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Extension of the project on

Cost components of cross border exchanges of electricity

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Cost components of cross border exchanges of electricity

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Extension of the project on

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Executive summary

Background

The objective of the present study is to provide the methodological basis for the choice and implementation of the long-term mechanism of cross-border tarification that, according to the conclusions of the Florence Forum, should be based on a scheme of inter-TSO payments. Phase I of the project has provided the basic principles of transmission regulation that are needed for this task, it has identified a number of candidate methods for the long-term mechanism and it has evaluated these methods with a very limited set of data. A preliminary selection of three methods was one of the major outcomes of Phase I.

The major objective of this Phase II of the study is to update and revise, -if this is the case-, the conclusions of Phase I, once that new and more abundant data about the functioning of the Internal Electricity Market have been made available for the project. This report examines in greater detail, -both conceptually and quantitatively-, those few algorithms that have been seriously considered as potential candidates to be used in the long-term mechanism for inter-TSO payments in the IEM. The three considered methods are real network flow methods, that is, methods that take as the starting point the actual physical flows that exist in the transmission networks. These methods, whose detailed description can be found in the final report of Phase I of this project, are:

a) The "with-and-without-transits" method (**WWT**), a simplified version of which has been used by ETSO during 2001 and 2003 in the computation of inter-TSO payments for a large number of countries participating in the IEM[1].

b) The "average participations" method (**AP**).

c) The "average participations applied to transits" method (**APT**) that was proposed during Phase I of this project.

Finally, Phase II of the project also tries to provide elements for the application of the algorithms that have been analyzed in the project to purposes other than inter-TSO payments, such as provision of long-term locational signals, a more accurate determination of the horizontal network for cross-border tarification studies, the allocation of the costs of new network investments or the design of strategies for IEM-wide transmission tariffs harmonization.

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[1] The most important results have been also obtained for the simplified version of the WWT method that is currently used for the computation of inter-TSO payments in the IEM.

The Data

Ideally, 8760 cases should be made available in order to compute annual inter-TSO payments and nodal transmission tariffs. However, this requires a fully automatic process. ETSO has decided that, for the time being, only a limited number of cases, –as many as they can be reasonably handled manually by a small group of expert people-, will be processed out of the 8760 snapshots collected for the year 2003.

While the set of data corresponding to the year 2003 is made available, ETSO has provided the data for 24 scenarios for the year 2002. Scenarios correspond to 4 different months: March, June, September and December with scenarios recorded at 03:30h, 11:30h and 19:30h of third Wednesdays and preceding Sundays. The data comprise 13 countries: Austria, Belgium, Switzerland, the Czech Republic, Germany, Spain, France, Hungary, Italy, The Netherlands, Portugal, Slovenia and Slovakia. These data were provided separately by each country, therefore resulting in a collection of 13 separate subsets of real network flow data for each hourly scenario.

Some TSOs were not capable of providing such data and submitted replacement data for analogous timings either of another week, another month or data recorded after 1.1.2003. Others did not provide any data at all for some of the scenarios. Those snapshots from a country that were not made available have been substituted with other snapshots from the same country, corresponding to operating conditions that were as similar as possible to those of the missing ones.

The table below summarizes the aggregate data for an average scenario trying to represent the 24 scenarios that have been used in the study. All numbers are expressed in MW.

	Generation	Load	exports	imports	net_E-I	transit
A	2193.2	2134.9	1464.8	1481.6	16.8	1464.8
B	6366.8	7130.2	921.4	1726.1	804.7	921.4
CH	5196.6	4498.7	3488.6	2931.5	557.1	2931.5
CZ	5167.6	3708.8	2250.7	1065.1	1185.6	1065.1
D	44187.6	43411.9	4437.7	4983.5	545.7	4437.7
E	18805.2	18221.1	743.8	1326.7	582.9	743.8
F	53158.3	42804.9	8284.6	91.0	8193.6	91.0
H	2492.6	2943.4	797.0	1275.0	478.0	797.0
I	16565.1	21860.6	13.6	5706.2	5692.7	13.6
NL	7317.5	9317.9	350.3	2455.1	2104.8	350.3
P	3951.9	3957.9	425.3	529.6	104.3	425.3
SLO	1088.9	626.7	986.9	703.4	283.4	703.4
SK	2308.2	1833.8	1059.1	608.2	450.8	608.2

Aggregate data for the average scenario

Some other data have been used to obtain the results shown in the report. In order to express both compensations among countries and nodal transmission tariffs in monetary terms, an annual cost per km of 400KV line has been estimated. The capacities of the lines have been also estimated, as well as the length of every line, from its impedance and using some coefficients provided by ETSO.

The per unit economic value that has been employed to express all the results in monetary terms was obtained as the average of the regulated per unit cost obtained for each country, resulting in an annual value of 0.0352 million Euros per km of 400 kV line. The European Commission has recently proposed a value ranging between €350.000 and €600.000 as the replacement cost per km of double circuit 380kV line for most of the countries considered in this study. This estimate results in an annual value which is in the same range as the one considered here when we take a depreciation period of 30 years and a cost of capital per annum of 6% real.

Results for the computation of inter-TSO payments

A quantitative evaluation of the three preferred algorithms (AP, APT and WWT) has been performed together with the provisional method (PM) currently applied to compute inter-TSO payments. A first crude evaluation of the actual values of the charges and compensations and, therefore, an estimation of the quantitative impact of the inter-TSO payment mechanism has been also obtained for each method.

When allocating the cost of a line or group of lines one must take into account the total benefit that each party gets from this line. Therefore, all the different scenarios, and not only those where the line is used to a higher extent, must be considered since agents are benefiting from the existence of the line in all cases. It is true, however, that the different scenarios should probably be given different weights in proportion to the use made of the line in each of them.

The limited availability of useful data does not appear to be an obstacle to arrive at firm conclusions about the weak and strong points of each method.

Results for inter-TSO payments because of the external utilization of network infrastructure

The tables with the results for AP, WWT and APT are shown below. All numbers in the tables are expressed in millions of euros per year[2]. A table summarizing the results for the 4 methods is presented below the 4 individual tables.

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[2] It follows the explanation of the figures in the table. If the numbers in any given column of Table 3, for instance column *F* for France, are considered:

- 31.2 means that the fraction of the French grid used by Italy is worth 31.2 million euros.
- 1121.9 is France's own utilization of its network.
- 1195.2 is the total cost of the French network and it is equal to the sum of all numbers in the column above.
- 1232.0 is the total use of France of the European network, including the French network, and it is equal to the sum of all numbers in the row labeled F.
- The difference between the two aggregate numbers: 1195.2 – 1232.0 = -36.8, is the inter-TSO payment for France. Since it is negative, France has to pay. This means that France uses other external networks more than other countries use the French network. This is the most important result of the analysis for France and this is why the corresponding row has been framed.

Consider now the numbers in row *F,* again for France:

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	86.0	0.0	0.0	7.4	6.5	0.0	0.0	1.5	3.5	0.0	0.0	3.4	1.0
B	0.0	123.1	0.0	0.0	0.5	0.0	7.2	0.0	0.0	11.0	0.0	0.0	0.0
CH	0.8	0.0	93.4	0.0	11.6	0.0	14.5	0.0	12.4	0.0	0.0	0.0	0.0
CZ	14.9	0.0	0.0	146.4	16.7	0.0	0.0	1.2	0.2	0.0	0.0	0.3	3.3
D	13.7	0.8	11.3	7.7	1228.8	0.0	5.8	0.0	2.7	26.9	0.0	0.1	0.0
E	0.0	0.0	0.0	0.0	0.0	791.2	14.6	0.0	0.0	0.0	17.2	0.0	0.0
F	0.0	22.1	20.0	0.0	29.1	11.1	1121.9	0.0	27.4	0.4	0.0	0.0	0.0
H	2.0	0.0	0.0	1.3	0.0	0.0	0.0	68.1	0.0	0.0	0.0	0.0	4.0
I	9.1	0.0	30.8	0.1	5.3	0.0	31.2	0.0	463.6	0.0	0.0	4.9	0.0
NL	0.0	2.5	0.0	0.0	9.9	0.0	0.1	0.0	0.0	195.1	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	133.3	0.0	0.0
SLO	7.3	0.0	0.0	0.2	0.1	0.0	0.0	0.0	1.9	0.0	0.0	14.2	0.0
SK	1.7	0.0	0.0	5.6	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	58.8
	135.4	148.4	155.6	168.7	1308.5	829.6	1195.2	78.3	511.7	233.4	150.6	23.0	67.1
	109.4	141.8	132.6	183.1	1297.7	823.0	1232.0	75.3	545.0	207.5	160.6	23.6	73.6
	26.0	6.6	22.9	-14.4	10.8	6.6	-36.8	3.0	-33.3	25.8	-10.0	-0.7	-6.5
	49.5	25.3	62.2	22.3	79.7	38.4	73.3	10.2	48.1	38.3	17.2	8.8	8.3
	23.5	18.7	39.2	36.7	68.9	31.8	110.1	7.3	81.4	12.4	27.2	9.5	14.8

Annual compensations, charges and net payments because of network use with the AP method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	99.0	0.2	1.6	-0.5	1.9	-0.4	0.0	0.7	0.0	0.3	-0.1	0.1	0.2
B	1.4	141.1	2.2	-0.6	2.7	-0.7	0.0	1.0	0.0	0.5	-0.1	0.1	0.2
CH	2.0	0.6	97.8	-1.0	4.3	-1.3	0.1	1.6	0.0	0.8	-0.2	0.2	0.4
CZ	2.2	0.5	3.6	202.3	4.2	-0.8	0.0	1.5	0.0	0.8	-0.4	0.2	0.5
D	1.8	0.7	3.5	-1.3	1261.8	-1.9	0.0	1.7	0.0	0.6	-0.4	0.2	0.6
E	1.4	0.3	2.2	-0.6	2.4	849.9	0.0	0.9	0.0	0.6	-0.1	0.2	0.2
F	15.3	3.3	24.2	-6.9	28.4	-6.2	1198.3	10.4	0.1	5.4	-1.3	1.5	2.7
H	0.7	0.2	1.2	-0.4	1.5	-0.4	0.0	70.8	0.0	0.2	-0.1	0.1	0.2
I	11.3	2.3	17.6	-5.0	20.6	-4.0	0.4	7.4	516.1	4.1	-0.9	1.1	2.0
NL	3.6	0.9	5.7	-1.8	7.8	-1.6	0.1	2.6	0.0	227.8	-0.5	0.3	0.9
P	0.5	0.1	0.7	-0.2	0.8	-0.2	0.0	0.3	0.0	0.2	154.9	0.0	0.1
SLO	0.5	0.1	0.8	-0.2	1.0	-0.2	0.0	0.3	0.0	0.2	-0.1	22.6	0.1
SK	0.9	0.2	1.4	-0.4	1.6	-0.3	0.0	0.6	0.0	0.3	0.0	0.1	74.7
	140.6	150.5	162.4	183.3	1339.0	831.8	1199.1	99.8	516.4	241.9	150.7	26.7	83.0
	103.1	147.8	105.2	214.7	1267.4	857.4	1275.2	73.8	573.0	245.9	157.2	25.2	79.1
	37.5	2.7	57.2	-31.4	71.6	-25.6	-76.0	25.9	-56.6	-4.0	-6.5	1.5	3.8
	41.6	9.3	64.6	-19.0	77.2	-18.1	0.8	29.0	0.3	14.0	-4.2	4.1	8.2
	4.1	6.6	7.4	12.4	5.6	7.5	76.8	3.0	56.9	18.1	2.3	2.6	4.4

Annual compensations, charges and net payments for network use with the WWT method

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- 20.0 represents the cost of that part of the Swiss network used by France.

There are also other numbers of interest in column *F*, for France:

- The number 73.3 in column *F* is the sum of all external utilizations of the French network by others (7.2 by Belgium, 14.5 by Switzerland, 5.8 by Germany, 14.6 by Spain, 31.2 by Italy and 0.1 by The Netherlands), excluding France's own use.
- Similarly, the number 110.1 in column *F* is the sum of all external utilizations that France makes of external networks, which are shown in row F, (22.1 of Belgium, 20.0 of Switzerland, 29.1 of Germany, 11.1 of Spain, 27.4 of Italy and 0.4 of The Netherlands).

It should be clear by now that the difference between these two numbers: 73.3 – 110.1 also equals the inter-TSO payment for France: -36.8.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	96.2	0.0	0.0	2.8	5.9	0.0	0.0	1.2	0.0	0.0	0.0	3.4	0.6
B	0.0	134.5	0.0	0.0	0.5	0.0	0.1	0.0	0.0	3.3	0.0	0.0	0.0
CH	0.7	0.0	106.8	0.0	8.5	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
CZ	12.0	0.0	0.0	158.2	14.4	0.0	0.0	0.8	0.0	0.0	0.0	0.3	2.7
D	9.9	0.4	8.9	3.7	1248.8	0.0	0.1	0.0	0.0	4.2	0.0	0.1	0.0
E	0.0	0.0	0.0	0.0	0.0	806.9	0.4	0.0	0.0	0.0	11.9	0.0	0.0
F	0.0	11.8	17.1	0.0	22.8	5.4	1197.3	0.0	0.1	0.0	0.0	0.0	0.0
H	1.7	0.0	0.0	0.4	0.0	0.0	0.0	74.9	0.0	0.0	0.0	0.0	2.4
I	8.4	0.0	24.3	0.0	4.5	0.0	0.3	0.0	516.1	0.0	0.0	3.5	0.0
NL	0.0	2.3	0.0	0.0	8.8	0.0	0.0	0.0	0.0	231.4	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	17.8	0.0	0.0	0.0	0.0	138.7	0.0	0.0
SLO	6.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	16.2	0.0
SK	1.4	0.0	0.0	4.0	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	62.9
	136.4	149.0	157.1	169.3	1314.3	830.1	1198.8	81.6	516.2	239.0	150.6	23.6	68.5
	110.1	138.4	116.7	188.3	1276.2	819.2	1254.5	79.4	557.1	242.5	156.4	22.5	73.0
	26.3	10.6	40.4	-19.0	38.1	10.8	-55.8	2.2	-40.8	-3.5	-5.8	1.1	-4.5
	40.3	14.5	50.3	11.1	65.5	23.2	1.5	6.7	0.1	7.6	11.9	7.4	5.7
	14.0	3.9	9.9	30.1	27.4	12.3	57.3	4.5	41.0	11.1	17.8	6.3	10.1

Annual compensations, charges and net payments because of network use with the APT method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	90.5	0.4	1.4	0.9	2.8	0.7	0.1	0.5	0.0	0.2	0.3	0.3	0.5
B	1.7	133.6	1.9	1.3	3.8	1.0	0.1	0.7	0.0	0.3	0.4	0.4	0.7
CH	2.7	0.9	104.9	2.3	6.2	1.7	0.3	1.1	0.0	0.5	0.7	0.7	1.1
CZ	2.6	0.9	3.2	146.4	6.0	1.3	0.1	1.2	0.0	0.6	0.6	0.6	1.1
D	3.1	1.1	3.4	2.5	1228.9	1.8	0.2	1.2	0.0	0.5	0.8	0.7	1.3
E	1.6	0.5	1.9	1.2	3.6	803.9	0.1	0.7	0.0	0.4	0.4	0.4	0.7
F	17.8	6.1	21.3	13.5	40.8	10.1	1196.8	7.8	0.2	3.7	4.5	4.4	7.3
H	0.9	0.3	1.1	0.8	2.1	0.5	0.1	78.1	0.0	0.2	0.2	0.2	0.4
I	12.9	4.3	15.3	9.4	29.5	7.1	0.9	5.7	516.0	2.7	3.1	3.1	5.2
NL	4.4	1.5	5.3	3.5	10.3	2.5	0.3	1.9	0.1	232.3	1.1	1.1	1.9
P	0.5	0.2	0.6	0.4	1.2	0.3	0.0	0.2	0.0	0.1	138.2	0.1	0.2
SLO	0.6	0.2	0.7	0.4	1.4	0.3	0.0	0.3	0.0	0.1	0.1	14.3	0.2
SK	1.0	0.3	1.2	0.7	2.3	0.6	0.1	0.4	0.0	0.2	0.2	0.2	62.3
	140.6	150.5	162.4	183.3	1339.0	831.8	1199.1	99.8	516.4	241.9	150.7	26.7	83.0
	98.7	146.0	123.2	164.7	1245.6	815.4	1334.1	85.1	615.3	266.2	142.1	18.8	69.7
	41.8	4.4	39.1	18.6	93.3	16.4	-135.0	14.7	-98.9	-24.3	8.7	7.9	13.3
	50.0	16.8	57.5	36.9	110.1	27.9	2.3	21.6	0.4	9.6	12.5	12.4	20.6
	8.2	12.4	18.3	18.3	16.8	11.5	137.3	7.0	99.3	33.9	3.9	4.5	7.3

