Losses by Network Operators. ERGEG Position Paper – 15 July 2008.

Valuation

Valuation refers to the ex-post procedure of calculating losses (in most cases per each voltage level). The determination of transmission losses is possible, since usually continuous metering of all consumption and generation is available at transmission level (this is not always the case in distribution level). Transmission losses are calculated by hourly energy balance (difference between injections and off-takes). ERGEG's Position Paper in its Annex

A2.3 provides a detailed overview of the losses valuation practices across EU member states.

Values

The table below shows transmission losses in various EU countries. For Ukraine, transmission losses for the years 2005 – 2006, are reported to be in the order of 3%[1]

Country	Average % of losses
Austria	1,5% of output
Czech Republic	1,5% of output
Finland	1,6% of output
France	2,3% of output
Greece	2,4% of output
Hungary	1,4% of output
Norway	1,6% of output
Poland	2,1% of output
Portugal	1,1% of output
Romania	2,6% of output
Slovakia	1,0% of output
Spain	1,2% of output
Sweden	2,1% of output
United Kingdom	1,6% of output

Table 1.Level of losses in the transmission and distribution European electricity networks (2005/06)

Source: Treatment of Losses by Network Operators. ERGEG Position Paper – 15 July 2008.

According to the explanations given by ERGEG, the differences in the percentages of losses are mainly due to:

- The national definition of what voltage levels are operated by TSOs and DSOs. If the TSO operates not only the transmission grid but also the regional grids, the average percentage of losses will be higher than if the TSO operates only the transmission grid. If the DSO operates not only the distribution grids but also the regional grids, the average percentage of losses will be lower, than if the DSO operates only the distribution grids.
- Values have been calculated with accordance to national regulatory definitions that differ from country to country.

[1] *source: Overview of Electricity Market in Ukraine, Anna Tsarenko, WP 1/2007,CASE Ukraine, 2007*

- The reference for the percentage. The level of the input includes the losses when the level of output does not. If the percentage of losses refers to output, it will be higher than if it refers to input.
- The level of theft on DSOs. As the DSO losses generally include theft, the higher the level of the theft is, the higher the percentage.

Procurement

Directive 2009/72/EC obliges TSOs to procure the energy they use to cover network losses according to transparent, non-discriminatory market-based procedures whenever they have this ability. As a European practice amongst TSO, two possible cases can be distinguished:

- **OPTION A:** TSOs are responsible for procurement of energy for losses ("**centralised' method**")
- **OPTION B:** Generators and/or Suppliers are mainly obliged to cover the losses ("**self-procurement method**")

Under OPTION A, the energy required to cover transmission losses is procured:

- on the power exchanges – PEX (day ahead or longer contracts),
- bilaterally – OTC,
- by auctions/tenders (generators or traders submit price offers).

It is common to use several possibilities together, for instance a combination of PEX and bilateral (longer term hedged contracts). The costs of losses, following an approval by the regulator, are used in the tariff calculation. Imbalances caused by losses are usually handled in the balancing market like any other imbalance. This option requires an ex-ante (e.g. on a yearly basis) estimation of losses, and of the cost to cover the losses, so that to include the cost to the network tariff.

In several cases incentives to TSOs to reduce losses / to minimise costs are used. Of course incentive schemes apply only to option A (centralised procurement), which is used in many EU countries, e.g.:

- France, Austria, Germany;
- Norway, Sweden, Finland;
- Hungary, Poland, Romania, Czech Republic, Slovakia .

The following table summarises the way transmission losses are treated in six EU countries.

	Who	**How**	**Tariffs**
Finland	Network operators	PEX or bilaterally	Paid by network tariffs
France			
Norway			
Sweden			
Czech Republic		Annual tenders	

Austria		Special balancing group	Paid by dedicated tariff

Table 2. Procurement solutions in some European Countries

Source: Treatment of Losses by Network Operators. ERGEG Position Paper – 15 July 2008.

Under OPTION B (self-procurement of transmission losses by Trading Participants), transmission losses are physically injected by the Generators. Further to the projected load demand, suppliers actually procure the additional energy for compensation of the transmission losses related to the demand during a specific trading period. For this purpose, ex-ante calculated Transmission Loss Factors (applied also to Generators should the market design provides for) are used. The estimated transmission losses are priced at the same price as load ('scheduled' energy).

Further losses due to real-time imbalances are treated like any other induced or occurred imbalance, i.e. the difference between effective (ex-post) losses and estimated (ex-ante) losses is priced at the cost of providing the extra energy on the balancing market. This option (B) is used in Ireland, Portugal, Italy and Greece.

Tariffs and regulation

In the case where costs of transmission losses are recovered through tariffs, there are two options possible:

- Include cost of losses in the network tariff
- separate network tariff components for losses

In the table that follows (ENTSO-e, 2010), the main characteristics of the TSO tariffs in EU are depicted.

