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IMPLEMENTATION OF THE NETWORK CODE ON HARMONISED TRANSMISSION TARIFF STRUCTURES FOR GAS

Annex - Comparison of Reference Price Methodologies

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1 INTRODUCTION

This annex to the public consultation "Implementation of the Network Code on Harmonised Transmission Tariff Structures for Gas" presents details on three methodologies for calculating reference prices for transmission tariffs and provides a brief comparison and a discussion of results.

Among the three methodologies is: (1) the model presented by ERSE in the public consultation and proposed as the reference price methodology; (2) the model defined in Article 8 of the tariff network code; and (3) a review of the matrix model used to determine the tariffs currently in force.[1]

The three methodologies determine tariff structures compatible with the 'entry-exit' model for the transmission of natural gas, in line with the provisions of Directive 73/2009 and Regulation 715/2009 of the European Commission, which require the application of separate tariffs at entry points and exit points of the natural gas transmission network. Such a design allows market agents to freely negotiate natural gas in the transmission networks, thereby fostering market efficiency.

The methodologies presented here are exclusively for the determination of capacity-based transmission tariffs. The calculation of energy-based transmission tariffs is described in the main document of the public consultation.

The rest of the document follows the following structure: Chapter 2 presents the details of the three methodologies mentioned and Chapter 3 compares the prices resulting from the three methodologies and presents an analysis of the differences in the values obtained.

[1] As will be explained in section 2.3, the revision of this last model results from the incorporation of more recent data on the national transmission network and the simplification of some aspects of the tariff calculation.

2 METHODOLOGIES TO DETERMINE TRANSMISSION TARIFFS

This chapter describes three methodologies for determining capacity-based transmission tariffs for natural gas.[2]

The first methodology, called the **modified capacity-weighted distance (modified CWD) methodology**[3], corresponds to the proposal presented in the public consultation as the reference price methodology, pursuant to Article 26(1)(a) of the tariff network code. The modified CWD methodology incorporates a matrix approach that utilizes forecasted gas capacities, distances between relevant points and unit capacity costs of the transmission network as allocation factors to define the transmission tariffs.

The second methodology, called **capacity-weighted distance (CWD) methodology**, is defined in Article 8 of the tariff network code. Where the reference price methodology is different from the capacity-weighted distance methodology of Article 8, the tariff network code requires a comparison with the latter.[4]

The third methodology corresponds to an **update of the matrix methodology currently in force**, which was implemented when ERSE introduced an 'entry-exit' approach to comply with the provisions of Directive 73/2009 and Regulation 715/2009 of the European Commission.[5] In this methodology, the entry tariffs and exit tariffs of the transmission network are determined based on a gas flow model for the transmission network and the corresponding calculation of the network costs depending on the contractual path of that gas flow. The entry tariffs and exit tariffs of the transmission network are however independent of the contractual path and are determined by an optimization algorithm that minimizes the differences in relation to the previously calculated flow-dependent network costs. The decision to stop using this more complex methodology, and opt for the methodology described in section 2.1, is to respond to the requirement of the tariff network code to choose a methodology that allows users to reproduce the calculation of reference prices. Indeed, the methodology now proposed in public consultation allows users to gain a better understanding of the tariff structure in the transmission of natural gas and an easier reproduction of the calculations, compared to the matrix methodology previously used in defining the tariff structure in force.

Sections 2.1, 2.2 and 2.3 describe each of these three methodologies in more detail.

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[2] The commodity-based price set for the exit points from the transmission network is defined in the main document of the public consultation.

[3] The acronym 'CWD' stands for the abbreviation of the capacity-weighted distance methodology, defined in Article 8 of the tariff network code.

[4] See Article 26(1)(vi) of the tariff network code.

[5] The detailed description of the methodology can be found in the ERSE document entitled 'Determinação da Estrutura Tarifária no ano gás 2010-2011' (only available in Portuguese), published in June 2010.

2.1 MODIFIED CAPACITY-WEIGHTED DISTANCE METHODOLOGY (PROPOSED IN THE PUBLIC CONSULTATION)

The modified capacity-weighted distance (modified CWD) methodology that is proposed in public consultation uses forecasted gas capacities, distances between entry points and exit points and unit capacity costs of the transmission network as allocation factors to define the tariffs for the use of the transmission network.

In addition to this document, an Excel file is provided with the calculations made in applying this modified capacity-weighted distance methodology.

The table below summarizes the main features of the reference price methodology proposed through this public consultation. The proposed methodology can be considered as a hybrid model between the currently applied methodology (matrix approach) and the methodology defined in the tariff network code (capacity-weighted distance). On the one hand, it adopts from the matrix methodology currently in force the perspective on unit costs of the transmission grid connecting entry points and exit points and, on the other hand, introduces simplifications that approximate it to the methodology defined in the tariff network code, providing greater transparency to the calculation and facilitating the reproduction of the results by the various stakeholders.