Annual compensations, charges and net payments because of network use with the PM method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
AP_CO	49.5	25.3	62.2	22.3	79.7	38.4	73.3	10.2	48.1	38.3	17.2	8.8	8.3
AP_CH	23.5	18.7	39.2	36.7	68.9	31.8	110.1	7.3	81.4	12.4	27.2	9.5	14.8
AP_N	26.0	6.6	22.9	-14.4	10.8	6.6	-36.8	3.0	-33.3	25.8	-10.0	-0.7	-6.5
WWT_CO	41.6	9.3	64.6	-19.0	77.2	-18.1	0.8	29.0	0.3	14.0	-4.2	4.1	8.2
WWT_CH	4.1	6.6	7.4	12.4	5.6	7.5	76.8	3.0	56.9	18.1	2.3	2.6	4.4
WWT_N	37.5	2.7	57.2	-31.4	71.6	-25.6	-76.0	25.9	-56.6	-4.0	-6.5	1.5	3.8
APT_CO	40.3	14.5	50.3	11.1	65.5	23.2	1.5	6.7	0.1	7.6	11.9	7.4	5.7
APT_CH	14.0	3.9	9.9	30.1	27.4	12.3	57.3	4.5	41.0	11.1	17.8	6.3	10.1
APT_N	26.3	10.6	40.4	-19.0	38.1	10.8	-55.8	2.2	-40.8	-3.5	-5.8	1.1	-4.5
PM_CO	50.0	16.8	57.5	36.9	110.1	27.9	2.3	21.6	0.4	9.6	12.5	12.4	20.6
PM_CH	8.2	12.4	18.3	18.3	16.8	11.5	137.3	7.0	99.3	33.9	3.9	4.5	7.3
PM_N	41.8	4.4	39.1	18.6	93.3	16.4	-135.0	14.7	-98.9	-24.3	8.7	7.9	13.3

Annual compensations, charges and net payments because of network use with the 4 methods

Results for inter-TSO payments because of losses

Inter-TSO payments because of network losses that are obtained with the AP, WWT, APT an PM methods are presented in the tables below. All figures are expressed in millions of euros per year.

The total volume of inter-TSO payments for losses is much smaller than that of the inter-TSO payments for use of infrastructure. Inter-TSO payments for losses represent only about 20% of the total volume of the payments for infrastructure. There are clear similarities between the results obtained for use and the ones obtained for losses with the four methods. Some significant differences can be found, however.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.0	0.0	0.0	0.6	0.7	0.0	0.0	0.1	0.9	0.0	0.0	0.5	0.2
B	0.0	20.9	0.0	0.0	0.2	0.0	3.1	0.0	0.0	1.2	0.0	0.0	0.0
CH	0.0	0.0	18.4	0.0	1.1	0.0	2.4	0.0	5.0	0.0	0.0	0.0	0.0
CZ	2.0	0.0	0.0	9.7	3.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.5
D	1.7	0.1	2.5	1.4	153.0	0.0	2.5	0.0	0.9	2.5	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	101.7	3.8	0.0	0.0	0.0	1.8	0.0	0.0
F	0.0	2.9	3.3	0.0	5.0	1.7	233.0	0.0	7.5	0.1	0.0	0.0	0.0
H	0.2	0.0	0.0	0.1	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.8
I	1.8	0.0	10.1	0.0	0.7	0.0	11.3	0.0	67.3	0.0	0.0	1.2	0.0
NL	0.0	0.8	0.0	0.0	2.4	0.0	0.0	0.0	0.0	23.1	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	21.5	0.0	0.0
SLO	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.4	0.0
SK	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	6.2
	20.2	24.7	34.3	12.1	166.4	106.6	256.1	7.8	81.8	26.8	23.3	4.2	7.8
	16.0	25.5	27.0	15.5	164.6	107.2	253.4	8.0	92.5	26.4	24.8	3.9	7.6
	4.2	-0.8	7.4	-3.4	1.9	-0.6	2.8	-0.2	-10.6	0.5	-1.5	0.3	0.1
	7.2	3.8	15.9	2.5	13.4	4.9	23.2	0.9	14.6	3.8	1.8	1.9	1.5
	3.0	4.6	8.6	5.9	11.5	5.6	20.4	1.1	25.2	3.3	3.3	1.6	1.4

Annual compensations, charges and net payments because of network losses with the AP method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.7	0.0	0.4	0.0	0.2	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
B	0.2	24.4	0.6	-0.1	0.3	-0.2	0.0	0.1	0.0	0.0	-0.1	0.1	0.0
CH	0.3	0.0	18.8	-0.1	0.5	-0.4	0.0	0.2	0.0	0.1	-0.1	0.1	0.0
CZ	0.4	0.0	1.0	15.7	0.6	-0.2	0.0	0.2	0.0	0.0	-0.1	0.1	0.0
D	0.1	0.1	0.8	-0.1	161.7	-0.5	0.0	0.2	0.0	0.0	-0.1	0.1	0.0
E	0.2	0.0	0.6	-0.1	0.3	112.3	0.0	0.1	0.0	0.0	0.0	0.1	0.0
F	2.7	0.2	6.4	-0.8	3.1	-1.9	256.5	1.0	0.0	0.3	-0.6	0.7	-0.1
H	0.1	0.0	0.3	0.0	0.2	-0.1	0.0	7.6	0.0	0.0	0.0	0.0	0.0
I	2.1	0.1	4.7	-0.5	2.3	-1.2	0.1	0.7	82.4	0.2	-0.4	0.5	0.0
NL	0.6	0.1	1.4	-0.2	0.9	-0.5	0.0	0.3	0.0	26.7	-0.1	0.2	0.0
P	0.1	0.0	0.2	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	25.1	0.0	0.0
SLO	0.1	0.0	0.2	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0
SK	0.2	0.0	0.4	0.0	0.2	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	8.6
	20.8	25.1	35.8	13.8	170.3	106.8	256.8	10.6	82.5	27.5	23.3	4.8	8.6
	14.2	25.4	19.3	17.8	162.2	113.5	267.6	8.1	91.0	29.3	25.4	3.4	9.3
	6.6	-0.3	16.5	-4.0	8.1	-6.7	-10.8	2.5	-8.5	-1.8	-2.1	1.5	-0.7
	7.1	0.6	17.0	-2.0	8.7	-5.5	0.3	2.9	0.1	0.7	-1.7	1.8	-0.1
	0.5	0.9	0.5	2.0	0.6	1.2	11.1	0.4	8.6	2.6	0.4	0.4	0.7

Annual compensations, charges and net payments for losses with the WWT method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	14.5	0.0	0.0	0.2	0.7	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.1
B	0.0	22.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
CH	0.0	0.0	21.5	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CZ	1.6	0.0	0.0	10.9	2.7	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.4
D	1.2	0.0	2.0	0.7	156.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	103.6	0.0	0.0	0.0	0.0	1.3	0.0	0.0
F	0.0	1.5	2.7	0.0	3.7	0.8	256.5	0.0	0.0	0.0	0.0	0.0	0.0
H	0.1	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.5
I	1.6	0.0	8.3	0.0	0.6	0.0	0.1	0.0	82.5	0.0	0.0	0.9	0.0
NL	0.0	0.8	0.0	0.0	2.1	0.0	0.0	0.0	0.0	26.6	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	22.0	0.0	0.0
SLO	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
SK	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	6.9
	20.3	24.8	34.6	12.2	167.2	106.6	256.8	8.1	82.5	27.3	23.3	4.3	7.9
	16.1	23.0	22.4	15.7	160.9	104.9	265.3	8.2	94.1	29.6	24.2	3.9	7.8
	4.2	1.9	12.3	-3.5	6.3	1.8	-8.6	-0.1	-11.5	-2.3	-1.0	0.4	0.1
	5.8	2.4	13.1	1.3	10.7	3.0	0.3	0.6	0.0	0.7	1.3	1.5	1.0
	1.6	0.5	0.8	4.8	4.4	1.3	8.8	0.7	11.6	3.0	2.2	1.1	0.9

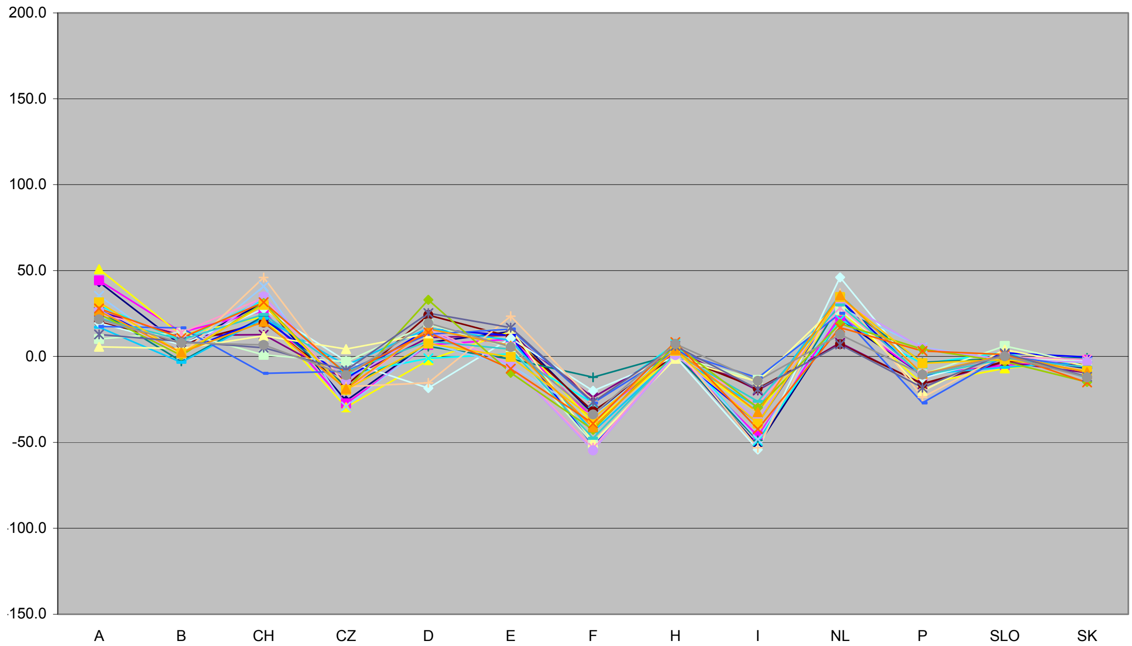
Annual compensations, charges and net payments because of network losses with the APT method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.3	0.1	0.3	0.1	0.4	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1
B	0.2	22.2	0.4	0.1	0.5	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1
CH	0.4	0.2	22.9	0.2	0.8	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1
CZ	0.4	0.1	0.7	10.8	0.7	0.2	0.0	0.1	0.0	0.0	0.1	0.1	0.1
D	0.4	0.2	0.7	0.2	156.6	0.3	0.0	0.1	0.0	0.1	0.1	0.1	0.1
E	0.2	0.1	0.5	0.1	0.4	103.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1
F	2.7	1.0	4.8	1.1	5.1	1.4	256.3	0.8	0.0	0.3	0.7	0.8	0.8
H	0.1	0.1	0.2	0.1	0.3	0.1	0.0	8.3	0.0	0.0	0.0	0.0	0.0
I	2.0	0.7	3.5	0.7	3.6	0.9	0.2	0.6	82.5	0.2	0.5	0.6	0.5
NL	0.6	0.3	1.1	0.3	1.3	0.4	0.1	0.2	0.0	26.6	0.2	0.2	0.2
P	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	21.3	0.0	0.0
SLO	0.1	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
SK	0.1	0.1	0.3	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	6.4
	20.8	25.1	35.8	13.8	170.3	106.8	256.8	10.6	82.5	27.5	23.3	4.8	8.6
	14.5	23.9	25.3	13.4	159.1	104.7	275.8	9.3	96.6	31.4	21.9	3.2	7.5
	6.3	1.1	10.5	0.3	11.3	2.1	-19.0	1.3	-14.0	-4.0	1.4	1.6	1.1
	7.5	2.9	12.9	3.0	13.7	3.7	0.5	2.3	0.1	0.9	2.0	2.2	2.1
	1.2	1.8	2.4	2.7	2.5	1.6	19.5	1.0	14.1	4.8	0.6	0.6	1.1

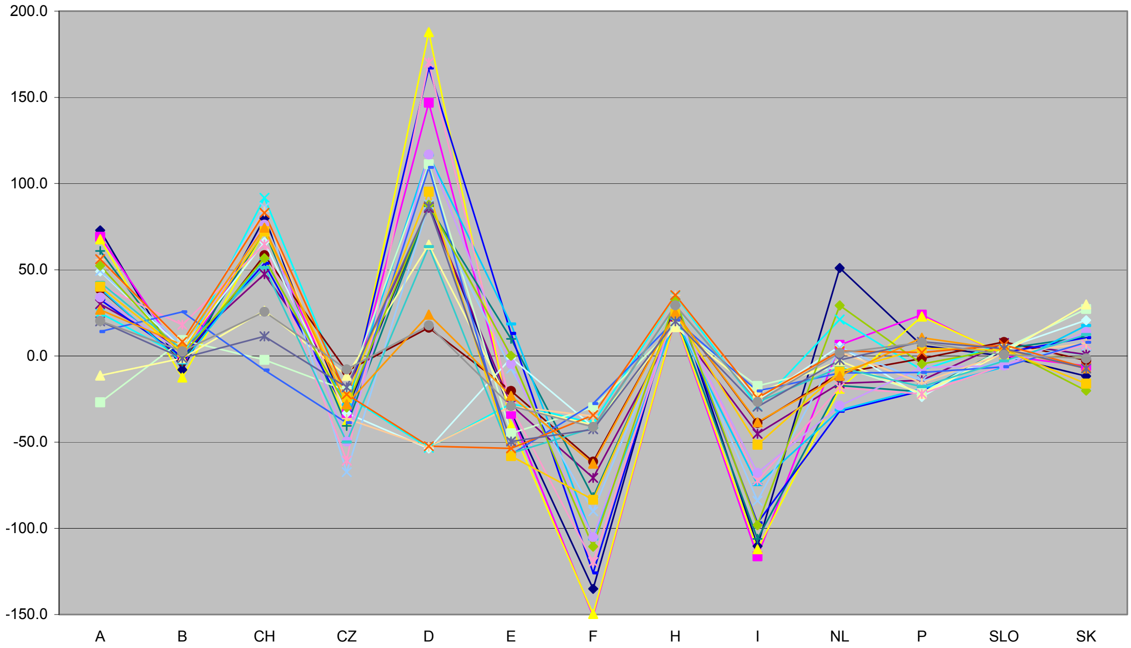
Annual compensations, charges and net payments because of network losses with the PM method

One can observe that the net payments for losses and infrastructure are smaller with AP than with WWT. The volatility of the results with the different scenarios is also significantly smaller with AP than with WWT, as shown in the figures that are shown below.