	Sharing of network operator charges		**Price signal**		**Are losses included in the tariffs charged by TSO?**	**Are system services included in the tariffs charged by TSO?**
	Generation	**Load**	**Seasonal/ time-of-day (1)**	**Location**		
Austria	15%	85%	-	-	Yes	Through a specific component to generators
Belgium	0%	100%	xxx	-	Not included for grid > = 150 kV	Tariff for ancillary services
Bosnia and Herzegovina	0%	100%	-	-	No	No
Bulgaria	0%	100%	-	-	Yes	Yes
Croatia	0%	100%	x	-	Yes	Yes
Czech Rep.	0%	100%	-	-	Yes	Yes
Denmark	2-5%	95-98%	-	-	Yes	Yes
Estonia				-	Yes	Yes
Finland	11%	89%	x	-	Yes	Yes
France	2%	98%	-	-	Yes	Yes
Germany	0%	100%	-	-	Yes	Yes
Great Britain	27% TNUoS tariff (2) 50% BSUoS Tariff (2)	73% TNUoS tariff 50% BSUoS Tariff	xx	TNUoS– locational; BSUoS–non-locational	No, recovered in the energy market	Included in BSUoS Tariff
Greece	0%	100%	x	-	No, recovered in	Included in Uplift

	Use of system (2) 0% Uplift charges (2)	Use of system 100% Uplift charges			the energy market	charges
Hungary	0%	100%	-	-	Yes	Tariff for ancillary services
Ireland	0%	80%	-	Generation only	No, recovered in the energy market	Yes
Italy	0%	100%	-	-	No	Yes
Latvia	0%	100%	-		Yes	Yes
Lithuania	0%	100%	-	-	Yes	Yes
Luxembourg	0%	100%	-	-	Yes	Yes
FYROM	0%	100%	-	-	Yes	Yes
Netherlands	0%	100%	-	-	Yes	Tariff for ancillary services
N. Ireland	25%	75%	xxx	-	No	Tariff for ancillary services
Norway	35%	65%	xxx (Via losses)	Location	Yes	Yes
Poland	0.60%	99,4%	-	-	Yes	Yes
Portugal	0%	100%	xx	-	No, recovered in the energy price	No, included in energy price
Romania	20.69% Use of system	79.31% Use of system	-	6G zones =6G tariffs values 8L zones =8L	Yes	Tariff for ancillary services
	0% system services	100% system services				
Serbia	0%	100%	x	-	Yes	Yes
Slovak Rep.	0%	100%	-	-	Through a specific fee	Through a specific fee
Slovenia	0%	100%	xx	-	Yes	Tariff for ancillary services
Spain	0%	100%	xxx	-	No, recovered in the energy price	No, included in energy price
Sweden	28%	72%	-	Location	Yes	Yes
Switzerland	0%	100%	-	-	By a separate tariff for losses	By separate tariffs for ancillary services

Remarks:
(1) The "X" indicates time differentiation. With one "X", there is only one time differentiation ("daynight", "summer-winter" or another one). With two "X" (or more), there are two (or more) time differentiations.
(2) TNUoS: Transmission Network Use of System; BSUoS=Balancing Services Use of System

Table 3. Main characteristics of the TSO tariffs in Europe

Source: ENTSO-E, Overview of transmission tariffs in Europe: Synthesis 2010.

Transmission tariffs in the Member States reflect most of the requirements of the Regulation 1228/2003 given that they are postage stamp tariff systems rather than being distance-based. In some countries a zonal tariff system (Bulgaria, Italy and Great Britain) or a nodal system (Norway) is applied. Article 4.2 of the Regulation 1228/2903 foresees the provision of locational signals to producers and consumers of electricity. Some countries have introduced systems providing such locational signals (Great Britain, Norway, Sweden, Romania and Slovakia). However, the majority of the EU countries do not have locational signals that take into account the network losses.

Regulatory and incentive mechanisms

Energy efficiency is an issue of increasing importance. Therefore, an incentive for taking measures to reduce losses should be provided to TSOs. There exist different approaches for such incentives in the various EU Member States. There are a number of external factors with significant influence on the level of losses. In particular, these include:

- the geographical size of the market, as well as,
- the number and degree of dispersion of loads,

which are ultimately important driving factors that cannot be modified.

Due to its complexity, the treatment of losses is also deeply related to other regulatory and operational issues, such as the national/international energy efficiency schemes and commitments, the general process of infrastructure planning and the network reconfiguration and development, that are far beyond the scope of this work.

Generally, it should be stated that losses are proportional to:

- the amount of energy that is delivered,
- the distance between generation and consumption, and,
- inversely related to the voltage level of the network.