Table 2-1 - Summary of the modified capacity-weighted distance methodology

Methodology	Modified capacity-weighted distance (modified CWD) methodology
Allocation factors	Distance, capacity, cost of transmission network.
Parameters	• Distance: matrix of distances between points of entry and exit. • Capacity: capacities contracted/used at points of entry and exit. • Cost of transmission network: CAPEX in transmission network. • Entry-exit split. Other parameters are also used for reconciliation with the allowed revenues of the transmission system operator, namely the detailed demand forecast, tariff options applicable to exits to domestic consumption and the discounts provided for in Article 9.
Steps	1. Determination of the cost matrix – Distribution of costs taking into account the allocation factors. 2. Calculation of reference prices (pre-adjustment) – Calculation of the pre-adjustment reference prices for the entry and exit points based on the cost matrix and the 'entry-exit' split, together with the price equalization in the domestic exit points and at the VIP. 3. Calculation of reference prices (post-adjustment) – Calculation of the post-adjustment reference prices by applying the discounts of Article 9 and ensuring the reconciliation with the allowed revenue.
Additional note	The reference price methodology results in zero prices for the points whose use does not entail costs for the system (for example, where the use is predominantly in reverse flow).

In order to better understand the method of calculating this methodology, a more detailed description is given in Table 2-2 in relation to the steps set forth in Table 2-1.

Table 2-2 – Details on the modified CWD methodology proposed in the public consultation

1. Cost matrix		
	Distance matrix	km
x	Flow matrix	kWh/day
x	Unit cost matrix	€ / [(kWh/day) · km]
=	**Cost matrix**	€
2. Reference prices (pre-adjustment)		
	Cost matrix	€
&	Entry-exit split	%
&	Investment (CAPEX)	€
&	Forecasted capacities (by point of entry/exit)	kWh/day
=	**Reference prices (pre-adjustment)**	€ / (kWh/day) per year
3. Reference prices (post-adjustment)		
	Reference prices (pre-adjustment)	€ / (kWh/day) per year
&	Allowed revenues	€
&	Detailed structure of forecasted demand	kWh/day
&	Entry-exit split	%
&	Multiplicative scaling factors	constant
=	**Reference prices (post-adjustment)**	€ / (kWh/day) per year

Note: The right column indicates the units applicable to each element.

The first step determines the cost matrix based on three other matrices, namely the distance matrix, the flow matrix and the unit cost matrix (costs per unit of capacity and distance). The distance matrix shows the distances between all points of entry and all points of exit of the national transmission network.[6] The flow matrix is a distribution of gas flows based on forecasted contracted capacity and forecasted used capacity at the points of entry and exit. The unit cost matrix identifies the unit cost of each section between the entry and exit points, measured in €/[(kWh/day)·km]. Currently, this unit cost matrix presents a simplified structure, since it assigns the same standard unit cost to all sections except those where the gas flow does not imply new investments in the transmission network, namely in the sections that have as exit point the interconnection points with Spain, the LNG terminal at Sines and the underground storage at Carriço.[7] To the gas paths ending in these exit points the methodology assigns a zero unit cost. Finally, the cost matrix results from the cell-to-cell multiplication of the three matrices mentioned above, producing a cost distribution across the possible paths connecting the entry and exit points. This calculation is shown in Table 2-3.

[6] In the case of exit points to customers in HP and to distribution system operators, as these have been grouped into a total of seven exit zones, the distances between the points of entry and those exit points are computed in relation to reference points of those exit zones, namely the points of greatest consumption.

[7] Regarding the exit points to the interconnection points and to the LNG terminal these are permanently serviced in reverse flow, allowing increased availability to contract gas in the opposite direction. In the case of underground storage, a higher flow of gas exiting the transmission network will firstly entail new investments in non-transmission assets, belonging to the underground storage facilities (for instance investments in surface facilities, such as increased capacity of compressors for gas injection and extraction).

Table 2-3 - Determination of the cost matrix

Distance matrix

km	A	B	C	D	E	F	G	H	I	J	K
A	0,0	509,0	481,8	254,3	416,9	434,0	290,2	148,2	477,8	441,0	274,9
B	509,0	0,0	549,5	321,9	484,5	190,7	357,9	371,0	71,7	508,6	334,0
C	481,8	549,5	0,0	294,7	276,8	474,4	330,7	343,8	518,2	51,1	462,8
D	254,3	321,9	294,7	0,0	229,7	246,9	36,0	116,2	290,6	253,8	235,2

x

Flow matrix

kWh/dia	A	B	C	D	E	F	G	H	I	J	K
A	0	6.132.437	0	10.641.080	25.123.818	30.050.398	26.074.590	12.820.990	1.806.727	11.262.110	1.336.685
B	0	827.431	0	1.435.769	3.389.881	4.054.609	3.518.166	1.729.897	243.776	1.519.563	180.355
C	0	8.593.033	0	14.910.737	35.204.570	42.107.905	36.536.831	17.965.320	2.531.663	15.780.951	1.873.020
D	0	3.140.663	0	5.449.717	12.866.899	15.389.995	13.353.826	6.566.135	925.296	5.767.771	684.569

x

Unit cost matrix

€ /((kWh/day)*km)	A	B	C	D	E	F	G	H	I	J	K
A	0	0	0	0	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
B	0	0	0	0	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
C	0	0	0	0	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
D	0	0	0	0	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002

=

Cost matrix

€	A	B	C	D	E	F	G	H	I	J	K
A	0	0	0	0	2.485.511	3.095.294	1.796.029	450.931	204.875	1.178.719	87.193
B	0	0	0	0	389.757	183.505	298.786	152.297	4.148	183.424	14.297
C	0	0	0	0	2.312.665	4.741.126	2.867.106	1.465.664	311.362	191.197	205.717
D	0	0	0	0	701.401	901.623	114.009	181.050	63.825	347.473	38.214

Note: Each of the four matrices has a number of rows and columns corresponding to the number of entry points and exit points, respectively. For the meaning of the letters 'A' to 'K' refer to Table 2-4.