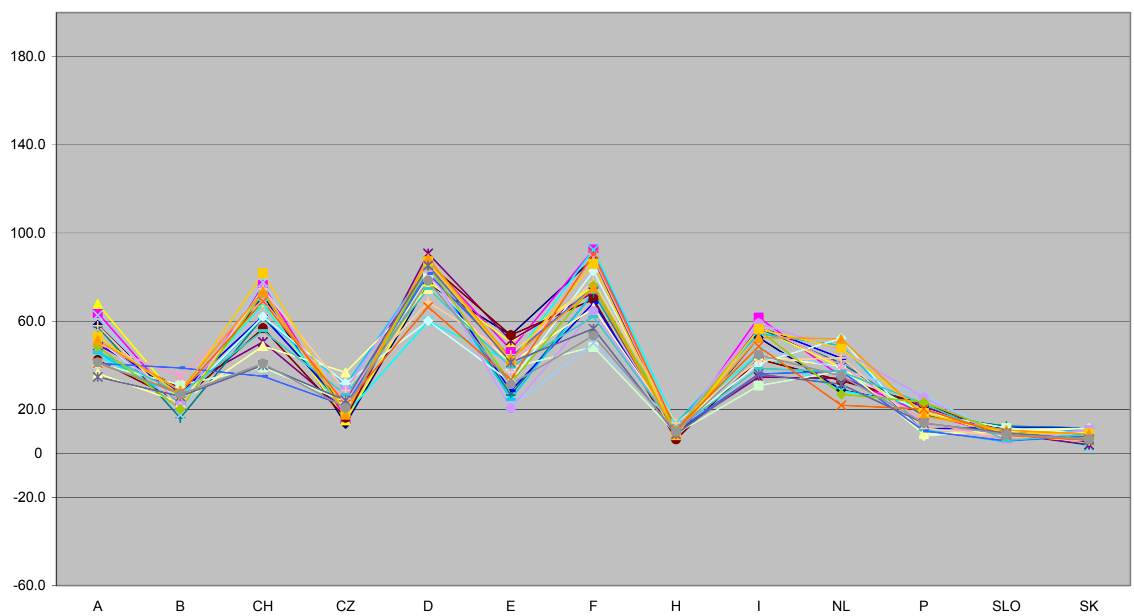
The first two figures show the distribution by country of the net inter-TSO payments. Each continuous line of a given color represents this distribution for each one of the scenarios. The next two figures correspond to the compensations and the last two ones to the charges. Compensations show more clearly defined patterns of behavior than the net inter-TSO payments, especially with the AP method. This is very logical, taking into account that inter-TSO payments are the difference between two different variables, compensations and charges. Charges computed with AP show again a clear pattern. Charges determined by WWT are low for all countries except for France, Italy and The Netherlands, since these are the ones with a larger volume of net imports or exports. The WWT method does not take into account the use made by other countries of the grid of almost purely exporting or importing ones like France or Italy. Thus, in WWT, neighboring countries would not compensate France for the use that consumers in this countries make of the French grid. Analogously, it is assumed that the generators that export to Italy do not make any use of the Italian grid, which consequently does not receive any compensation. Additionally, in many cases WWT over estimates the effect that the transit may have on the use of the grid of a country by forcing a power flow through the entire grid of the country while in reality the grid that is internal to the country may not be affected by the actual transit. The results obtained for the provisional method (PM) resemble most those of the WWT method. After all, in both methods the compensation to be paid to a country are related to the transit through the grid of the country, which is computed in the same way in WWT and PM. Besides, both methods follow the same procedure to allocate the compensation due to a country among all the others. But, when comparing the results for WWT and PM in more detail we can see how the negative net payments are concentrated in less countries in PM than in WWT. These differences are obviously explained by the different ways in which the impact of the transit on the use made of the grid of a country is determined in each method. Contrary to what happens with PM, the WWT method allows for the existence of negative compensations when the removal of the transit reduces the total use made of the grid.



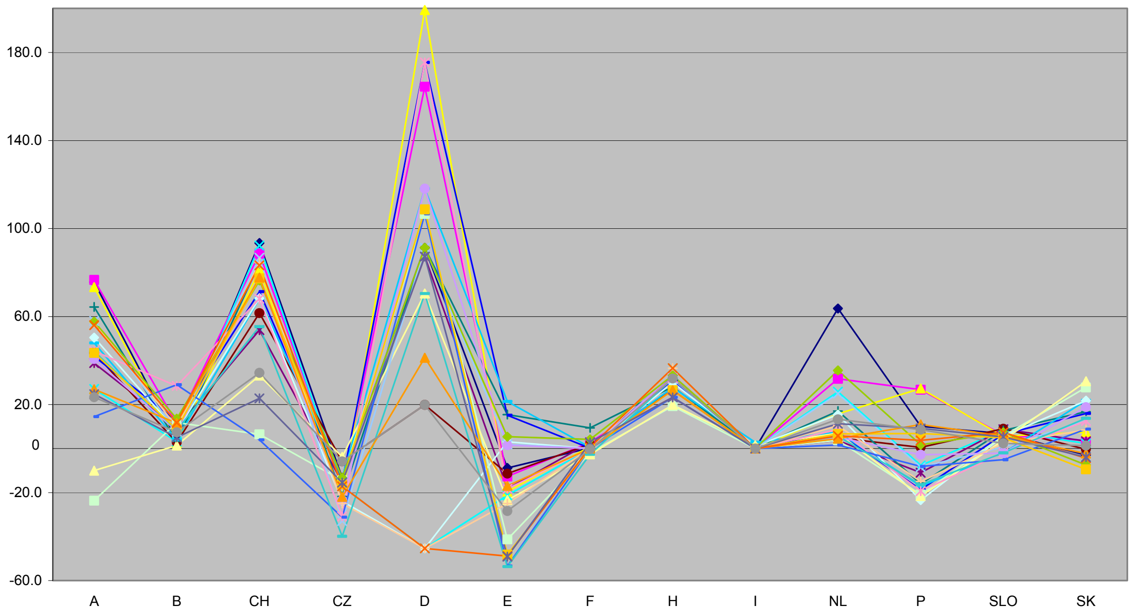
Geographical distribution of the net inter-TSO payments with AP



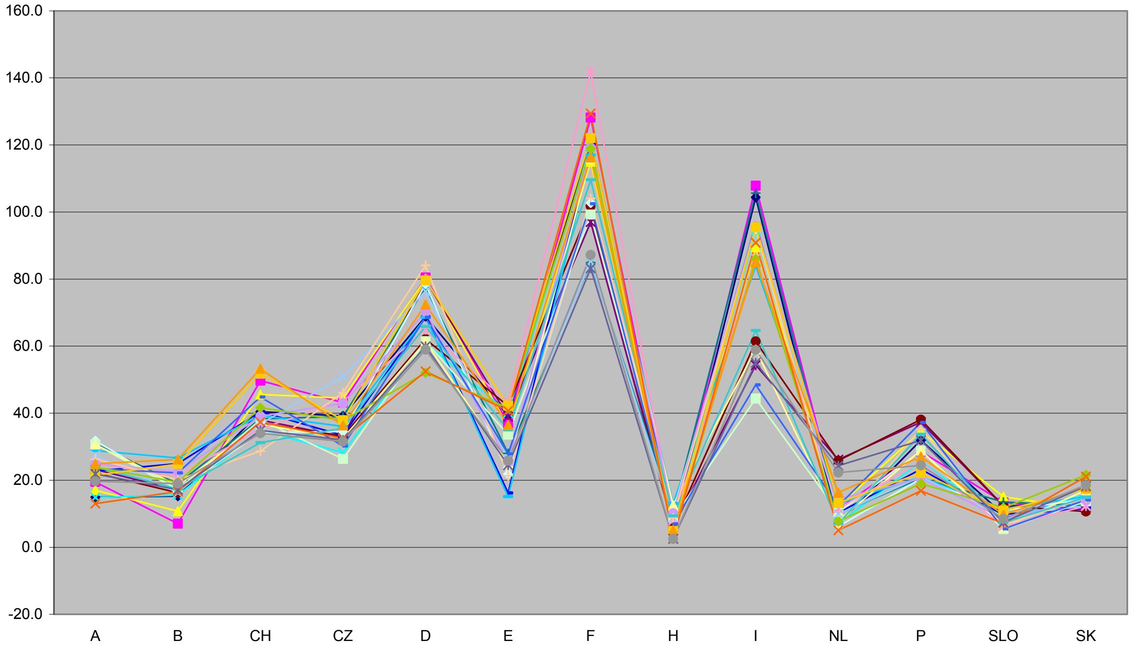
Geographical distribution of the net inter-TSO payments with WWT



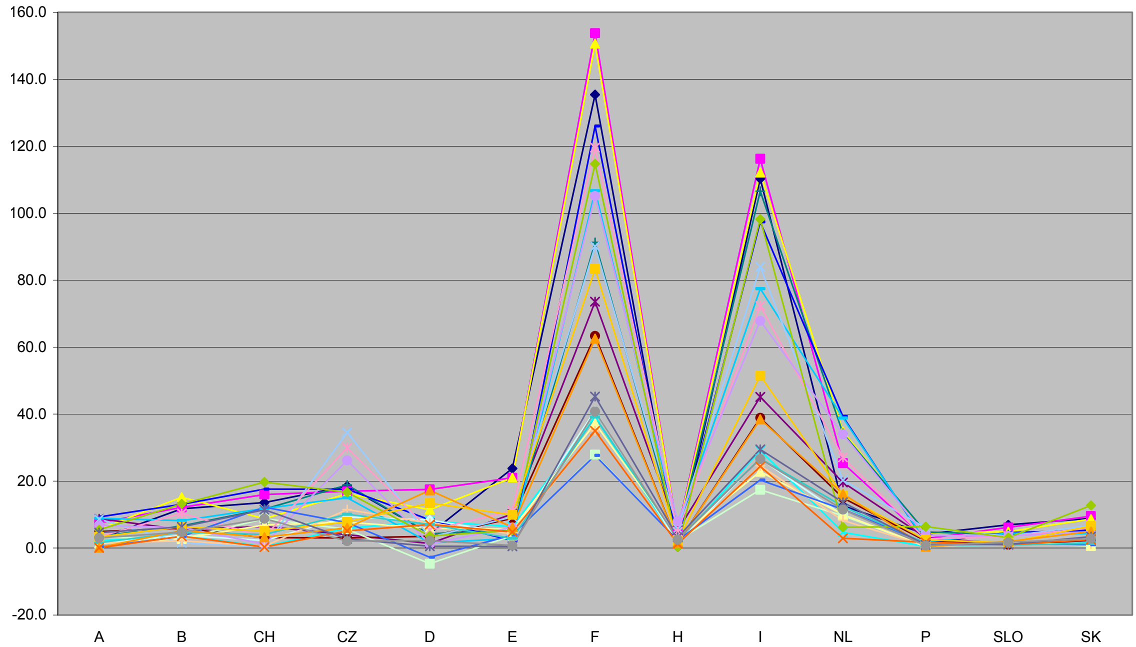
Geographical distribution of compensations to countries with the AP method



Geographical distribution of compensations to countries with the WWT method



Geographical distribution of charges to be levied on countries with the AP method



Geographical distribution of charges to be levied on countries with the WWT method

Allocation of the cost of new network investments

The main objective of this section is to show the impact that the three main approaches that have been considered in this Phase II of the project, -namely AP, WWT and APT-, will have in the allocation of the cost of new investments in the transmission network.

This is a very relevant issue in the allocation of the cost of new network investments. Why? Because, implicit in the inter-TSO payment mechanism, is the fact that any new relevant transmission investment will be included in the horizontal network and its costs will be allocated following the same rules that apply to any other network asset. In conclusion, the cost of any new relevant network investment will be allocated to the different countries via the inter-TSO payment mechanism.

The rules of cost allocation of the three considered methods (AP, WWT and APT) have been applied to several case examples of individual lines. These lines are located in different locations in the IEM and they have different roles. This quantitative comparison provides a different perspective from which to evaluate the several methods that have been considered for the long-term mechanism to determine inter-TSO payments.

In the case examples that have been examined of allocation of costs of new investments, WWT frequently provides results that are difficult to accept. This has two major reasons. The first one is a consequence of the basic concept of the WWT method, when contemplated from the perspective of a single line in the transited country. Removal of the transit in the “without transit” case forces changes in flows in all lines situated in between the interconnections with import flows and the ones with export flows. These changes in flows may not have much to do with the actual pattern of distribution of import and export flows in the considered country. Moreover, according to the logic of WWT, it will frequently happen that the flow in the new line being considered happens to increase when the transit is removed. Application of the standard WWT method results in a *negative* compensation to the country where the line is located, i.e. the country must pay others because of this line. The result of WWT is unreasonable when applied to infrastructure costs, since the questionable concept of "transit" cannot be a determining factor to reduce investment in a network. This notion of benefit because of the existence of a transit makes more sense with losses, which can really decrease at a given time because of an actual transit flow.

The second reason why the results of WWT for the allocation of costs of individual lines are difficult to accept has to do with the second step in the inter-TSO payment method: the allocation of the charges. How much should each external country be charged? The internal logic of the WWT method does not provide a reasonable answer to this question. WWT, as it is currently implemented now, allocates the cost to every country in direct proportion to the sum of the absolute values of the net imports and next exports of the country during a given year. The problem with this network cost allocation rule is that the allocation of the cost of the external use of a line in a country k is dispersed among all countries with any imports or exports.

Due to the fact that the distribution of the cost of a new network investment resulting from the application of WWT may be perceived as unfair by many countries, they may be reluctant to pay its share of the line cost. Consequently, the construction of the line may prove much more difficult than if the allocation of its cost is closely related to the actual flows.

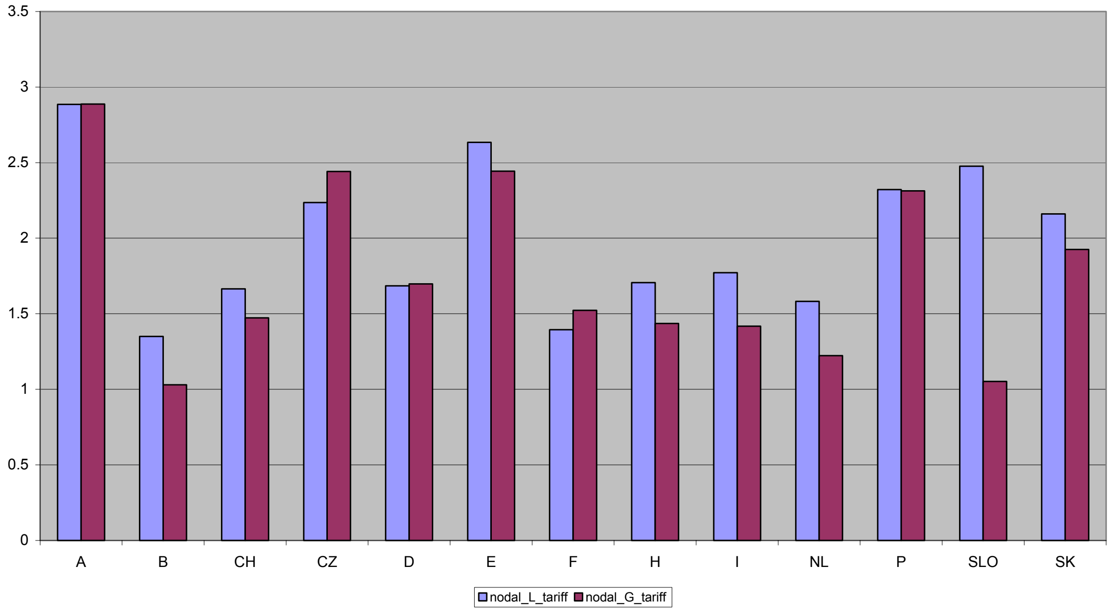
On the other hand, the results that have been obtained with AP appear to be reasonable in all cases. This has to do with the internal logic of the method: track the flow of each line, both upstream and downstream, to determine who are the individual agents (countries) that are responsible for this flow. Therefore, the AP method is perfectly suited to allocate the cost of a new transmission investment, since this is exactly what the method does: to individually allocate the cost of each investment.

APT provides a solution to the two major problems of WWT that were identified above. On one hand, APT tracks the transit flows at the borders of each country, both upstream and downstream, in order to determine the external use of the network of the country and who is responsible for this external use, but it does not force an incremental flow (the transit) across the country. Therefore the impact of the transit on the individual lines is closer to the AP philosophy and the results appear to have the same physical meaning as with AP. On the other hand, the allocation of the charges (step 2 in the inter-TSO payment mechanism) takes into account the topology of the network and the pattern of flows, therefore avoiding the quasi arbitrary allocation of the WWT method.