Consequently, any measures or actions focused on reducing or smoothing the demand for energy, (re)locating generation plants closer to demand, and upgrading the voltage level of the network, are anticipated to have definitely a positive impact on transmission losses.

Regulatory incentives – the practice in EU

At least the following cases may be distinguished concerning regulatory incentives practices for transmission losses in the EU:

1. No regulatory or incentive mechanism (which is common among most countries);
2. Incentive-based regulatory model where the incentives for the network losses are equal to the incentives for any other costs; (e.g. Norway)
3. Allowed rate of losses to include in tariffs capped to a maximum value in %; (e.g. Austria, Czech Republic, UK)
4. Incentive mechanism allowing the network operator to be rewarded (or charged) if cost for losses lower (or above) than a reference value are achieved (e.g. Germany)
5. Upper limit ('cap') on acceptable amount of losses (Portugal, UK)

ERGEG's Position Paper (**Error! Reference source not found.**) in its Annex A2.7 provides a detailed overview of the regulatory incentives to reduce losses across EU member states.

2.2 Country-specific case studies

France

In France there is in place a voluntary Power Exchange and an OTC market. The transmission system operator (RTE) buys from various sources (from a yearly horizon to D-2) the volume corresponding to the forecasted losses. The challenge, therefore, is to come up with secure predictions for the quantities of these losses for the year down to 2 days. The main elements for medium and long term predictions, for a week to a year are briefly presented below.

Losses depend directly on the network configuration, and generation and consumption at each node of the transmission network. A few months ahead, none of this information is available with accuracy. However, indirectly, losses depend on temperature since, when temperature drops, consumption (and thus production) increase, which brings about an increase in losses. Losses also depend on the season, since outages of production units as well as network maintenance often take place during slack months, which influences both production plan and network configuration. Finally, consumption predictions at standard temperature are available for France for the week ahead, and prediction at forecast temperatures beyond that.

The process for yearly prediction of losses is as follows:

- Determination of the curve of hourly losses,
- Application of this curve to predicted daily volumes,
- Prediction of hourly volumes.

This process relies on the use of statistics, predictive methods (mobile averages, linear regressions, etc.) derived from experience, historical data on losses and consumption, seasonal characteristics (month, type of day, etc.) and predicted daily volumes. The method has been used since the end of 2001 and a substantial experience feedback is now available. It shows that prediction is satisfactory for the specific process. It also indicates paths for evolution of the method, namely a more diversified taking into account of forecast temperatures and the consumption structure.

System operators (TSO and DSO) buy the losses:

- on the OTC market by an auction mechanism, or directly on the PEX market, as products in the futures market (i.e. from the EPD power exchange) for the calendar, quarter and monthly products;
- on the OTC market by an auction mechanism, or directly on the PEX market, as products in the Day Ahead market (i.e. EpexSpot power exchange) for the hourly needs known the Day Ahead;

- as products in the balancing market for the half-hourly needs, at prices accurately known 12 months after real time (calculation done at M+1 M+3 M+6 and M+12);

Each week, RTE draws up loss forecasts for the coming week. These forecasts are established on the basis of predicted consumption, generation and exchanges. The forecasts are refined two days before (D-2) according to the latest meteorological forecasts. They are then used to establish the delivery programmes sent to Suppliers with whom RTE has signed relevant contracts for supply of losses.

The sale of losses to grid operators reveals a growing share of options products, sold by a limited number of participants backed by generation facilities. Purchases by the grid operators RTE and ERDF, necessary to offset their losses, represented 33 TWh in 2008 and 17 TWh in the first half of 2009. RTE and ERDF put out tenders several times a month to buy products enabling them to cover losses on their grid. In 2008, 112 calls for tenders were put out by the two grid operators; 49 were organised in the first half of 2009. This should be compared with the 121 calls for tenders in 2007. As a result of the calls for tenders in 2008 and the first half of 2009, grid operators bought monthly products (from M+1 to M+18), quarterly products (from Q+1 to Q+5), and annual products (from Y+1 to Y+4). Since early 2009, RTE has also been covering part of its needs on the EPEX Spot (day-ahead) market.

Table 2-4 summarises the breakdown of energy committed contractually by sellers. Participants are selling growing volumes of options products and the share of firm products or products similar to firm products for the sellers (otherwise called premium deals) was lower in 2008 than 2007. In 2008, grid operators used 40% of options or premium deal products. In the first half of 2009, this ratio stood at 68%.

Volume in TWh	Firm Products	Take or Pay[2]	Optional Products	Swap
2007	22.0	17.0	18.0	
2008	18.5	15.0	20.5	
H1 2009	4.5	8.5	10.0	0.45[3]

Table 2-4. Volume of energy sold to grid operators to make up for losses

Source: RTE, ERDF; Analysis: CRE.