The following table identifies the list of relevant points in the national gas transmission network together with the classification of the entry points and exit points.

Table 2-4 - List of relevant points of the national natural gas transmission network

Name	Type	Entry	Exit
A - Campo Maior	IP	Yes	Yes
B - Valença do Minho	IP	Yes	Yes
C - LNG terminal in Sines	LNG terminal	Yes	Yes
D - Carriço	Storage	Yes	Yes
E - Lisboagás, Setgás, Carregado, Ribatejo	Consumption	No	Yes
F - Portgás, Outeiro power plant	Consumption	No	Yes
G - Lusitâniagás, Lares power plant, Figueira da Foz power plant	Consumption	No	Yes
H - Tagusgás, Pego power plant	Consumption	No	Yes
I - Portucel	Consumption	No	Yes
J - Sines refinery, Portucel	Consumption	No	Yes
K - Beiragás	Consumption	No	Yes

The second step determines reference prices, measured in €/(kWh/day) per year, for each of the entry points (REFen) and exit points (REFex), as shown in Table 2-5. In this step the reference prices are based on the distribution of values in the cost matrix, the amount of investment in CAPEX and the entry-exit split. By way of example, costs to be recovered at entry point A correspond to the proportion of the sum of costs in line A of the cost matrix compared to the sum of all costs in the matrix, corrected for the percentage of costs to be recovered at entry points.

Table 2-5 - Determination of reference prices without equalization and before final reconciliation

€	A	B	C	D	E	F	G	H	I	J	K	W.en	CAP Entry	REFen
A	0	0	0	0	2.485.511	3.095.294	1.796.029	450.931	204.875	1.178.719	87.193	15%	142.061.928	0,0758
B	0	0	0	0	389.757	183.505	298.786	152.297	4.148	183.424	14.297	2%	19.167.987	0,0741
C	0	0	0	0	2.312.665	4.741.126	2.867.106	1.465.664	311.362	191.197	205.717	19%	199.063.256	0,0704
D	0	0	0	0	701.401	901.623	114.009	181.050	63.825	347.473	38.214	4%	72.755.519	0,0374

W.ex	0%	0%	0%	0%	14%	21%	12%	5%	1%	5%	1%
CAP Exit	0	16.184.186	0	28.083.000	66.304.565	79.306.360	68.813.757	33.836.026	4.768.154	29.721.968	3.527.661
REFex	0,0000	0,0000	0,0000	0,0000	0,1543	0,1955	0,1282	0,1155	0,2129	0,1111	0,1701

In order to complete the second step, it is necessary to equalize prices at the entry point from the VIP, at the exit point to the VIP and at the exit points to national consumption (Table 2-5 does not yet include this equalization).[8] Prices for these three situations, measured in €/(kWh/day) per year, are 0,0756, 0,0000 and 0,1515, respectively.

In the third and final step, the reference prices are determined by applying the final adjustments, namely the Article 9 discounts and the multiplicative scaling that ensure the reconciliation of the revenues recovered by the entry and exit transmission tariffs with the allowed revenues, preserving the entry-exit split applied in the second step.

Discounts applied at the entry point to and the exit point from storage facilities are both 95%. The multiplicative scaling factors that ensure revenue reconciliation are 2,45 and 1,14 at the entry points and exit points, respectively.

2.2 CAPACITY-WEIGHTED DISTANCE METHODOLOGY

The capacity-weighted distance methodology is defined in Article 8 of the tariff network code. Although the tariff network code does not require the adoption of this methodology to determine the reference prices for gas transmission tariffs, it requires the use of the capacity-weighted distance model as a reference for comparison with the reference price methodology actually applied. Even before this public consultation, ERSE already presented in the context of the tariffs and prices for the gas year 2017-2018 a first application

[8] The virtual interconnection point (VIP) corresponds to the sum of the two interconnection points with Spain (Campo Maior and Valença do Minho).

of the capacity-weighted distance methodology to the transmission network in Portugal[9], comparing the results obtained with those resulting from the matrix model used at that time.

In addition to this document, an Excel file is provided with the calculations made in the application of the capacity-weighted distance methodology.

Table 2-6 - Summary of the capacity-weighted distance methodology

Methodology	Capacity-weighted distance (CWD) methodology
Allocation factors	Distance, capacity
Parameters	• Distance: matrix of distances between points of entry and exit. • Capacity: capacities contracted/used at points of entry and exit. • Entry-exit split (50% - 50%). Other parameters are also used for reconciliation with the allowed revenues of the transmission system operator, namely the detailed demand forecast, tariff options applicable to exits to domestic consumption and the discounts provided for in Article 9.
Steps	1. Determination of the distance matrix – Distances between the entry points and exit points of the transmission network. 2. Calculation of reference prices (pre-adjustment) – Calculation of the pre-adjustment reference prices for the entry and exit points based on the capacity-weighted distances and the 'entry-exit' split, together with the price equalization in the domestic exit points and at the VIP. 3. Calculation of reference prices (post-adjustment) – Calculation of the post-adjustment reference prices by applying the discounts of Article 9 and ensuring the reconciliation with the allowed revenue.

Based on the forecasted capacities at each point (Table 2-7) and the distance matrix between the relevant points in the transmission network (Table 2-8), the methodology determines average distances, which correspond to capacity-weighted distances.[10]

[9] See subchapter 5.4 of the document "Estrutura Tarifária no ano gás 2017-2018" (only available in Portuguese), published in June 2017.