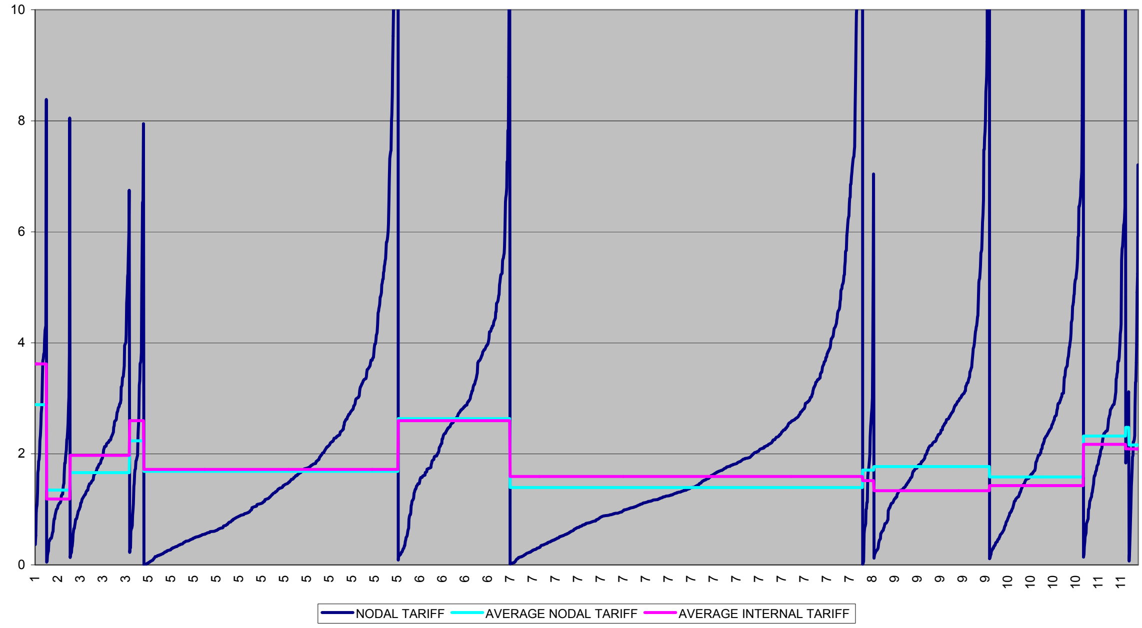
Assessment of Locational Signals produced by AP

In this section it is shown that long-term locational signals (nodal transmission tariffs) can be preliminary computed from the available data that has been gathered by ETSO. Methods that are based on the assignment of the network utilization to individual generators and consumers (such as the AP method) can be used in the computation of nodal transmission tariffs (not to be mistaken as nodal energy prices). On the other hand, algorithms that are based on the impact of transits on each considered country (such as WWT and APT) cannot be used for the calculation of transmission tariffs.

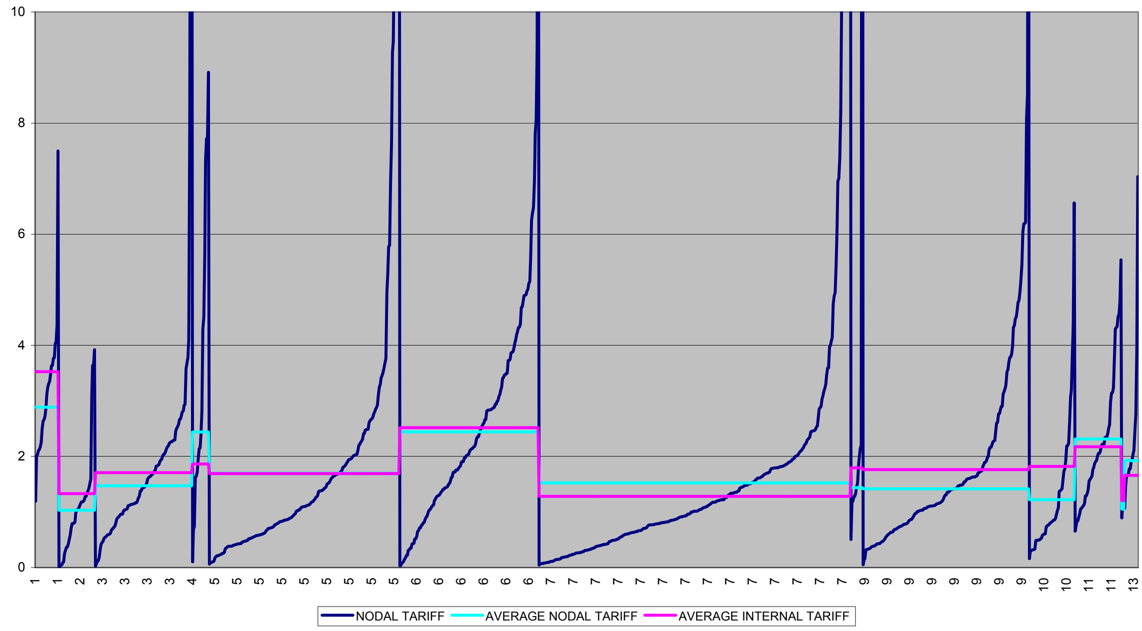
The AP method has been used to obtain nodal transmission charges for each one of the 3965 nodes of the IEM-13 network model, in each one of the 24 scenarios for the year 2002 that have been provided by ETSO. From these nodal tariffs for each agent and scenario an average annual tariff has been obtained for every agent. In order to calculate the average tariff for an agent its nodal tariff in each scenario has been weighted with the amount of power either produced or consumed by the agent. The AP method allocates the total flow over each line both to the generators and to the loads in the system. Therefore 50% of the use made of the line (and consequently of its cost) is allocated to generators and 50% to loads. However, the method allows for any other split of the cost of the grid between generation and load.



Average nodal L and G tariffs for the 13 countries in the IEM network



Nodal L tariffs for all the nodes in the IEM-13 network. The highest tariffs are not shown in the figure.



Nodal G tariffs for all the nodes in the IEM-13 network. The highest tariffs are not shown in the figure.

The first of the three figures above shows the average nodal L and G tariffs for the 13 countries considered in the study. For each country, the L tariff is represented with a blue column and the G tariff with a red one. The next two following figures show the nodal L and G transmission tariffs, respectively, for all the nodes in the IEM-13 network. The average values for G and L for each country have been represented with a blue line, whereas the average internal tariffs for each country (resulting from dividing half of the cost of the national grid by the total amount of load or generation in the country; this is the internal average transmission tariff for each country before the application of inter-TSO payments) are represented with a solid pink line. The difference between both horizontal lines in each country indicates the significance of the impact of the inter-TSO payment mechanism on the transmission tariffs of each country. Numbers are expressed in €/MWh.

We can appreciate from the figures that the distribution of the average values is not too disperse in all countries (the average values for G range between 1.03 €/MWh and 2.89 €/MWh, with an average value for the IEM of 2.02 €/MWh. In the same way, the average values for L range between 1.35 €/MWh and 2.89 €/MWh, with an average value for the IEM of 2.33 €/MWh). The significant differences among the average transmission charges in different countries are not only due to the different pattern of flows existing in each part of the grid but also to the fact that the amount of transmission assets per MWh varies widely from one country to another. Inter-TSO payments among countries account for the difference between the average transmission charge that would exist in each country if there were not cross border exchanges of electricity (pink line in every figure) and the computed average transmission charges per country (blue line).

Implications on tariff harmonization

A suggested procedure

A sound transmission tarification procedure at IEM level should be based on the responsibility of each network user, regardless of political borders, in the utilization or the development of each one of the elements of the transmission network of the IEM. The implementation of such a tarification procedure would consist of the three following steps:

- Assign the responsibility of every network user in the development or the utilization of each one of the facilities of the transmission network, regardless of political borders.
- Use standard transmission costs across the IEM in order to make the conversion from the responsibility factors in step (i) to assignment of costs.
- Translate the assigned costs into transmission tariffs G and L (i.e. charges per kWh, per kW or per customer) using some harmonized procedure.

The procedures to calculate the remaining transmission charges in the Member States, beyond the G and L charges above, should be harmonized. For instance, the remaining charges (or credits) that are needed for complete transmission cost recovery of a given country or TSO could be totally assigned to consumers, either uniformly or in such a way that total charges to demand may become uniform, if this is required by the national regulation. This harmonization approach would have a number of advantages.

The procedure to compute IEM-wide transmission tariffs that has just been presented implicitly contains an inter-TSO compensation scheme. In fact, political borders have been ignored when the allocation of transmission responsibility and cost was performed. Therefore, the G and L tariffs so computed already contain the compensations and charges (evaluated using standard costs) that are required because of the external use of the networks of other countries or TSOs.

Comparative evaluation of the selected methods

The criteria that a sound method to be applied in the long-term inter-TSO payment mechanism has to meet have been identified and applied to the three selected approaches. This task has made good use of the knowledge that has been gathered during the realization of this study. The criteria that have been identified can be classified into three groups.

A. The broader context.

This first set of criteria look at the consistency of the network cost allocation method with the underlying paradigm of the IEM that is contained in the EC Regulation and the methodological decisions already made within the context of the Florence Forum.

- *Criterion #1: The method for network cost allocation must be consistent with the fundamental approach inspiring the construction of the IEM*:
- *Criterion #2: The method for network cost allocation must be consistent with the overall framework of transmission regulation, so that any mutual implications with other aspects of transmission regulation do not create undesirable conflicts, now or in the future*. In particular, the method should be consistent with the remaining elements of cross-border transmission regulation?
    - a) investment in new infrastructures;
    - b) locational signals for operation and investment;
    - c) network tariff harmonization and potential pan-European or at least regional transmission tariffs.

B. Economic, technical and legal soundness of the method.

Soundness of the method in all relevant aspects, -economic, technical or legal-, will facilitate its understanding and minimize potential conflicts in its application, therefore contributing to its acceptance.

- *Criterion #3: Economic soundness.* Is the method based on sound economic principles or does it have economic justification? Does the method promote economic efficiency (productive efficiency, allocative efficiency)? Does the method at least not distort efficiency? Do the results of application of the method make economic sense? Can relevant counterexamples be found?
- *Criterion #4: Technical and logical soundness.* Is the method based on sound engineering principles or does it have technical justification? Does it rely on non justified hypotheses or definitions? Is there any technical inconsistency in the algorithms that are needed for the application of the method? Do the results of application of the method make engineering sense? Can relevant counterexamples be found? Do the numerical results make sense according to the rationale of the method?

- *Criterion #5: Legal soundness.* Does the method have any kind of incompatibility with the existing regulation? Will be the method perceived as fair?

C. Implementation issues.

The practical aspects in the implementation of the method can sometimes be decisive in the final choice of one method or another. Excessive complexity in the algorithms, difficulties in data acquisition and handling or lack of robustness in the results may dissuade from choosing one particular method.

- *Criterion #6: Data availability, acquisition and handling.* Volume and availability of required data, difficulty in obtaining or processing the data.
- *Criterion #7: Availability and complexity of procedures or commonly agreed definitions that are required to apply the method. Experience with its utilization.* This includes: Definition of transit, definition and determination of the horizontal network, algorithms and computer models, commonly agreed standard costs of network infrastructure and losses.
- *Criterion #8: Ability to be easily understood and verified.* Is the method easy to understand and to apply? Is the basic concept of the method easy to explain and communicate? Are there any special difficulties in the practical implementation of the method or in the interpretation of the results? Can the results be verified or replicated easily?

Conclusions

Some general conclusions can be drawn from the numerical results shown in chapter 3 and the ones in the final report of Phase I of this project. Those methods that link compensations to the use made by the transit of the grid of each country tend to favor heavily transited countries, like Germany or Switzerland, at the expense of others with large imports or exports, like France, Italy or The Netherlands, in the case examples that have been made available for this study. The compensation due to mainly importing or exporting countries with these methods is smaller than the amount they would receive if total cross border flows were taken into account instead of just transits. At the same time, when using the WWT method, countries importing or exporting heavily are the ones that are significantly charged to pay for these compensations. In this respect, a method like AP, which uses all cross border flows and not only part of them, seems to be more neutral for all types of situations.

Countries with large transits and comparatively smaller net imports or exports tend to have larger positive net payments with WWT, and also with APT, than with AP. This is for instance the case of Switzerland or Germany, in the case examples that have been made available for this study. The same type of conclusions can be drawn, in general, from the results for compensations because of network losses. These conclusions appear to be even stronger when the simplified version of WWT that is presently used to compute inter-TSO payments in the IEM is used instead of the full-fledged WWT method.

Final recommendation

The thorough review of the three considered methods allows one to reach a firm conclusion: The average participations method (AP) is clearly preferable to the with-and-without transits method (WWT), with the average participations applied to transits method (APT) being only an alternative if, for some reason, it is decided to maintain the transit paradigm while trying to avoid some of the major problems of the WWT method.

AP is the clear winner in the "broader context" set of criteria (criteria #1 and 2). Neither WWT nor APT satisfy these criteria. In the category of "economic, technical and legal soundness of the method" (criteria # 3, 4 and 5) AP is again the winner, WWT performs the worst and APT is somewhere in the middle. WWT fares better than AP and APT in the implementation criteria # 6 and 7. The practical disadvantages of AP with respect to WWT are not critical, nevertheless. Finally, both AP and WWT basically tie in criterion #8. APT is the worst method of the three according to the implementation criteria.

This conclusion is more drastic than the one that was reached in the Phase I of the project, where AP was considered to be the preferred method, but WWT was considered to be an interesting and acceptable alternative and APT a reasonable compromise between the two other methods. The lack of synchrony of WWT and APT with some aspects of the EU Regulation, the much better quality of the numerical results of AP over the two other methods, especially WWT, the inability of WWT and APT to provide any kind of locational signals and the poor performance of WWT in the implicit allocation of the cost of new network investments definitely tilt the balance towards AP as the preferred method for the long-term mechanism of inter-TSO payments in the Internal Electricity Market.

1 Introduction and objectives of the study

1.1 Objectives of the study

The objective of the present study is to provide the methodological basis for the implementation of the long term mechanism of cross-border tarification that, according to the conclusions of the Florence Forum, should be based on a scheme of inter-TSO[3] payments. More specifically, the objective of the study is to examine different alternatives in order to propose a method that, within the guidelines established at the Florence Forum, can effectively compute the compensations and charges due to losses and network utilization that are incurred by cross-border transactions and loop flows.

This Phase II of the study on "Cost components of cross-border exchanges of electricity"[4], has the primary objective of confirming or, -if this is the case-, revising the conclusions of Phase I of the project, once a more complete set of data has been made available on the actual network flows in the Internal Electricity Market (IEM) of the European Union. Besides, this Phase II also examines in greater detail, -both conceptually and quantitatively-, some of the more critical aspects of those few algorithms that have been seriously considered as potential candidates to be used in the long-term mechanism for inter-TSO payments in the IEM: the method of Average Participations (AP), -with the possible variation of Average Participations with Transits (APT)-, and the "With-and-Without Transits" (WWT) method. Finally, Phase II of the project also tries to provide elements for the application of the algorithms that have been analyzed in the project to other purposes other than inter-TSO payments, such as provision of long-term locational signals, a more accurate determination of the horizontal network for cross-border tarification studies, the allocation of the costs of new network investments or the design of strategies for IEM-wide transmission tariffs harmonization.

New and more extensive data collection procedures have been implemented by ETSO during 2003. Each country or TSO collects snapshots of network flows and sends them to an ETSO task force to be processed. Processing of this data is

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[3] TSO stands for "Transmission System Operator", which is the term that has been adopted to designate the entity that is in charge of operating the electric power system, with a special responsibility on preserving the security of the system while allowing the commercial transactions that the purchasing and selling agents are entitled to engage in. In most countries the TSO is also owner of transmission assets, which is the reason for the name TSO, although it is not the case in all systems. Most European countries have a single TSO per country, but some countries have several TSOs (Germany has 6, Switzerland has 5, Denmark has 2 and Austria has 2), which apply different transmission network tariffs within their territories. In this report the terms "country", "TSO" and "Member State" will be indistinctly used for the only purposes of cross-border tarification.