[2] Take or pay contracts deals involve products which are paid for by the grid manager at a contractual price, but which have the possibility of not withdrawing the energy. In this case, the seller resells the energy on the spot market receives the contractual price from the grid manager and pays the spot price back to the latter. For the seller, premium deals are therefore similar to a firm product.

[3] Buying and selling

Error! Reference source not found. comprises an article prepared by RTE staff for CIGRE in 2004 referring to losses prediction methodology. Further information on losses can be found at RTE website's designated section[4].

Italy

The situation in Italy concerning transmission losses may be summarised as follows. The wholesale market model includes a Power Exchange and bilateral contracts. The treatment of losses is based on the principle that "load" (i.e. end-users of electricity or the Suppliers representing them) should bear the cost for the losses. Moreover, the method followed corresponds to the "self-procurement" one. In the Day Ahead market (PX and bilateral contracts) bids and offers are adjusted to 'ex ante' Transmission Load Factor (TLFs) (eg. calculated every 5 years), whilst an additional "error" factor is also applied. With respect to cost allocation:

- In the DA market, losses are priced at the energy clearing price.
- The difference between the DA estimation of losses and the actual level of losses is paid by the TSO (TERNA) at the balancing price in real time and later subdivided among all network users (uplift applied to the network tariff).

United Kingdom

The market model in the UK is of totally decentralized nature, with energy trading based on bilateral contracts as well as trading in power exchanges (continuous trading). Transmission losses allocation according to Option B' (self-procurement).

Actual losses are metered as the difference between the metered quantity of energy off-taken and injected by trading participants (more specifically by the Balancing Mechanism (BM) units, which form each trading participant). There is a locational feature (calculation of TLFs) in the allocation methodology, but currently it remains inactive (TLF is set to zero). Losses are then allocated to "injection" at proportion of 45% and "off-take" by 55% by the so-called "BSC System Parameter a".

In summary therefore, the UK system provides for the possibility to set nodal or zonal TLFs by calculating the latter per settlement period. Moreover, the share between generation and demand can be adjusted through the proportion parameter "a". Settlement calculations take into account losses adjustment in:

- Scaling the payments and charges associated with accepted Bid and Offers in the Balancing Mechanism.
- Determining the System Buy and System Sell prices.

[4] http://clients.rte-france.com/lang/an/visiteurs/vie/vie_previ_perte.jsp

- Calculating the Balancing Services Volumes.
- Scaling the payments and charges associated with non delivery in the Balancing Mechanism.

An incentive formula to minimize balancing costs including losses is used. The Transmission System Operator is externally incentivised in its role as the system operator for the onshore and offshore electricity transmission systems in England, Scotland and Wales by the Balancing Services Incentive Scheme (BSIS). BSIS provides a focus on key areas where National Grid is able to create value for the industry and consumers by reducing operating costs, and improving the accuracy and provision of information for use by the industry to better facilitate the market. BSIS costs can be categorised into two main groups; external costs and internal costs;

- The internal incentive scheme costs include National Grid's internal costs for operating the transmission system. For example, staff and overheads.
- The external BSIS costs recover the external costs National Grid incurs when operating the transmission system. These costs include Balancing Mechanism (BM) charges, contracts and trading carried out to minimise the costs of actions.

These external costs are grouped in the following categories; constraints, black start, reactive power, energy related services, SO internal costs and incentive payments. External costs in their turn are part of the overall cost for balancing the system and thus in both the electricity supply industry's interest and the TSO interest to minimise.

Yet, losses are only one of the parts comprising the TSO incentive scheme, the latter being committed to a target which is mutually agreed with the regulatory authority on an ex-ante basis and verified/adjusted regularly using the out-turn of the losses (ex-post). As also mentioned earlier in this report, losses depend on a number of network characteristics including the topology of the generators, the demand development, etc. A steady increase of losses has been observed since the introduction of BETTA (British Electricity Trading and Transmission Arrangements) from 2005 and onwards, with which the systems of Scotland (where some large nuclear power generators are included) has incorporated to the common market and owned to this development a substantial change in power flows has been realised. Further to this change the TSO observed substantial deviations from 2007 and onwards between the forecasted losses and the actual losses, which led to a negotiation process with the regulatory authority. In the 30th of June 2008 the TSO submitted a report to the regulatory authority presenting their analyses and proposals for the forecasting of losses in the UK transmission system. In summary the report:

- summarised the investigation (statistical & analytical) carried out;
- proposed a new model for forecasting the losses; and

- tested the model and produced sensitivity analyses in order to validate it and reveal any limitations.

The “Investigations into Transmission Losses on UK Electricity Transmission System, June 2008” provides a quite diversified approach as compared to that in France and it is attached to this report for a more thorough consideration (**Error! Reference source not found.**). It should be noted however that the model presented in the report is based on the established knowledge of the nature and size of transmission losses in the UK system, which takes into account a long track of previous analyses and data.