[10] By way of example: the average distance for a particular point of entry (exit) is calculated by averaging the distances to all points of exit (entry) connected to that point, weighted by the capacities of the various exit (entry) points.

Table 2-7 - List of points of entry and exit of the national transmission network

Description of the network points	Type of point	Forecasted contracted capacity, in MWh/day	
		Entry	Exit
A - Campo Maior	IP	142.062	0
B - Valença do Minho	IP	19.168	16.184
C - LNG terminal in Sines	LNG terminal	199.063	0
D - Carriço	Storage	72.756	28.083
E - Lisboagás, Setgás, Carregado, Ribatejo	Consumption	-	66.305
F - Portgás, Outeiro power plant	Consumption	-	79.306
G - Lusitâniagás, Lares power plant, Figueira da Foz power plant	Consumption	-	68.814
H - Tagusgás, Pego power plant	Consumption	-	33.836
I - Portucel	Consumption	-	4.768
J - Sines refinery, Portucel	Consumption	-	29.722
K - Beiragás	Consumption	-	3.528

Note: Forecasted contracted capacities were determined from the maximum daily capacities of 2016 and 2017.

Table 2-8 - Matrix of distances between entry points and exit points

		Exit										
	km	A	B	C	D	E	F	G	H	I	J	K
Entry	A	0,0	509,0	481,8	254,3	416,9	434,0	290,2	148,2	477,8	441,0	274,9
	B	509,0	0,0	549,5	321,9	484,5	190,7	357,9	371,0	71,7	508,6	334,0
	C	481,8	549,5	0,0	294,7	276,8	474,4	330,7	343,8	518,2	51,1	462,8
	D	254,3	321,9	294,7	0,0	229,7	246,9	36,0	116,2	290,6	253,8	235,2

Note: The descriptions of points 'A' through 'K' are given in Table 2-7.

Subsequently, the use of the network by a given point is determined from the product of the average distance and the forecasted contracted capacity of that point. Finally, this network utilization indicator is compared with the other points and the proportion of revenues to be recovered at each entry point and at each exit point is determined, respecting an entry-exit split of 50%-50%.[11]

The following table shows the calculations made in the determination of the reference prices, measured in €/(kWh/ day) per year, for each of the entries (TARen) and exits (TARex).

Table 2-9 - Determination of reference prices without equalization and before final reconciliation

km	A	B	C	D	E	F	G	H	I	J	K	CAP Entry	ADen	Wc,en
A	0,0	509,0	481,8	254,3	416,9	434,0	290,2	148,2	477,8	441,0	274,9	142.061.928	359	37%
B	509,0	0,0	549,5	321,9	484,5	190,7	357,9	371,0	71,7	508,6	334,0	19.167.987	350	5%
C	481,8	549,5	0,0	294,7	276,8	474,4	330,7	343,8	518,2	51,1	462,8	199.063.256	342	49%
D	254,3	321,9	294,7	0,0	229,7	246,9	36,0	116,2	290,6	253,8	235,2	72.755.519	186	10%

	A	B	C	D	E	F	G	H	I	J	K
CAP Exit	0	16.184.186	0	28.083.000	66.304.565	79.306.360	68.813.757	33.836.026	4.768.154	29.721.968	3.527.661
ADex	427	496	429	280	324	410	269	243	447	233	357
Wc,ex	0%	7%	0%	7%	20%	30%	17%	8%	2%	6%	1%

[11] That is, half of the revenues must be recovered at the entry points and the other half at the exit points.

In order to complete the second step, it is necessary to apply the price equalization at the entry point from the VIP, at the exit point to the VIP, and at the exit points to national consumption[12] to the prices in Table 2-9. Prices for these three situations, measured in €/(kWh/day) per year, are 0,0929, 0,0888 and 0,1075, respectively.

In the third and final stage, the reference prices are determined by applying the final adjustments, namely the Article 9 discounts and the multiplicative scaling that ensure the reconciliation of the revenues recovered by the entry and exit transmission tariffs with the allowed revenues, preserving the entry-exit split applied in the second step.

Discounts applied at the entry point to and the exit point from storage facilities are both 95%. The multiplicative scaling factors that ensure revenue reconciliation are 2,46 and 1,32 at the entry points and exit points, respectively.

2.3 MATRIX METHODOLOGY (UPDATE OF PREVIOUS MODEL)

The transmission tariffs for the gas year 2018-2019 were based on the methodology that was introduced in 2010 and that determined the tariff structure for the transmission network.[13]

The adoption of this model allowed the Portuguese system to be aligned with the provisions of Directive 73/2009 and Regulation 715/2009 of the European Commission, where the introduction of the 'entry-exit' model was envisaged, which contrasted with previous models where the transmission tariff was calculated based on the specific distance between an entry point and an exit point and depended on the contractual path. It is now established that decoupled 'entry-exit' models are more efficient as they deepen the natural gas market by facilitating natural gas exchanges between market agents within the system.

The methodology presented in this section, which is different from the methodology proposed in the public consultation (section 2.1) constitutes a review of the matrix model presented in 2010 in two dimensions:

1. Updating the data used, including more recent data on investments and the configuration of the transmission network.
2. Simplification in the matrix calculation in the sense of not separating the investments by typology, namely into pipelines, connections to end-customers and GRMS.

[12] The virtual interconnection point (VIP) corresponds to the sum of the two interconnection points with Spain (Campo Maior and Valença do Minho).