[4] See the final report for Phase I of this project: "Cost components of cross-border exchanges of electricity", prepated by the Instituto de Investigación Tecnológica (Universidad Pontificia Comillas de Madrid) for the Directorate-General for Energy and Transport of the European Commission, November 2002. See http://europa.eu.int/comm/energy/electricity/publications/index_en.htm.

performed on an individual basis level and global European network models are not produced any more. Since the computer algorithms that were developed for Phase I of the project were meant to deal with a single European network model, a significant effort has been made to design and then to reprogram the AP and APT algorithms so that they can now be applied to a collection of individual network models of countries or TSOs.

1.2 Background

This extension (Phase II) of the previous study (Phase I) on "Cost components of cross-border exchanges of electricity" must be also understood within the context of the global effort that is taking place, within the EU and at different fronts, with the purpose of achieving a workable and efficient Internal Electricity Market (IEM).

Phase I of the project met the objectives of developing and programming a number of alternative algorithms for the allocation of the costs of losses and network use that are caused by cross-border transactions and loop flows. Data availability was a critical issue during the realization of Phase I of the project. The following data were delivered to the IIT team for Phase I of the project by ETSO, -the European Association of Transmission System Operators-:

- Three snapshots (one for 2002 and two for 2001) of the physical transmission flows in all the lines of UCTE; NORDEL, UK and Ireland.
- Hourly data for one year of the net values of exports minus imports, and also of the internal demand, for all the considered countries.

This information (as much as ETSO itself had for the realization of its studies on cross-border tarification) allowed in Phase I the verification and preliminary comparison of several alternative methods, and it also has allowed the attainment of methodological conclusions about the considered approaches. Some conclusions were also obtained regarding the number of scenarios that should be considered in the actual implementation. These were the major objectives of Phase I of the study.

A new fact is that, since January 1st 2003, the member companies of ETSO have been collecting detailed hourly information about the electricity flows that take place in each one of the lines of the transmission network of the IEM. This wealth of information allows a more detailed analysis than the one that was possible during Phase I, and it also allows the improvement of the approximation to the actual values of annual measures of external network use for each country and the ensuing compensations and charges. These results will hopefully be useful to guide the future decision concerning the choice of a permanent method of computation of inter-TSO payments.

Phase II of the project has tried to exploit this increased availability of information. Refinements of the comparisons among the few dominant alternatives have then been possible. The properties of the numerical results, regarding their robustness with respect to different conditions of operation, can also be examined. It is also clear the interest that some byproducts of the methodologies that have been developed during the project will have in the development of a comprehensive cross-border tarification model: spatial distribution of transmission nodal tariffs in Europe, a more precise definition of the horizontal network to be used in these studies, insights on cost allocation of possible future network reinforcements.

1.2.1 An update on the Florence process and beyond

The Florence process

A description of the Florence Regulatory Forum was presented in the Final Report of Phase I of this project, together with a chronology of the results of this process until February 2002[5]. The new developments concerning cross-border tarification will be reviewed here.

The 9th Florence meeting.[6]

ETSO presented a proposal for the implementation of a revision of the existing mechanism to be put into effect on January 1st, 2003. This is not yet the long-term mechanism that should replace the provisional one. The adopted mechanism differs from the one operated since March 1st, 2002, in several respects:

- A common methodology is adopted to define the horizontal network[7].
- The regulated network costs that are currently established by each national regulatory authority will be accepted as the network costs for each country in the application of the method.
- The export fee was halved, from 1 €/MWh to 0.5 €/MWh.

The Forum stressed the importance of developing, together with a fully cost-reflective inter-TSO compensation mechanism, the harmonization of national tarification systems and the introduction of long-term locational signals.

The 10th Florence meeting.[8]

The Forum welcomed the final approval of the new Directive and Regulation on the internal energy market in June 2003. This package will become applicable on July 1st 2004.

The Forum stressed the need for further measures leading to a progressive harmonization of notably G charges in the internal market, to avoid distortions of competition between generators. The Forum also considered that further research and expertise is necessary in order to develop an appropriate system of locational signals provided through specific G-charges reflecting current and future

[5] See Annex 1 and section 1.1. of the Final Report.

[6] In Rome, October 2002.

[7] . See the last version of this procedure in the document "ETSO CBT 2004. Procedure to be followed to determine the horizontal network of each country and its cost" by ETSO.

[8] In Rome, July 2003.

infrastructure costs. In this light the Forum expressed the view that the immediate introduction of a specific locational G charge after the Regulation becomes applicable in mid 2004 would be inappropriate. However, the Forum stressed the need to closely monitor developments and to continue the work on a proper, longer-term system of locational signals in the internal electricity market and to examine possibilities to reflect losses at the EC level in charges, as an interim solution.

The Forum recalled that the inter-TSO compensation mechanism currently in place runs until the end of 2003. Any subsequent mechanism must be compatible with the cross-border Regulation, once the latter is applicable from 1 July 2004 onwards. ETSO presented a proposal for a TSO compensation mechanism to enter into force on 1 January 2004. The main new feature of this system is the abolition of the currently existing export charge of 0,5€ MW/h. Under the new system no cross-border charges would thus be applied for participating countries, in full compliance with the Regulation.

Regarding the longer-term inter-TSO payment mechanism, the Forum participants acknowledged the variety of different models available for calculating the precise amounts of payments to be made. The effect of different methods requires more analysis, using the database currently being collected by TSOs on flows during 2003.

New documents from the EU Commission

Since Phase I of the project was finished, two important documents have been issued by the EU Commission that are very relevant for cross-border tarification. It follows a brief summary of the major points that are relevant for this project.

Strategy Paper: Medium term vision for the Internal Electricity Market.

This Strategy Paper (still a draft) establishes medium and long term goals for the implementation of the IEM and the development of cross-border trade in particular. The overall goal is for the EU and wider market to function in the same way as a national market. Eventually, therefore, all system operators should use the same assumptions and mechanisms to manage their networks and network users would face a single interface. The Strategy Paper establishes that:

- Regarding tariffs, it is clear that for the medium term, an approach whereby tariffs for cross-border trade are a combination of different national tariff schemes and where TSOs are compensated for transit and/or other cost inducing flows is the most sensible. However in the longer term, a pan-European tarification mechanism would contribute to the further integration of markets.
- In the medium term inter-TSO compensation should allow for suitable compensation between Member States for, as a minimum, transit flows and other cross-border flows in some cases.
- In the medium term transmission charges on generators should be harmonized within a fairly narrow range with, if appropriate, some locational signals introduced at EU level.
- In the longer term both tariffs and inter-TSO compensations should be based on a single common model of the European network with, ultimately,

zonal based transmission charges covering, as a minimum, losses and also potentially, fixed investment costs.

Regulation on conditions for access to the network for cross-border exchanges in electricity.

The full text of the most relevant articles of this Regulation are contained in Annex 1 of this report.

1.2.2 Main conclusions of Phase I of the project

The major conclusion of Phase I of the study is that algorithms that are based on real flow network models can be used for the computation of inter-TSO payments and they are far superior to the present provisional mechanism. Data requirements to feed these models are demanding but feasible. A few alternative options exist regarding the specific algorithm to be used, with each one of them reflecting different underlying regulatory criteria and resulting in outcomes with significant numerical differences. Therefore, it is not irrelevant to try to examine them in more depth so that an informed choice can be made.

The detailed conclusions of the report can be grouped into two major categories. The first one concerns the data requirements. The second one refers to the qualitative and quantitative evaluation of each method.

Conclusions regarding data requirements.

In principle it is recommended to use 8,760 hourly historical scenarios of the last available complete year. This would eliminate any discussion on the procedure of selection of any reduced set of scenarios. However, if it is deemed that a reduced number of representative scenarios should be employed in order to reduce the required computational resources, Phase I of the study indicates that it seems plausible that these representative scenarios exist and that they could be determined via the clustering techniques that were explored in Phase I.

Conclusions of the comparative evaluation of the considered methods

After examining six alternative methods, Phase I of the study concluded that two approaches appear to be dominant as a result of the evaluation: the average participations (AP) method on one side, and, on the other side, the “with and without transit “ (WWT) method, with the method of average participations applied to transits (APT) as a possible variant. The following strong and weak points of the AP and WWT methods were identified:

- The AP method is fully consistent with the “single system paradigm”, i.e. it is based on nodal transmission tariffs that are computed, -just for the purpose of the inter-TSO mechanism-, by the allocation of the electrical use of each transmission facility, with independence of the political borders or configurations of TSOs. All the actual physical flows are considered in the AP method. On the other hand the WWT method is specifically based on the definition of transit for each country or TSO, which is a concept that directly depends on the flows at the political borders and only makes use of a fraction of these flows. WWT therefore departs from the "single system paradigm" and implies a special treatment for a certain type of flows: the transits, with their ad hoc and controversial definition. The procedures of the WWT method, as well as its results, are very dependent on political borders between countries, or boundaries between TSOs.

- Both methods start off from some heuristic and reasonable assumptions. The WWT method makes use of the intuitive but ambiguous concept of "transit" of a country and adopts a definition for it. The AP method assumes that it is possible to trace the origin and the end of the flows and applies a simple proportionality branching rule for this purpose. The essential advantage of this approach is that, once the flow tracing rule has been accepted, everything else directly follows: nodal transmission tariffs, compensations, charges, inter-TSO payments and their assignment to the local G and L charges, allocation of the costs of new investments, and so on. On the other hand, the WWT method requires additional assumptions or ad hoc rules in order to determine charges and inter-TSO payments, or to assign the costs of a new network investment.
- The allocation of charges in WWT ignores the topology of the IEM system and spreads the charges for the compensation due to any country over most other countries. Actually, WWT only computes compensations, and some ad hoc scheme has to be devised in order to determine the charges, so that the final net inter-TSO payments can be determined.
- Both methods yield numerical results that, in general, make economic and engineering sense. The results for both methods are different, although there are important similarities in broad terms, i.e., which countries should receive the largest compensations or which ones should pay most. These discrepancies were expected, since both methods have essential differences: AP is based on the complete physical flows, while WWT looks for the impact of just the transit flows at the borders between countries and it ignores the physical flows in the allocation of charges (in its present implementation). In quantitative terms, both methods can only be compared on the basis of the final net inter-TSO payments that result from the application of compensations and losses to each country.
- Despite the methodological differences, both methods have provided inter-TSO payments of almost the same global economic volume, when applied to the single scenario that has been examined in detail.
- Data requirements are similar for both methods, since they make use of real network flows for a representative number of scenarios.
- Cross-border tarification is just one among several pieces of the puzzle of transmission regulation in the IEM, with others being congestion management, transmission tarification and tariff harmonization –with particular attention to the provision of locational signals-, and treatment of new investments. The AP method can be used, if desired, as an aid in performing some of these tasks, while WWT can exclusively be used for the computation of compensations to

countries because of transits. This feature will become very relevant, in the discussion of the allocation of the costs of new network reinforcements.

The average participations applied to transits (APT) method tries to eliminate some practical implementation difficulties of the WWT algorithm, while preserving the same philosophy of relating all external network use to the concept of transit. APT does not require the specification or utilization of a “without transit” operating condition and APT is able to identify the responsibilities for the transits, therefore providing a solution to the problem of allocation of the charges, which the WWT method is unable to address.

Phase I of the study concluded that the method of average participations (AP) is the preferred approach for the computation of inter-TSO payments. Despite some shortcomings, the “with and without transit” (WWT) method with real network flows would represent a considerable improvement over the current provisional approach, where only aggregated values of flows and demand at country level are used. The APT method should be given due consideration since it successfully addresses some of the implementation problems with the WWT approach.

1.3 Road map of this report

This report is mostly devoted to present the new quantitative results that have been made possible because of the data that ETSO has made available recently. Specifically this data correspond to 24 snapshots, distributed along the year 2002, of the transmission network of an ensemble of 13 countries belonging to the IEM. The qualitative analysis and the conclusions of Phase I of this project have been revised after the examination of the new numerical results.

After this first introductory chapter, Chapter 2 describes the new data that have been made available for this Phase II of the project, and also the modifications that have been necessary in the computer models to handle the data in the new decentralized (i.e. country by country) format. The extended comparative evaluation of the three considered cost allocation methods with the new data is presented in Chapter 3. Chapter 4 expands on these results and analyzes possible variants of the original algorithms. The tricky concept of transit is examined in Chapter 5, jointly with the issue of definition of the horizontal network. The role of the inter-TSO payment mechanism in the allocation of the cost of new transmission investments is studied in Chapter 6. An assessment of the desired number of annual scenarios that are needed to obtain a precise calculation of the inter-TSO payments is attempted in Chapter 7. Chapter 8 examines the potential of the different methods of network cost allocation that have been considered for the mechanism of inter-TSO payments, but now from the point of view of the determination of locational signals and pan-European transmission tariffs. Finally, in Chapter 9, a detailed appraisal of the weak and strong points of the three considered methods is performed, taking into account the information that has been gathered in the preceding chapters.

2 The data

Ideally, 8760 cases should be made available in order to compute annual inter-TSO payments and nodal transmission tariffs. However, this requires a fully automatic process. ETSO has decided that, for the time being, only a limited number of cases, –as many as they can be reasonably handled manually by a small group of expert people-, will be processed out of the 8760 snapshots collected for the year 2003. In principle, ETSO is collecting 6 snapshots per month of the year 2003. Therefore, the total number of processed scenarios that would be available for analysis would be 72 for the entire year. So far (November 2003) they have collected 42 (for the initial 7 months) which have not been made available yet for the study, since some difficulties have been founded in handling the deficient data reported by some countries.

While the set of data corresponding to the year 2003 is made available, ETSO has provided the data for 24 scenarios for the year 2002. ETSO has collected these data with the purpose of computing the compensations that are due because of losses for the years 2002 and 2003. The following properties apply to the 13 separate sets of data provided for each of the 24 scenarios:

- A perfect match can not be expected due to the properties of State Estimation Procedures. This primarily relates to the comparison of recorded flows on tie lines between neighboring transmission systems, which in some cases differ substantially.
- Data is provided applying the UCTE-Format including the "X-Node" convention. In more detail, "X-Node" convention fictitiously cuts each tie line between Countries / Control-Blocks at a border point and allows to force the flow on each half of that line individually by inserting an artificial generator or load. Data was formatted applying the same UCTE-Format as the data provided last year for Phase I of this study.
- Representation of borders between transmission systems may be different. This is related to the fact that interconnections at lower voltage levels may be not part of regular recordings and considered as negligible. Either the representation of these interconnections is omitted completely or simplified by introducing fictitious elements into the model. The purpose of introducing these elements was to observe the interconnection but not to represent its electrical connection to the internal transmission system.
- Delimitation of transmission systems is not always coincident with political borders and reflects the structure of Control Blocks.
- Representation of borders is not stable because of structural changes. This is due to either putting a new interconnection into operation or putting an interconnection temporarily out of operation. Since a common rule on how to represent such changes does not exist, some tie lines have been omitted on one side of the border and represented as switched off on the other side.
- Models of transmission systems may be composed of two or more electrically non connected parts, due to the outage of an internal line or the separation

of bus bars for congestion management purposes. In these cases interconnection was forced by manual intervention.

- DC-Links in received data sets are represented by a "Load" or "Generator" connected to the node where the AC/DC converter is connected instead of X-Nodes.

2.1 Data that has been used in this study

The set of 24 scenarios provided by ETSO was determined based on a statistical analysis of hourly values of power flows on tie lines,. Scenarios correspond to 4 different months: March, June, September and December with scenarios recorded at 03:30h, 11:30h and 19:30h of third Wednesdays and preceding Sundays. The data comprise 13 countries: Austria, Belgium, Switzerland, the Czech Republic, Germany, Spain, France, Hungary, Italy, The Netherlands, Portugal, Slovenia and Slovakia. These data were provided separately by each country, therefore resulting in a collection of 13 separate subsets of real network flow data for each hourly scenario.

Some TSOs were not capable of providing such data and submitted replacement data for analogous timings either of another week, another month or data recorded after 1.1.2003. Others did not provide any data at all for some of the scenarios. Those snapshots from a country that were not made available have been substituted with other snapshots from the same country, corresponding to operating conditions that were as similar as possible to those of the missing ones.

All the scenarios have been received in ‘UCT’ format and a translator program has been needed to obtain the PSS format data files that are used to run the algorithms.

Table 1 summarizes the aggregate data for an average scenario trying to represent the 24 scenarios that have been used in the study. The aggregate values of generation, load, exports, imports, absolute value of net exports and transits are provided for each country. All numbers are expressed in MW. The IEM-13 network has around 3950 nodes and 5700 lines (numbers vary depending on the considered scenario).

Some other data have been used to obtain the results shown throughout the report. In order to express both compensations among countries and nodal transmission tariffs in monetary terms, the annual cost per km of 400KV line has been estimated. First, the number of kilometers of equivalent 400KV lines for the horizontal network of 11 European countries. has been computed. These countries were Austria, Belgium, France, Germany, Italy, Portugal, Spain, Switzerland, the Czech Republic, The Netherlands and Slovenia. The numbers of kilometers of equivalent 400kV lines obtained were 3896 for Austria, 3930 for Belgium, 4477 for Switzerland, 5116 for the Czech Republic, 34811 for Germany, 21511 for Spain, 27916 for France, 13019 fro Italy, 3737 for The Netherlands, 3627 for Portugal and 696 for Slovenia. Second, the regulated cost of the horizontal network of each country (the values used in the provisional method for the year 2003) was divided by the number of kilometers obtained for each system in the previous step, thus obtaining a regulated cost per kilometer of equivalent 400KV line for each one of the countries. Finally, the economic per unit value that has been employed to express all the results in monetary terms was obtained as the average of the regulated cost obtained for each country. An annual value of 0.0352 millions Euro per km of 400 kV line was obtained. The European Commission has recently estimated a value in the range of €350.000 to €600.000 as the replacement cost per km of double circuit 380kV line for most of the countries considered in this study. This estimate results in an annual value which is in the same range as the one considered here when we a depreciation period of 30 years and a cost of capital per annum of 6% real are adopted.

	Generation	Load	exports	imports	net_E-I	transit
A	2193.2	2134.9	1464.8	1481.6	16.8	1464.8
B	6366.8	7130.2	921.4	1726.1	804.7	921.4
CH	5196.6	4498.7	3488.6	2931.5	557.1	2931.5
CZ	5167.6	3708.8	2250.7	1065.1	1185.6	1065.1
D	44187.6	43411.9	4437.7	4983.5	545.7	4437.7
E	18805.2	18221.1	743.8	1326.7	582.9	743.8
F	53158.3	42804.9	8284.6	91.0	8193.6	91.0
H	2492.6	2943.4	797.0	1275.0	478.0	797.0
I	16565.1	21860.6	13.6	5706.2	5692.7	13.6
NL	7317.5	9317.9	350.3	2455.1	2104.8	350.3
P	3951.9	3957.9	425.3	529.6	104.3	425.3
SLO	1088.9	626.7	986.9	703.4	283.4	703.4
SK	2308.2	1833.8	1059.1	608.2	450.8	608.2

Table 1: Aggregate data for the average scenario

The capacity of the lines used to obtain numerical results for inter-TSO payments in chapter 4 was obtained from the data that were provided by ETSO as part of the snapshots. The capacity of some lines was not provided, however. In these cases, the corresponding capacity was supposed to be equal to the average value for the lines of the same type in the system.

Also the length of every line has been estimated from its impedance and using some coefficients provided by ETSO. These coefficients were dependent on the type of line.

2.2 Decentralized *versus* centralized data sets

The data provided for Phase I of this project corresponded to the real network flows in a single network encompassing 17 countries. Since it was a single network, the continuity of the flows across borders was guaranteed and programming the algorithms for tracking flows in the AP and APT methods was relatively easy.

As said before, the data that have been gathered by ETSO to build the 24 snapshots for the year 2002, as well as the data that are systematically collected hourly since the 1st of January 2003, are provided separately by each country, therefore resulting in a collection of 13 separate subsets of real network flow data for each hourly scenario. Programming the AP and APT algorithms so that the flows can be tracked across political borders is not easy anymore, and the models that were already available during Phase I of the project have had to be reprogrammed. Details are provided in sections 3.2.1, 3.2.2 and 3.2.3.

3 A first comparative evaluation of the preferred methods for the computation of inter-TSO payments

3.1 Background

As shown in the conclusions of Phase I of this project, two methods: the Average participations method (AP) and the With-and-Without Transits method (WWT) appear to be the most serious contenders for being adopted in the long-term mechanism. A variation of the AP method, -the Average Participations method applied to Transits (APT)-, somehow lies in between AP and WWT and it may provide a useful compromise between both.

In this chapter a comparative evaluation of the three preferred algorithms will be performed. A first crude evaluation of the actual values of the charges and compensations and, therefore, an estimation of the quantitative impact of the inter-TSO payment mechanism will be also obtained for each method. Results will be presented also for the provisional method currently being used.

When allocating the cost of a line or group of lines one must take into account the total benefit that each party gets from this line. Therefore, all the different scenarios, and not only those where the line is used to a higher extent, must be considered, since agents are benefiting from the existence of the line in all cases. It is true, however, that the different scenarios should probably be given different weights in proportion to the use made of the line in each of them.

The limited availability of useful data does not appear to be an obstacle to arrive at firm conclusions about the weak and strong points of each method. The conclusions about the comparison of the three methods will be left for a comprehensive analysis to be performed in Chapter 9 of this report.

3.2 Quantitative evaluation of each method

For each one of the three methods the following results will be presented:

- The table showing the compensations, total charges and inter-TSO payments for each one of the 13 countries and 24 scenarios for which data have been available.
- The table showing the complete map of compensations, bilateral charges and net payments for each one of the 13 considered countries.

Numbers in the tables are expressed in millions of euros. The explanation of the numbers displayed in each one of the two types of tables is identical for the three methods and can be found after the corresponding table for the AP method.

3.2.1 Results for the Average Participations method (AP)

The new algorithm to track flows with 13 separate data sets of real network flows.

Separate data sets have been made available for each one of the 13 countries considered in the study. Due to this fact, programming a different implementation of the same AP algorithm that was used in the first part of the project turned out to be necessary. In this new implementation, the process of tracking the flows within each country remains the same as in the original one. However, a new way of relating the flows on both sides of each border has been devised, so that cross border flows can be tracked too.

The identification of the counterpart of each cross border flow is carried out by using the node code provided by ETSO. A virtual node has been inserted at the point where each line between two neighboring transmission systems crosses the border. An artificial generator or load located at each virtual node forces the flow over the cross border line to have the scheduled value.[9]

The AP algorithm is now applied in two steps. In the first step it is computed how much each agent is using the lines within its own country, including the cross-border lines. In the second step, the participations of agents in the use made of lines in neighboring countries are determined. In order to do so, the participations computed in the first step for every virtual agent are assigned to those agents using the corresponding cross border line on the other side of the border.

Calculating inter-TSO compensations and, if needed, nodal tariffs from the individual snapshots of the countries, is straightforward with the new algorithm[10]. This makes the application of the AP method easier, since the significant effort of joining all the national snapshots together is now avoided.

Results for the inter-TSO payments because of network use

In Table 2 CO stands for *compensation* and refers to how much others are using the network of the corresponding country (excluding how much this country is using its own network). CH stands for *charge* and represents the total use by the corresponding country of the network of other countries (excluding itself). Finally, N stands for net compensation or inter-TSO payment and is the *net payment* that is due to the country. This last figure is obtained as the difference between the previous two ones. The number following these alphabetic codes refers to the number of the scenario. All figures in the table are millions of euros. The algorithm

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[9] Flows over the same line on neighboring countries may differ in some cases. Different properties of the state estimation procedures used by different countries and the lack of consistency between the snapshots that we had to use, when the original ones were missing, account for these differences. The flow over a line between two countries has been scaled up or down, as needed, in order to make the tracking of this flow in both directions possible. Cross-border flows that go in opposite directions on both sides of the border have not been followed beyond the border.

[10] In some cases, part of the grid of a system could not be allocated to any other country in particular. Both the lack of consistency in the representation of the interconnection between systems and the fact that not all the UCTE electrically connected countries were considered in the study caused this to happen. Hence, the size of grid allocated by the different methods may not be the same. Whereas the WWT method is able to allocate the whole cost of the grid for every country, AP and APT may or may not be able to do so, depending on the possibility of tracking the flows on the borders beyond them.

only computes percentages of utilization of the network or of individual lines. In 2 it has been explained how these utilizations have been turned into annual costs.

Compensations, charges and inter-TSO payments are displayed in three different rows for each one of the 24 scenarios. Numbers in the same row represent compensations or charges to different countries. Numbers correspond to the annual figure that would have been obtained if the corresponding scenario had been representative of the whole year. Therefore in row CO1 58.3 represents what would be the annual compensation due to Austria because of the external use of its grid

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
C01	58.3	21.7	71.7	13.4	77.0	53.7	88.5	7.8	52.6	28.8	21.3	10.3	5.2
CH1	15.0	15.3	40.5	39.2	68.9	39.2	121.9	5.1	104.4	7.0	31.9	9.8	12.1
N1	43.3	6.4	31.2	-25.8	8.1	14.5	-33.5	2.8	-51.8	21.8	-10.6	0.5	-7.0
CO2	63.8	21.1	76.3	15.8	87.2	47.1	92.5	8.7	61.6	34.9	18.0	8.3	9.3
CH2	19.5	7.1	49.7	43.2	80.5	37.0	128.2	7.0	107.8	11.4	28.6	13.4	11.2
N2	44.3	14.1	26.6	-27.4	6.8	10.1	-35.7	1.7	-46.2	23.4	-10.6	-5.1	-2.0
CO3	67.8	23.3	68.8	15.0	78.0	50.5	75.8	7.3	57.0	39.0	18.8	8.1	9.1
CH3	17.0	10.8	45.6	44.5	80.2	36.0	115.0	6.5	89.5	12.3	34.7	15.1	11.5
N3	50.8	12.5	23.2	-29.5	-2.2	14.5	-39.2	0.8	-32.5	26.7	-15.9	-6.9	-2.4
CO4	44.4	25.0	67.9	17.8	59.9	41.6	92.4	13.6	45.3	28.6	21.3	10.4	3.3
CH4	14.9	15.6	34.9	28.3	61.0	40.1	119.5	6.3	94.5	7.0	25.6	7.9	15.9
N4	29.6	9.4	32.9	-10.5	-1.1	1.5	-27.1	7.3	-49.2	21.5	-4.3	2.5	-12.6
CO5	49.3	29.4	50.6	19.3	90.8	51.3	73.1	10.0	34.6	34.1	21.2	8.9	3.9
CH5	23.2	17.1	37.9	33.0	79.8	38.9	97.0	6.0	54.3	26.2	37.3	12.3	13.4
N5	26.1	12.3	12.7	-13.7	11.0	12.3	-23.9	3.9	-19.7	7.9	-16.1	-3.3	-9.5
CO6	42.4	23.5	56.8	16.2	86.2	53.7	69.9	6.4	42.8	33.1	22.3	9.6	6.2
CH6	22.2	16.3	37.1	33.1	62.1	42.2	101.7	5.8	61.4	25.9	38.1	12.4	10.7
N6	20.2	7.3	19.7	-16.9	24.1	11.5	-31.9	0.5	-18.6	7.2	-15.8	-2.8	-4.5
CO7	57.5	16.1	61.7	21.6	83.4	26.5	72.8	11.8	56.8	41.0	17.2	12.4	11.5
CH7	30.9	19.0	38.3	39.0	77.5	28.0	84.9	10.4	105.6	10.0	20.6	13.5	12.4
N7	26.6	-2.8	23.4	-17.4	5.8	-1.4	-12.1	1.3	-48.9	30.9	-3.4	-1.1	-0.9
CO8	50.1	27.5	62.2	20.6	84.7	28.4	68.4	9.5	57.6	43.2	11.2	11.7	11.3
CH8	22.8	25.0	40.4	33.3	68.7	16.2	120.2	8.5	96.4	10.3	23.3	9.6	11.6
N8	27.3	2.6	21.8	-12.8	16.0	12.2	-51.9	1.0	-38.8	32.9	-12.1	2.1	-0.3
CO9	45.9	23.2	61.7	31.0	85.0	24.6	73.2	13.7	54.3	49.0	10.7	5.2	12.0
CH9	28.9	26.7	39.4	36.1	68.6	15.1	117.0	13.1	84.0	13.0	21.0	11.5	15.1
N9	17.0	-3.4	22.3	-5.1	16.4	9.4	-43.8	0.7	-29.7	35.9	-10.3	-6.3	-3.1
CO10	51.2	23.9	62.1	31.9	60.1	32.5	82.7	10.8	40.8	52.3	7.9	11.0	11.4
CH10	31.8	17.1	34.3	34.5	78.5	21.8	102.7	10.9	95.0	6.2	20.5	11.0	14.3
N10	19.5	6.8	27.8	-2.6	-18.4	10.7	-20.0	-0.1	-54.2	46.1	-12.6	-0.1	-2.8
CO11	40.8	31.1	39.0	23.4	80.2	38.8	48.3	9.0	30.7	37.4	18.4	11.5	9.2
CH11	30.7	17.2	38.1	26.4	61.5	33.6	99.3	8.6	44.4	10.4	28.8	5.4	13.7
N11	10.1	13.9	0.9	-3.0	18.7	5.3	-50.9	0.4	-13.6	27.0	-10.4	6.1	-4.5
CO12	36.3	23.0	48.8	36.7	74.7	41.1	66.0	11.2	44.4	39.4	8.9	9.9	11.4
CH12	30.7	18.4	36.7	32.4	61.4	24.9	115.9	12.6	59.0	7.8	28.9	6.0	17.0
N12	5.6	4.6	12.0	4.3	13.3	16.1	-49.9	-1.3	-14.6	31.5	-20.1	4.0	-5.6
CO13	62.7	17.5	77.7	22.0	84.0	21.0	50.1	13.0	48.1	38.3	26.4	7.2	9.0
CH13	27.4	16.3	36.8	51.0	76.4	26.4	85.2	8.7	96.2	10.0	21.0	9.2	12.4
N13	35.3	1.2	40.9	-29.0	7.6	-5.3	-35.1	4.3	-48.1	28.4	5.3	-2.0	-3.4
CO14	49.7	35.0	69.7	23.4	81.1	38.7	88.8	9.6	57.9	40.0	14.5	6.1	10.6
CH14	25.1	21.2	35.5	43.5	64.9	43.3	141.9	8.0	86.1	11.6	25.4	6.3	12.3
N14	24.6	13.8	34.2	-20.0	16.2	-4.6	-53.1	1.6	-28.2	28.3	-10.9	-0.3	-1.7
CO15	52.1	23.4	74.0	28.8	84.9	20.5	64.5	10.9	59.0	47.0	25.4	6.6	10.8
CH15	24.9	22.5	39.1	42.9	70.2	25.4	119.2	10.2	95.8	14.4	20.5	8.6	14.1
N15	27.1	0.9	34.9	-14.1	14.7	-4.9	-54.7	0.8	-36.8	32.6	4.9	-2.0	-3.4
CO16	57.9	20.9	74.6	28.5	68.7	44.8	78.0	13.9	42.1	43.4	11.5	7.7	5.7
CH16	26.3	20.1	28.7	46.1	84.1	21.3	104.1	8.8	95.2	6.5	35.2	6.6	14.8
N16	31.6	0.8	45.9	-17.6	-15.4	23.5	-26.1	5.0	-53.1	36.9	-23.7	1.1	-9.1
CO17	40.8	38.8	35.0	21.6	81.6	43.8	75.3	10.1	36.0	37.4	10.2	5.8	7.8
CH17	23.4	22.2	44.8	30.2	68.6	27.8	102.5	7.0	48.4	12.3	37.2	5.5	14.1
N17	17.4	16.6	-9.8	-8.6	12.9	15.9	-27.1	3.1	-12.4	25.1	-27.0	0.3	-6.3
CO18	46.2	27.1	55.6	26.7	74.8	39.2	62.0	11.1	38.6	37.1	22.6	5.9	8.7
CH18	24.0	17.4	31.2	35.5	65.9	35.0	109.6	9.4	64.7	7.1	33.7	7.3	14.9
N18	22.2	9.7	24.4	-8.8	8.9	4.2	-47.6	1.7	-26.1	30.0	-11.0	-1.4	-6.2
CO19	48.6	20.0	72.8	18.1	85.0	32.0	76.3	10.6	56.1	26.8	23.2	8.8	6.7
CH19	23.9	19.4	41.6	37.8	52.1	41.5	118.9	3.8	85.9	7.8	19.0	11.8	21.6
N19	24.7	0.6	31.2	-19.7	33.0	-9.5	-42.7	6.8	-29.8	19.1	4.2	-3.0	-14.8
CO20	53.0	26.6	81.7	18.6	87.1	42.0	86.1	8.2	56.4	47.8	18.3	9.2	9.0
CH20	21.5	24.8	51.7	37.9	79.6	42.3	122.0	4.9	95.4	13.2	22.2	10.9	17.4
N20	31.5	1.8	30.0	-19.4	7.5	-0.3	-35.9	3.3	-39.1	34.6	-3.9	-1.7	-8.4
CO21	51.3	28.6	73.5	17.6	88.5	42.9	74.9	9.0	52.6	52.0	16.9	10.5	8.7
CH21	24.9	26.2	53.3	36.3	72.4	36.5	116.2	5.1	85.0	16.4	27.1	9.7	17.9
N21	26.4	2.4	20.3	-18.8	16.1	6.3	-41.3	3.9	-32.4	35.6	-10.1	0.8	-9.2
CO22	41.0	27.4	68.9	22.3	66.5	33.6	90.4	10.9	48.5	21.9	20.1	8.2	5.9
CH22	13.0	16.6	37.4	32.4	52.5	40.7	129.4	2.5	90.8	5.0	16.9	7.1	21.1
N22	27.9	10.8	31.6	-10.2	14.0	-7.1	-39.0	8.4	-42.3	16.8	3.2	1.1	-15.2
CO23	34.7	25.9	40.0	24.1	85.2	41.3	56.7	8.7	35.9	31.3	13.7	9.3	6.4
CH23	21.9	17.2	34.9	32.0	59.9	24.5	83.2	2.5	55.0	24.4	31.9	7.5	18.2
N23	12.9	8.7	5.1	-8.0	25.3	16.8	-26.5	6.1	-19.1	7.0	-18.2	1.8	-11.8
CO24	41.3	26.9	40.8	20.7	78.4	31.4	53.4	9.8	44.7	35.1	13.9	8.6	6.4
CH24	19.7	19.0	34.0	31.6	59.0	25.9	87.2	2.5	58.9	22.3	24.4	8.5	18.6
N24	21.6	7.9	6.7	-10.9	19.4	5.5	-33.8	7.3	-14.1	12.8	-10.5	0.1	-12.1