[13] The detailed description of the methodology can be found in the ERSE document entitled 'Determinação da Estrutura Tarifária no ano gás 2010-2011' (only available in Portuguese), published in June 2010.

In addition to this document, an Excel file is made available with the calculations made in the application of this revised matrix methodology.

The following table summarizes the main features of the revised matrix model. As mentioned, the model presented here includes a simplification of the matrix calculation compared to the model introduced in 2010. Previously, the network was classified into central sections used by all points in the network and into peripheral sections used only by the exit points. In the review of this methodology, all investments, namely in pipelines, connections to end-customers and GRMS are treated in the same way, but a differentiation of the investments according to 8 geographical areas of the transmission network is carried out, in order to reflect that the costs depend on the geography.

Table 2-10 - Summary of the matrix methodology (update of previous model)

Methodology	Matrix methodology
Allocation factors	Distance, capacity, costs
Parameters	• Distance: matrix of distances between points of entry and exit. • Capacity: capacities contracted/used at the points of entry and exit, distributed according to a maximum demand flow. • Costs: unit costs differentiated by network segment, depending on the investments made and the gas flow in the day of maximum demand. • Entry-exit split (50% - 50%). Other parameters are also used for reconciliation with the allowed revenues of the transmission system operator, namely the detailed demand forecast, tariff options applicable to exits to domestic consumption and the discounts provided for in Article 9.
Steps	1. Determination of the unit cost matrix – Determination of the unit cost matrix, measured in €/(kWh/day), for the various sections connecting the entry points to the exit points. 2. Minimization algorithm – Application of a quadratic error minimization algorithm to ensure that the unit costs associated with each contractual path are adhering in average terms to the sum of the prices of the entry and exit tariffs. 3. Calculation of reference prices (pre-adjustment) – Calculation of the pre-adjustment reference prices, reflecting the price equalization for domestic exit points and at the VIP. 4. Calculation of reference prices (post-adjustment) – Calculation of the post-adjustment reference prices by applying the discounts of Article 9 and ensuring the reconciliation with the allowed revenue.
Additional note	The reference price methodology results in zero prices for the points whose use does not entail costs for the system (for example, where the use is predominantly in reverse flow).

The first step in the methodology is to determine the unit cost matrix, measured in €/(kWh/day). For this purpose, the various investments (CAPEX) in the national transmission network were collected, differentiated by the eight geographic areas, corresponding to separate segments of the network (see Table 2-11). From these investments, at current prices, the annuities were calculated in capitalized value assuming an average lifespan of 37 years[14] and a discount rate of 6,02%, in line with the compensation rate of 2017 of the assets of the transmission activity, Table 2-12.[15]

Table 2-11 - Investments in the national natural gas transmission network

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8
1997	222.914,6	241.677,0	116.878,1	22.491,3	0,2	931,6	0,0	0,0
1998	8.274,3	9.264,9	4.859,3	21.085,8	37,3	820,7	0,0	0,0
1999	810,6	1.701,0	326,2	5.638,7	3.264,7	0,0	0,0	0,0
2000	2.496,0	8.806,0	37,9	756,0	0,0	9,5	225,9	0,0
2001	463,3	788,7	316,3	394,2	2.220,2	173,9	0,0	0,0
2002	2.770,4	1.304,1	776,1	131,5	762,3	2.070,6	0,0	0,0
2003	968,7	1.518,5	680,4	207,9	2.808,7	27.801,5	48.873,4	0,0
2004	2.403,9	1.343,4	305,5	5.786,7	266,5	130,1	1.328,1	0,0
2005	607,9	1.408,8	1.333,7	2.008,1	198,5	398,8	442,5	0,0
2006	585,5	509,2	663,9	295,0	98,6	382,9	206,8	0,0
2007	128,1	72,5	9,6	596,5	14,4	9,5	388,7	0,0
2008	942,5	4.373,3	195,2	17,7	23,9	29,5	2.741,8	0,0
2009	4.885,4	23.321,8	2.157,4	206,7	74,8	256,3	4.411,6	0,0
2010	14.189,2	21.944,4	6.838,6	52,0	671,4	124,6	239,8	0,0
2011	4.558,5	2.518,9	143,5	1.391,0	76,9	167,3	1.363,3	0,0
2012	127,9	2.226,1	67,0	78,7	11,8	0,0	405,2	0,0
2013	277,9	-44,4	2,3	19,2	11,5	13,0	8,7	41.769,9
2014	1.327,8	1.317,2	836,5	57,8	134,4	165,0	1.062,1	0,0
2015	657,9	1.750,2	404,0	351,7	107,9	60,1	371,6	24,4
2016	1.347,9	1.070,2	266,9	306,1	283,8	274,6	219,8	44,0
2017	902,1	824,9	730,6	632,0	656,6	632,0	920,3	632,0
2018	359,8	359,8	359,8	359,8	359,8	359,8	408,6	359,8
2019	856,1	856,1	856,1	856,1	1.126,1	1.126,1	856,1	856,1

Note: Investments in thousands of euros (at current prices).