Table 2: Compensations, charges and net payments because of network use for each one of the 24 scenarios obtained with the AP method

by others (excluding the Austrian use of its own network), if we had to compute it taking into account only scenario number 1. The same applies to the corresponding row for charges (CH1) and net payments (N1).

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	86.0	0.0	0.0	7.4	6.5	0.0	0.0	1.5	3.5	0.0	0.0	3.4	1.0
B	0.0	123.1	0.0	0.0	0.5	0.0	7.2	0.0	0.0	11.0	0.0	0.0	0.0
CH	0.8	0.0	93.4	0.0	11.6	0.0	14.5	0.0	12.4	0.0	0.0	0.0	0.0
CZ	14.9	0.0	0.0	146.4	16.7	0.0	0.0	1.2	0.2	0.0	0.0	0.3	3.3
D	13.7	0.8	11.3	7.7	1228.8	0.0	5.8	0.0	2.7	26.9	0.0	0.1	0.0
E	0.0	0.0	0.0	0.0	0.0	791.2	14.6	0.0	0.0	0.0	17.2	0.0	0.0
F	0.0	22.1	20.0	0.0	29.1	11.1	1121.9	0.0	27.4	0.4	0.0	0.0	0.0
H	2.0	0.0	0.0	1.3	0.0	0.0	0.0	68.1	0.0	0.0	0.0	0.0	4.0
I	9.1	0.0	30.8	0.1	5.3	0.0	31.2	0.0	463.6	0.0	0.0	4.9	0.0
NL	0.0	2.5	0.0	0.0	9.9	0.0	0.1	0.0	0.0	195.1	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	133.3	0.0	0.0
SLO	7.3	0.0	0.0	0.2	0.1	0.0	0.0	0.0	1.9	0.0	0.0	14.2	0.0
SK	1.7	0.0	0.0	5.6	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	58.8
	135.4	148.4	155.6	168.7	1308.5	829.6	1195.2	78.3	511.7	233.4	150.6	23.0	67.1
	109.4	141.8	132.6	183.1	1297.7	823.0	1232.0	75.3	545.0	207.5	160.6	23.6	73.6
	26.0	6.6	22.9	-14.4	10.8	6.6	-36.8	3.0	-33.3	25.8	-10.0	-0.7	-6.5
	49.5	25.3	62.2	22.3	79.7	38.4	73.3	10.2	48.1	38.3	17.2	8.8	8.3
	23.5	18.7	39.2	36.7	68.9	31.8	110.1	7.3	81.4	12.4	27.2	9.5	14.8

Table 3: Annual compensations, charges and net payments because of network use with the AP method

Again, all numbers in Table 3 are expressed in millions of euros. It follows the explanation of the figures in the table. If the numbers in any given column of Table 3, for instance column *F* for France, are considered:

- 31.2 means that the fraction of the French grid used by Italy is worth 31.2 million euros.
- 1121.9 is France's own utilization of its network.
- 1195.2 is the total cost of the French network and it is equal to the sum of all numbers in the column above.
- 1232.0 is the total use of France of the European network, including the French network, and it is equal to the sum of all numbers in the row labeled F.
- The difference between the two aggregate numbers: 1195.2 – 1232.0 = -36.8, is the inter-TSO payment for France. Since it is negative, France has to pay. This means that France uses other external networks more than other countries use the French network. This is the most important result of the analysis for France and this is why the corresponding row has been framed.

Consider now the numbers in row *F,* again for France:

- 20.0 represents the cost of that part of the Swiss network used by France.

There are also other numbers of interest in column *F,* for France:

- The number 73.3 in column *F* is the sum of all external utilizations of the French network by others (7.2 by Belgium, 14.5 by Switzerland, 5.8 by Germany, 14.6 by Spain, 31.2 by Italy and 0.1 by The Netherlands), excluding France's own use.

- Similarly, the number 110.1 in column *F* is the sum of all external utilizations that France makes of external networks, which are shown in row F, (22.1 of Belgium, 20.0 of Switzerland, 29.1 of Germany, 11.1 of Spain, 27.4 of Italy and 0.4 of The Netherlands).
- It should be clear by now that the difference between these two numbers: 73.3 – 110.1 also equals the inter-TSO payment for France: -36.8.

Results for inter-TSO payments because of losses

Inter-TSO payments because of network losses that are obtained with the AP method are presented in Table 4. All figures are expressed in millions of euros. The procedure used to compute compensations and charges is completely analogous to the one used for electrical use, and it was explained in section 3.2.1 of the Final Report of Phase I of this project. The total volume of inter-TSO payments for losses is much smaller than that of the inter-TSO payments for use of infrastructure. Inter-TSO payments for losses represent only 20% of the total volume of the payments for infrastructure. There are clear similarities between the results obtained for use and the ones obtained for losses. Some significant differences can be found, however. While France is the country with the most negative inter-TSO payment because of network use (see Table 3), it receives a net positive payment because of losses. These discrepancies can be explained in terms of the significant difference that may exist between the total cost of a line (which determines the compensations for the use of infrastructure) and the amount of flow it carries (which determines the losses to be compensated). Some lines of high capacity may carry far less power than others that are smaller. This may be the cause for the significant lack of proportion between the compensations for infrastructure and losses. One could argue that the French grid may probably be used to a greater extent than that of most other countries. The same argument is considered again when presenting the results obtained with the WWT method.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.0	0.0	0.0	0.6	0.7	0.0	0.0	0.1	0.9	0.0	0.0	0.5	0.2
B	0.0	20.9	0.0	0.0	0.2	0.0	3.1	0.0	0.0	1.2	0.0	0.0	0.0
CH	0.0	0.0	18.4	0.0	1.1	0.0	2.4	0.0	5.0	0.0	0.0	0.0	0.0
CZ	2.0	0.0	0.0	9.7	3.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.5
D	1.7	0.1	2.5	1.4	153.0	0.0	2.5	0.0	0.9	2.5	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	101.7	3.8	0.0	0.0	0.0	1.8	0.0	0.0
F	0.0	2.9	3.3	0.0	5.0	1.7	233.0	0.0	7.5	0.1	0.0	0.0	0.0
H	0.2	0.0	0.0	0.1	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.8
I	1.8	0.0	10.1	0.0	0.7	0.0	11.3	0.0	67.3	0.0	0.0	1.2	0.0
NL	0.0	0.8	0.0	0.0	2.4	0.0	0.0	0.0	0.0	23.1	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	21.5	0.0	0.0
SLO	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.4	0.0
SK	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	6.2
	20.2	24.7	34.3	12.1	166.4	106.6	256.1	7.8	81.8	26.8	23.3	4.2	7.8
	16.0	25.5	27.0	15.5	164.6	107.2	253.4	8.0	92.5	26.4	24.8	3.9	7.6
	4.2	-0.8	7.4	-3.4	1.9	-0.6	2.8	-0.2	-10.6	0.5	-1.5	0.3	0.1
	7.2	3.8	15.9	2.5	13.4	4.9	23.2	0.9	14.6	3.8	1.8	1.9	1.5
	3.0	4.6	8.6	5.9	11.5	5.6	20.4	1.1	25.2	3.3	3.3	1.6	1.4

Table 4: Annual compensations, charges and net payments because of network losses with the AP method

3.2.2 Results for the With-and-Without Transit method (WWT)

The new algorithm to track flows with 13 separate data sets of real network flows.

The fact that a different set of data was provided for each country did not affect the application of the method substantially. The method already considered each country disconnected from the rest of the system when determining its compensation. Contributions to the global compensation fund are computed on the basis of the net export of each country, which does not need any data related to connectivity. Some programming was necessary, however, to deal now with several data files while only one was used originally.

Results for the inter-TSO payments because of network use

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	99.0	0.2	1.6	-0.5	1.9	-0.4	0.0	0.7	0.0	0.3	-0.1	0.1	0.2
B	1.4	141.1	2.2	-0.6	2.7	-0.7	0.0	1.0	0.0	0.5	-0.1	0.1	0.2
CH	2.0	0.6	97.8	-1.0	4.3	-1.3	0.1	1.6	0.0	0.8	-0.2	0.2	0.4
CZ	2.2	0.5	3.6	202.3	4.2	-0.8	0.0	1.5	0.0	0.8	-0.4	0.2	0.5
D	1.8	0.7	3.5	-1.3	1261.8	-1.9	0.0	1.7	0.0	0.6	-0.4	0.2	0.6
E	1.4	0.3	2.2	-0.6	2.4	849.9	0.0	0.9	0.0	0.6	-0.1	0.2	0.2
F	15.3	3.3	24.2	-6.9	28.4	-6.2	1198.3	10.4	0.1	5.4	-1.3	1.5	2.7
H	0.7	0.2	1.2	-0.4	1.5	-0.4	0.0	70.8	0.0	0.2	-0.1	0.1	0.2
I	11.3	2.3	17.6	-5.0	20.6	-4.0	0.4	7.4	516.1	4.1	-0.9	1.1	2.0
NL	3.6	0.9	5.7	-1.8	7.8	-1.6	0.1	2.6	0.0	227.8	-0.5	0.3	0.9
P	0.5	0.1	0.7	-0.2	0.8	-0.2	0.0	0.3	0.0	0.2	154.9	0.0	0.1
SLO	0.5	0.1	0.8	-0.2	1.0	-0.2	0.0	0.3	0.0	0.2	-0.1	22.6	0.1
SK	0.9	0.2	1.4	-0.4	1.6	-0.3	0.0	0.6	0.0	0.3	0.0	0.1	74.7
	140.6	150.5	162.4	183.3	1339.0	831.8	1199.1	99.8	516.4	241.9	150.7	26.7	83.0
	103.1	147.8	105.2	214.7	1267.4	857.4	1275.2	73.8	573.0	245.9	157.2	25.2	79.1
	37.5	2.7	57.2	-31.4	71.6	-25.6	-76.0	25.9	-56.6	-4.0	-6.5	1.5	3.8
	41.6	9.3	64.6	-19.0	77.2	-18.1	0.8	29.0	0.3	14.0	-4.2	4.1	8.2
	4.1	6.6	7.4	12.4	5.6	7.5	76.8	3.0	56.9	18.1	2.3	2.6	4.4

Table 5: Annual compensations, charges and net payments for network use with the WWT method