Table 2-12 - Annuities of investments in the national natural gas transmission network

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Area 1	51.752	50.626	47.918	45.684	43.175	41.204	39.022	37.177	35.155	33.239	31.368	29.702	28.578	28.496	27.345	25.804	24.364	23.095	21.837	20.700	19.590	18.502	17.506
Area 2	56.108	54.951	52.182	50.935	48.188	45.677	43.332	41.079	38.951	36.809	34.729	33.290	34.085	34.532	32.829	31.180	29.406	27.849	26.410	24.992	23.632	22.315	21.103
Area 3	27.135	26.658	25.212	23.787	22.495	21.352	20.251	19.148	18.255	17.309	16.328	15.424	14.797	14.699	13.879	13.098	12.354	11.725	11.092	10.482	9.940	9.400	8.921
Area 4	5.222	9.542	10.165	9.735	9.255	8.752	8.289	8.711	8.508	8.066	7.685	7.251	6.863	6.479	6.253	5.906	5.572	5.261	4.991	4.731	4.508	4.276	4.088
Area 5	0	8	682	643	1.015	1.089	1.487	1.443	1.390	1.325	1.251	1.183	1.125	1.134	1.077	1.017	960	917	874	846	846	822	848
Area 6	216	384	362	343	356	694	5.200	4.925	4.703	4.489	4.235	3.998	3.801	3.598	3.411	3.217	3.036	2.878	2.719	2.586	2.485	2.368	2.306
Area 7	0	0	0	44	42	39	8.027	7.776	7.399	7.007	6.659	6.616	6.748	6.391	6.168	5.857	5.525	5.302	5.031	4.763	4.558	4.327	4.137
Area 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.806	3.590	3.388	3.199	3.063	2.913	2.803
TOTAL	**140.433**	**142.169**	**136.522**	**131.172**	**124.524**	**118.808**	**125.608**	**120.259**	**114.361**	**108.243**	**102.255**	**97.465**	**95.996**	**95.329**	**90.962**	**86.079**	**85.024**	**80.617**	**76.342**	**72.298**	**68.621**	**64.923**	**61.711**

[14] It results from the average depreciation rate of the transmission assets for the years 2014, 2015 and 2016.

[15] That is, the investments in Table 2-11 were divided into 37 installments, starting in different years, and the present value of these annuities was determined for the reference year of 2018.

In addition, a maximum demand scenario was established, based on the utilized capacity values registered in the years 2016 and 2017, which correspond to the daily maximum values. It was also necessary to build a gas flow scenario for the day of greatest demand.

With the maximum demand scenario and the annuities associated with the various sections of the national transmission network, it was possible to determine the unit cost, measured in €/(kWh/day), for each of the network sections. Finally, to determine the unit cost matrix for the various paths connecting entries and exits, the unit costs were added up across the sections used to connect an entry point with an exit point, Table 2-13.

Table 2-13 - Unit costs of the various sections of the gas transmission network

						Unit costs for entry-exit combinations, €/(kWh/day)									
Area	**Segment**	**Annuity**	**Capacity**	**Unit cost**		**AF**	**AG**	**AH**	**AK**	**BF**	**BI**	**CE**	**CG**	**CJ**	**DG**
		thousand €	*MWh/day*	*€/(kWh/day)*											
3	Aa	2.404	109.561	0,02194		0,02194	0,02194283	0,02194283	0,02194283						
5+8	aK	1.921	3.528	0,54446					0,54446474						
3	ah	3.555	106.033	0,03353		0,03353084	0,03353084	0,03353084	0,03353084						
3	hH	211	33.836	0,00623				0,00622614							
3	hc	3.230	72.197	0,04473		0,04473479	0,04473479		0,04473479						
4	Bi	2.324	0	0,00000						0	0				
4	iI	914	4.768	0,19164							0,19164214				
4+2	if	4.857	4.768	1,01868						1,01867797					
2	fF	3.783	79.306	0,04770		0,04769638				0,04769638					
2	fb	5.067	84.075	0,06026		0,06026357									
6+8	bK	4.183	0	0,00000					0						
2	bc	5.100	84.075	0,06066		0,06066416			0,06066416						
2	DG	2.353	68.814	0,03419			0,0341878						0,0341878		0,0341878
2	Dc	2.194	0	0,00000			0						0		
7	Cj	2.151	126.751	0,01697								0,01697119	0,01697119	0,01697119	
7	jJ	239	29.722	0,00805										0,0080502	
7+1	je	7.465	97.029	0,07694								0,07694031	0,07694031		
1	eE	7.005	66.305	0,10565								0,10565145			
1	ec	5.968	30.724	0,19425									0,19425298		
					Total	**0,26883**	**0,13440**	**0,06170**	**0,70534**	**1,06637**	**0,19164**	**0,19956**	**0,32235**	**0,02502**	**0,03419**

Note: Refer to Table 2-14 for the meaning of the letters used to identify the 'segments' and the 'entry-exit combinations'.

Table 2-14 - Identification of entry points, exit points and auxiliary points of the gas transmission network

Entry points		Area
A	Campo Maior	3
B	Valença do Minho	4
C	LNG terminal in Sines	2
D	Carriço	7

Exit points		Area
A	Campo Maior	3
B	Valença do Minho	4
C	LNG terminal in Sines	2
D	Carriço	7
E	Lisboagás, Setgás, Carregado, Ribatejo	1
F	Portgás, Outeiro power plant	2
G	Lusitâniagás, Lares power plant, Figueira da Foz power plant	2
H	Tagusgás, Pego power plant	3
I	Portucel	4
J	Sines refinery, Portucel	7
K	Beiragás	8

Auxiliary points		Area
a	Bifurcation close to entry point A	3+5
b	Bifurcation close to entry point B	2+6
d	Crossing close to entry point D	1+2+3
e	Point close to exit point E	1
f	Point close to exit point F	2
h	Point close to exit point H	3
i	Point close to exit point I	4
j	Point close to exit point J	7
k	Point close to exit point K	8

In the second step, referred to in Table 2-10, a quadratic error minimization algorithm is applied, in which the error is the difference between the sum of the entry and exit tariffs and the unit cost associated with that path. The minimization algorithm is defined in the following expression:

$$\min_{\{T_i,T_j\}} \sum_{i,j} \left(T_i + T_j - UC_{i,j}\right)^2 \quad ,$$

where T_i e T_j are the transmission tariffs of entry point i and exit point j, respectively, and ensure the minimization of the objective function, defined as the sum of the squared differences between the sum of the entry and exit tariffs $(T_i + T_j)$ and the unit cost of that path $(UC_{i,j})$. Another restriction that must be imposed on the results is that the tariffs obtained are non-negative, that is, that they respect the following condition: $T_i, T_j \geq 0$.

Since there are infinite sets of solutions for this minimization problem, the solution is chosen such that the entry tariffs T_i and the exit tariffs T_j represent constant proportions of the average unit costs per point of entry and exit. This approach resulted in reference prices for the entry points (REFentry) representing a proportion of 16,8% and in reference prices for the exit points (REFexit) representing a weight of 83.2%. Notwithstanding this entry-exit split at the level of unit prices, the last step of the methodology ensures that the entry-exit split of 40%-60% at the level of revenue recovery is preserved.

Table 2-15 - Determination of reference prices without equalization and before final reconciliation

			REFexit tariffs										
			0,0000	**0,0000**	**0,0000**	**0,0000**	**0,0415**	**0,2777**	**0,1021**	**0,0128**	**0,0399**	**0,0052**	**0,1467**
		€/(kWh/d)	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
REFentry tariffs	**0,0179**	**A**	0,0179	0,0179	0,0179	0,0179	0,0594	0,2956	0,1200	0,0307	0,0577	0,0231	0,1646
	0,0192	**B**	0,0192	0,0192	0,0192	0,0192	0,0607	0,2969	0,1213	0,0321	0,0591	0,0244	0,1659
	0,0084	**C**	0,0084	0,0084	0,0084	0,0084	0,0499	0,2861	0,1105	0,0212	0,0482	0,0136	0,1551
	0,0005	**D**	0,0005	0,0005	0,0005	0,0005	0,0420	0,2782	0,1026	0,0134	0,0404	0,0057	0,1472

In the fourth and final step, the reference prices are determined by applying the final adjustments, namely the Article 9 discounts and the multiplicative scaling that ensure the reconciliation of the revenues recovered by the entry and exit transmission tariffs with the allowed revenues, preserving the entry-exit split applied in the third step.

Discounts applied at the entry point to and the exit point from storage facilities are both 95%. The multiplicative scaling factors that ensure revenue reconciliation are 12,46 and 1,89 at the entry points and exit points, respectively.

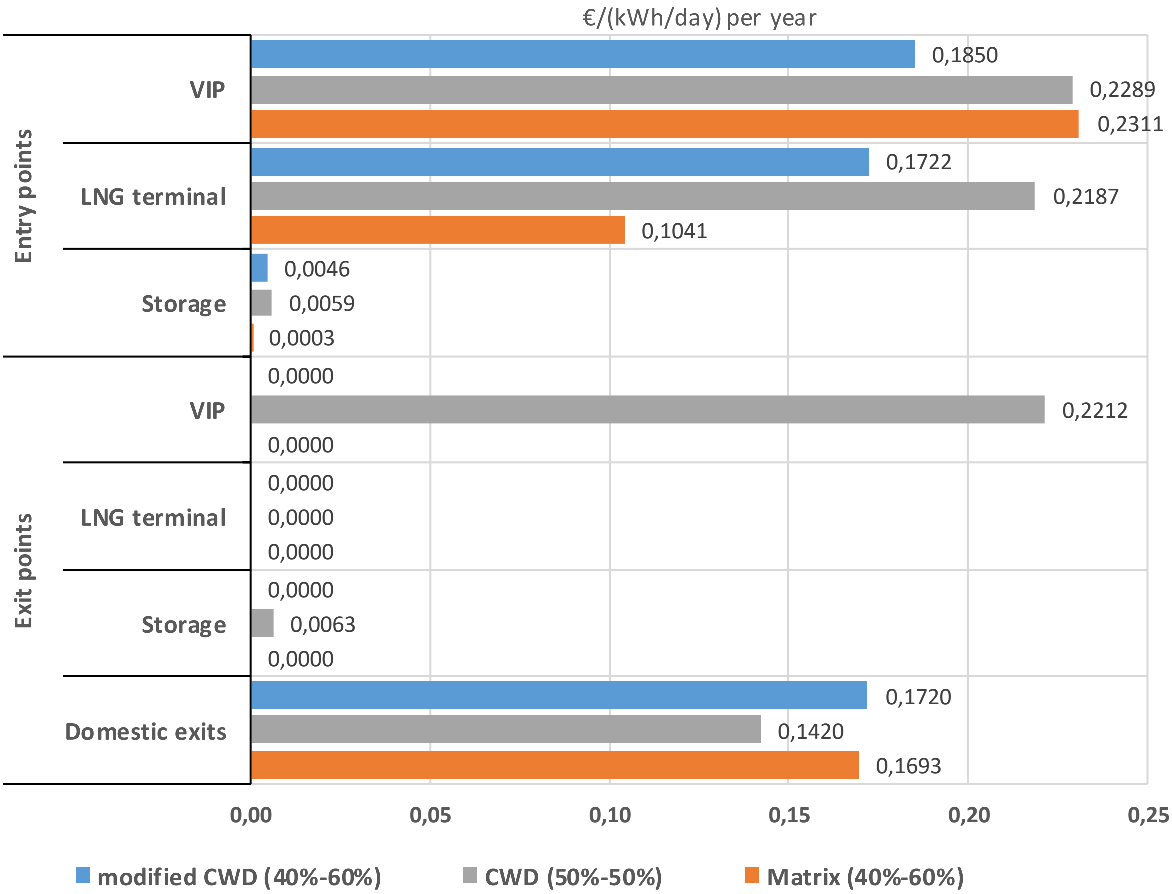
3 COMPARING THE RESULTS OF THE THREE METHODOLOGIES

This chapter attempts to analyse briefly the differences in the results of the three methodologies described above.

Figure 3-1 compares the capacity-based transmission tariff prices of entry points and exit points resulting from the three methodologies. These transmission tariffs incorporate the effects from price equalization, from discounts under Article 9 of the tariff network code and from the final adjustments to ensure revenue reconciliation. These final adjustments also include the effect of the multipliers of the short-term capacity products contracted by market agents, as well as the effects of the short-term and flexible tariffs applied to the exit points to end-customers.

With regard to the discounts applicable under Article 9 of the tariff network code, a 95% discount at the entry point from and the exit point to storage facilities is considered. This option is justified by the fact that underground storage is a structural infrastructure offering flexibility to the system, in particular to market players, facilitating the entry on the market of smaller agents and contributing to the reduction of entry barriers. It should be added that, by applying the discounts indicated, the entry tariffs and exit tariffs applicable at the underground storage are in line with those determined by the matrix methodology in force up to the present date, without the consideration of any discount. Under these circumstances and based on the results of the matrix methodology, it could be stated that the adoption of lower transmission tariffs at the interface with the underground storage is justified by reasons for efficient allocation of costs.

Figure 3-1 - Indicative reference prices of the three methodologies



Note: Modified CWD methodology (section 2.1); CWD methodology (section 2.2); matrix methodology (section 2.3).

When comparing the modified CWD methodology proposed in the public consultation with the CWD methodology, two differences stand out. Firstly, there are higher prices at entry points in the CWD methodology. This result stems directly from the entry-exit split of 50%-50% imposed by Article 8 of the tariff network code. As in the proposed methodology (modified CWD), as well as in the matrix methodology, an 'entry-exit' split of 40%-60% is followed, these methodologies present lower prices at the entry points.[16]

When comparing the modified CWD methodology proposed in the public consultation with the matrix methodology used to determine the tariffs currently in force, there are three observations that deserve to be highlighted. First, prices at exit points are similar. This similarity results from the assumption of zero costs applicable at points of the transmission network in permanent reverse flow (VIP) or in backpressure

[16] This 40%-60% split is closer to the current division and is driven by evenly allocating to entry and exit points the investments in central pipelines and by exclusively allocating peripheral sections (connections to end-customers and GRMS) to exit points. See also the justification in the public consultation document at the end of section 3.2.

(underground storage) and the use of the same 'entry-exit' split.[17] Secondly, regarding the entry points, the modified CWD methodology proposed in the public consultation presents a lower price at the VIP and a higher price at the LNG terminal. The main reason for this difference lies in the determination of the unit costs for the different gas paths. In the case of the matrix methodology defined in the past (section 2.3), unit costs are directly influenced by the gas flow scenario adopted. In that gas flow scenario, it is implicitly assumed that most exit zones are only served by the closest entry point.[18]

Finally, it should be noted that there are non-zero and significant exit prices at the VIP and at the underground storage when using the methodology defined in the tariff network code (CWD in section 2.2) although these exit points are used exclusively in reverse flow (VIP) or in backpressure (storage). The contracting of capacity in the opposite direction to the dominant flow at the VIP contributes to the release of capacity, generating no need of investment and consequently presenting a zero incremental capacity cost. Likewise, the contracting of capacity at the underground storage in backpressure is conditioned by the capacity of the underground storage compressors (active restriction) and not by the transmission network. In fact, since the latter is much higher than the capacity of the compressors, it is justified to adopt a zero incremental capacity cost at the exit point to underground storage. The CWD methodology, ignoring the concept of incremental cost related to the necessity for new investments (concept incorporated in the modified CWD methodology and the matrix methodology), applies unduly high prices to the exit points to the VIP and to the underground storage, generating inefficiencies in the use of the transmission network. In both methodologies - modified CWD and matrix - the contracting of capacity at the exit points to the VIP and to the underground storage presents null prices as the incremental cost of capacity is also null. This ensures an efficient allocation of transmission network costs and consequently an efficient use of the transmission network and other infrastructures.

[17] The exit price applicable to domestic consumption is not identical across the two methodologies because the pre-adjustment prices before revenue reconciliation are different. Since commodity-based prices are scaled by the same factor as the capacity-based prices in the income reconciliation process, the commodity-based prices, in €/kWh, offset the difference in capacity-based prices between these two methodologies.

[18] In the case of underground storage, which is located in the central part of the network, the flow scenario results in limited use of the transmission network by the storage facility. In the case of the VIP, namely through the interconnection point at Campo Maior, the flow scenario presents a large area of coverage and consequently requires a deep use of the transmission network.

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