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
C01	75.7	3.7	93.4	-13.3	91.3	-8.8	0.3	33.2	0.0	63.6	10.1	6.8	-2.9
CH1	2.8	11.7	13.6	18.5	4.2	23.7	135.4	0.4	110.3	12.6	4.2	6.9	8.8
N1	72.8	-8.0	79.9	-31.7	87.0	-32.6	-135.1	32.9	-110.3	51.0	6.0	-0.1	-11.8
CO2	76.6	11.4	88.6	-16.3	164.4	-12.7	2.9	26.5	0.0	31.7	26.8	6.1	3.8
CH2	7.5	12.1	16.0	16.9	17.5	21.0	153.8	5.0	116.3	25.4	2.8	6.1	9.5
N2	69.1	-0.7	72.6	-33.2	146.9	-33.7	-150.9	21.5	-116.3	6.4	24.0	-0.1	-5.7
CO3	73.4	2.6	81.1	-22.0	199.3	-19.5	0.9	26.5	0.0	15.8	27.3	5.7	7.4
CH3	5.7	15.2	8.7	16.2	11.4	21.0	150.7	4.7	112.2	34.8	4.4	4.9	8.7
N3	67.7	-12.5	72.3	-38.2	187.8	-40.5	-149.7	21.8	-112.2	-19.0	22.9	0.8	-1.2
CO4	27.1	3.2	92.2	-17.1	-45.3	-21.3	0.0	36.5	0.0	25.8	-7.7	8.4	2.3
CH4	2.2	3.6	0.5	5.9	8.0	6.4	39.0	1.6	29.2	4.7	0.5	1.0	1.6
N4	24.9	-0.5	91.8	-23.1	-53.3	-27.7	-39.0	34.9	-29.2	21.1	-8.2	7.4	0.7
CO5	38.8	9.4	53.9	-15.5	87.3	-18.3	2.8	23.3	0.0	3.7	-11.0	8.8	3.4
CH5	8.7	5.5	6.5	4.0	1.3	10.2	73.6	5.2	45.1	19.6	3.1	1.2	2.6
N5	30.1	3.8	47.4	-19.4	85.9	-28.5	-70.7	18.1	-45.1	-15.9	-14.1	7.6	0.8
CO6	43.5	2.8	61.5	-5.8	19.9	-11.4	2.1	26.5	0.0	4.9	0.6	9.0	-0.3
CH6	4.9	5.9	3.1	3.0	3.5	8.8	63.4	1.5	38.9	15.0	2.1	0.9	2.3
N6	38.6	-3.2	58.5	-8.8	16.4	-20.2	-61.3	25.1	-38.9	-10.1	-1.6	8.1	-2.6
CO7	64.4	3.3	84.2	-21.8	91.3	15.4	9.4	28.1	0.4	17.0	-16.0	8.2	16.7
CH7	3.5	6.6	11.6	18.8	4.3	5.5	91.3	3.8	106.6	34.2	4.8	4.0	5.7
N7	60.9	-3.3	72.6	-40.6	87.0	9.9	-81.9	24.3	-106.1	-17.2	-20.8	4.2	11.0
CO8	41.9	12.5	71.3	-15.1	175.5	15.2	0.1	31.2	0.6	7.2	-18.6	6.5	15.9
CH8	9.2	13.1	17.6	17.5	8.4	2.2	126.0	1.9	97.4	39.2	1.6	4.6	5.3
N8	32.7	-0.6	53.7	-32.6	167.0	13.0	-125.9	29.2	-96.8	-32.1	-20.2	1.9	10.6
CO9	48.0	4.1	68.1	-13.3	118.1	21.4	0.6	27.7	2.9	7.5	-17.1	-2.0	21.9
CH9	8.9	8.2	11.8	15.0	1.5	2.9	106.7	5.9	77.5	38.8	1.9	4.4	4.2
N9	39.1	-4.1	56.3	-28.3	116.5	18.5	-106.1	21.8	-74.6	-31.4	-18.9	-6.5	17.7
CO10	50.4	8.0	68.4	-23.9	-45.3	3.1	0.0	30.0	1.1	15.4	-23.4	5.7	21.8
CH10	1.4	3.8	2.2	9.3	8.4	4.3	41.0	1.5	26.7	9.8	0.4	1.4	1.0
N10	49.0	4.2	66.1	-33.2	-53.7	-1.2	-41.0	28.5	-25.6	5.6	-23.8	4.3	20.7
CO11	-23.7	11.8	6.5	-14.5	106.6	-41.3	-2.0	19.3	0.0	3.7	-20.8	5.7	27.8
CH11	3.2	2.7	8.8	5.6	-4.7	3.7	27.9	2.2	17.4	9.6	0.7	1.6	0.6
N11	-26.9	9.1	-2.3	-20.0	111.3	-44.9	-29.9	17.0	-17.4	-5.9	-21.5	4.1	27.2
CO12	-10.0	1.4	33.2	-3.8	70.4	-23.4	-2.6	19.9	1.4	7.0	-21.6	3.8	30.6
CH12	1.4	2.8	6.9	7.7	5.9	5.7	37.3	3.1	22.8	10.0	0.4	1.9	0.7
N12	-11.4	-1.4	26.3	-11.4	64.5	-29.1	-39.9	16.7	-21.3	-2.9	-22.0	2.0	29.9
CO13	58.0	7.7	86.7	-32.9	91.3	1.9	0.0	31.6	0.0	25.0	-8.5	0.8	12.6
CH13	8.6	1.6	0.4	34.5	3.2	9.3	90.1	5.8	84.0	20.3	6.0	3.5	6.8
N13	49.4	6.2	86.3	-67.4	88.0	-7.4	-90.1	25.8	-84.0	4.7	-14.5	-2.8	5.8
CO14	44.3	28.5	68.1	-30.8	175.5	-18.3	0.0	32.1	0.0	8.7	-19.3	-1.9	12.6
CH14	3.4	10.4	3.4	29.9	5.3	11.1	119.6	4.8	72.3	27.1	2.7	3.5	6.0
N14	40.9	18.1	64.7	-60.7	170.2	-29.4	-119.6	27.2	-72.3	-18.4	-22.0	-5.3	6.6
CO15	40.7	7.9	77.3	-23.5	118.1	1.5	0.0	33.4	0.0	5.1	-2.8	-2.0	18.8
CH15	6.7	6.1	1.2	26.2	1.2	6.2	105.1	8.0	67.8	33.9	3.7	3.6	4.9
N15	34.0	1.8	76.1	-49.6	116.9	-4.6	-105.1	25.5	-67.8	-28.8	-6.5	-5.6	14.0
CO16	57.4	9.9	84.4	-24.9	-45.3	-25.0	0.0	36.5	0.0	10.4	-14.9	2.4	8.5
CH16	1.5	2.2	0.5	11.5	7.4	4.3	35.0	1.4	24.6	8.2	0.6	0.9	1.2
N16	55.8	7.7	83.8	-36.4	-52.8	-29.2	-34.9	35.1	-24.6	2.2	-15.6	1.5	7.3
CO17	14.5	29.0	4.0	-31.2	106.6	-53.4	0.0	23.3	0.0	1.6	-8.1	-5.1	8.8
CH17	0.3	3.5	12.2	7.5	-2.8	3.8	27.7	2.3	20.3	11.5	1.5	1.2	1.0
N17	14.1	25.6	-8.2	-38.7	109.3	-57.2	-27.7	21.0	-20.3	-9.9	-9.6	-6.3	7.9
CO18	44.2	8.3	55.4	-39.9	70.4	-53.6	-2.6	31.9	0.0	5.7	-16.4	-2.0	13.8
CH18	1.6	4.7	4.1	10.1	7.0	2.9	39.1	2.8	26.7	12.4	1.4	0.9	1.4
N18	42.6	3.6	51.3	-49.9	63.4	-56.5	-41.8	29.1	-26.7	-6.8	-17.8	-2.9	12.4
CO19	57.7	13.6	76.4	-13.3	91.3	5.4	4.1	33.2	0.0	35.5	1.7	7.4	-7.4
CH19	5.4	13.1	19.7	16.7	3.6	5.3	114.7	0.3	98.2	6.2	6.4	3.1	12.7
N19	52.3	0.4	56.7	-29.9	87.7	0.1	-110.6	32.9	-98.2	29.3	-4.7	4.2	-20.2
CO20	43.5	8.7	77.4	-16.3	108.7	-48.2	0.0	26.5	0.0	6.6	6.8	4.9	-9.5
CH20	3.3	6.4	5.0	7.8	13.4	9.9	83.4	2.1	51.5	15.7	2.5	1.6	6.6
N20	40.2	2.3	72.3	-24.0	95.2	-58.1	-83.4	24.4	-51.5	-9.1	4.4	3.3	-16.0
CO21	27.0	11.6	77.7	-22.0	41.3	-17.0	0.0	26.5	0.0	4.5	11.0	5.7	-2.3
CH21	0.1	5.2	3.3	6.0	17.3	6.2	62.6	1.5	38.5	16.1	0.4	2.0	5.0
N21	26.8	6.4	74.4	-28.0	24.0	-23.2	-62.6	25.1	-38.5	-11.6	10.6	3.7	-7.2
CO22	56.1	11.8	83.3	-17.1	-45.3	-48.8	0.6	36.5	0.0	5.8	3.7	7.3	-4.4
CH22	0.0	3.5	0.3	5.1	7.0	4.8	35.0	1.2	24.4	2.9	1.7	1.0	2.5
N22	56.1	8.3	83.0	-22.2	-52.4	-53.6	-34.4	35.3	-24.4	2.9	2.0	6.4	-6.9
CO23	24.7	5.1	22.8	-15.5	87.3	-49.1	2.7	23.3	0.0	11.3	9.2	5.3	-3.9
CH23	4.6	6.3	11.4	2.7	0.5	0.5	45.3	3.2	29.5	13.6	1.0	1.0	3.4
N23	20.1	-1.3	11.4	-18.2	86.7	-49.6	-42.5	20.1	-29.5	-2.4	8.2	4.2	-7.3
CO24	23.3	7.4	34.4	-5.8	19.9	-28.4	-0.3	31.9	0.0	13.3	8.6	2.4	1.4
CH24	3.0	4.7	8.7	2.1	2.2	0.8	40.8	2.5	26.6	11.5	0.7	1.7	2.8
N24	20.3	2.7	25.7	-7.8	17.7	-29.1	-41.1	29.4	-26.6	1.8	7.8	0.7	-1.4

Table 6: Compensations, charges and net payments for each one of the 24 scenarios obtained with the WWT method

Results for the inter-TSO payments because of losses

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.7	0.0	0.4	0.0	0.2	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
B	0.2	24.4	0.6	-0.1	0.3	-0.2	0.0	0.1	0.0	0.0	-0.1	0.1	0.0
CH	0.3	0.0	18.8	-0.1	0.5	-0.4	0.0	0.2	0.0	0.1	-0.1	0.1	0.0
CZ	0.4	0.0	1.0	15.7	0.6	-0.2	0.0	0.2	0.0	0.0	-0.1	0.1	0.0
D	0.1	0.1	0.8	-0.1	161.7	-0.5	0.0	0.2	0.0	0.0	-0.1	0.1	0.0
E	0.2	0.0	0.6	-0.1	0.3	112.3	0.0	0.1	0.0	0.0	0.0	0.1	0.0
F	2.7	0.2	6.4	-0.8	3.1	-1.9	256.5	1.0	0.0	0.3	-0.6	0.7	-0.1
H	0.1	0.0	0.3	0.0	0.2	-0.1	0.0	7.6	0.0	0.0	0.0	0.0	0.0
I	2.1	0.1	4.7	-0.5	2.3	-1.2	0.1	0.7	82.4	0.2	-0.4	0.5	0.0
NL	0.6	0.1	1.4	-0.2	0.9	-0.5	0.0	0.3	0.0	26.7	-0.1	0.2	0.0
P	0.1	0.0	0.2	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	25.1	0.0	0.0
SLO	0.1	0.0	0.2	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0
SK	0.2	0.0	0.4	0.0	0.2	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	8.6
	20.8	25.1	35.8	13.8	170.3	106.8	256.8	10.6	82.5	27.5	23.3	4.8	8.6
	14.2	25.4	19.3	17.8	162.2	113.5	267.6	8.1	91.0	29.3	25.4	3.4	9.3
	6.6	-0.3	16.5	-4.0	8.1	-6.7	-10.8	2.5	-8.5	-1.8	-2.1	1.5	-0.7
	7.1	0.6	17.0	-2.0	8.7	-5.5	0.3	2.9	0.1	0.7	-1.7	1.8	-0.1
	0.5	0.9	0.5	2.0	0.6	1.2	11.1	0.4	8.6	2.6	0.4	0.4	0.7

Table 7: Annual compensations, charges and net payments for losses with the WWT method

As with Average Participations, results for losses with the WWT method bear some resemblance with the ones for electrical use. There are however some discrepancies that can be explained when taking into account the fact that the full cost of a line has been assigned to those countries making use of it, with independence of the degree of total utilization of the capacity of the line. There are many long lines whose level of utilization is very small. For some of them the impact of the transit on the flow over the line calculated with the WWT method may be quite large. These lines will contribute much more to the compensation due to the corresponding country because of network use (in proportion to the total volume of compensations for this concept) than to the compensation because of transmission losses. It can be observed again that, on average, the volume of the compensations for losses is much smaller than the corresponding amounts for network use.

3.2.3 Results for the Average Participations applied to Transits method (APT)

The new algorithm to track flows with 13 separate data sets of real network flows.

Similar modifications to those made for the AP method were necessary to adapt the APT method to the new data format. The new algorithm is basically the same as that for the AP method, bearing in mind that in this method countries are compensated only for the use made of its grid by cross-border flows that are part of the transit they host.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
C01	54.4	10.4	62.8	7.4	75.0	18.6	0.8	7.7	0.0	16.9	18.2	7.9	2.4
CH1	9.4	8.5	9.8	38.0	36.8	18.3	61.8	2.6	62.4	6.2	12.6	4.7	11.3
N1	44.9	1.9	53.0	-30.5	38.2	0.3	-61.0	5.0	-62.4	10.8	5.6	3.1	-8.9
CO2	54.7	13.5	65.1	9.9	75.3	19.8	1.1	7.2	0.0	10.7	16.2	6.5	5.8
CH2	13.0	0.3	12.6	36.6	37.3	16.6	61.4	4.3	63.0	8.5	13.3	10.2	8.7
N2	41.7	13.2	52.4	-26.7	38.1	3.2	-60.3	3.0	-63.0	2.2	2.8	-3.7	-2.9
CO3	59.5	10.1	62.5	9.6	70.4	23.1	0.5	5.9	0.0	10.8	16.6	6.6	6.0
CH3	11.4	2.8	10.7	38.9	37.4	16.9	53.5	4.2	58.4	9.2	16.9	12.4	9.0
N3	48.1	7.3	51.8	-29.3	33.0	6.1	-53.0	1.8	-58.4	1.6	-0.3	-5.8	-3.0
CO4	34.3	12.0	60.0	11.4	49.5	17.3	0.0	8.5	0.0	9.5	17.0	9.0	2.2
CH4	8.7	6.0	6.9	23.6	28.1	17.0	55.1	4.0	48.1	6.5	12.2	3.3	11.4
N4	25.7	6.0	53.1	-12.1	21.4	0.3	-55.1	4.5	-48.1	3.0	4.8	5.7	-9.2
CO5	24.7	18.6	41.2	15.9	87.1	24.1	1.9	3.8	0.0	3.3	19.3	8.2	2.8
CH5	18.5	2.1	17.0	31.2	26.4	19.8	56.1	3.0	20.7	26.0	18.5	3.5	8.2
N5	6.2	16.5	24.1	-15.3	60.7	4.3	-54.2	0.9	-20.7	-22.7	0.8	4.7	-5.4
CO6	24.4	10.5	48.9	13.5	82.2	26.2	0.7	5.0	0.0	4.1	20.4	8.9	4.3
CH6	18.0	2.4	11.6	32.8	20.1	20.8	55.9	3.8	28.1	22.7	19.4	4.4	9.1
N6	6.3	8.1	37.3	-19.4	62.1	5.4	-55.2	1.2	-28.1	-18.6	1.1	4.5	-4.8
CO7	53.6	11.8	51.6	7.0	80.9	22.4	8.4	9.4	0.3	8.0	8.9	10.8	9.2
CH7	19.1	4.1	8.4	36.3	35.6	13.6	54.3	6.7	57.7	9.4	17.4	11.1	8.5
N7	34.5	7.7	43.2	-29.3	45.3	8.8	-45.9	2.7	-57.4	-1.5	-8.5	-0.2	0.6
CO8	42.3	17.5	47.7	6.8	71.9	26.7	0.1	8.5	1.3	6.3	9.1	10.1	8.8
CH8	13.1	3.2	9.0	26.7	25.4	9.1	72.3	5.5	44.4	10.2	21.5	8.4	8.3
N8	29.2	14.3	38.7	-20.0	46.5	17.5	-72.1	3.0	-43.1	-3.8	-12.4	1.7	0.5
CO9	36.0	14.3	50.0	9.6	84.1	22.1	0.3	8.8	0.8	5.7	7.8	4.8	9.8
CH9	16.6	2.7	6.6	30.0	20.4	7.8	75.3	7.8	36.6	12.6	18.5	11.4	8.0
N9	19.4	11.6	43.4	-20.3	63.8	14.2	-75.0	1.0	-35.8	-6.9	-10.7	-6.6	1.8
CO10	41.1	11.9	50.0	10.0	49.7	16.0	0.4	7.3	0.4	8.8	6.8	8.9	9.4
CH10	17.1	3.2	5.1	25.1	25.4	6.8	56.4	6.8	39.6	6.2	11.5	9.1	8.1
N10	23.9	8.6	44.9	-15.2	24.3	9.2	-56.0	0.5	-39.1	2.6	-4.8	-0.2	1.2
CO11	32.2	19.8	15.5	9.7	35.3	23.9	5.4	3.6	0.0	3.8	14.6	9.1	7.2
CH11	15.6	2.5	11.0	18.5	19.7	15.5	41.0	5.8	12.3	10.0	18.6	2.7	7.0
N11	16.6	17.3	4.4	-8.7	15.7	8.4	-35.6	-2.2	-12.3	-6.2	-4.0	6.5	0.2
CO12	32.5	13.6	29.3	12.0	30.0	17.3	2.8	5.0	0.3	5.4	8.6	7.4	10.0
CH12	13.8	3.3	6.5	19.4	20.6	8.9	44.5	8.1	16.3	7.6	13.4	4.6	7.4
N12	18.7	10.2	22.7	-7.4	9.5	8.5	-41.7	-3.2	-16.0	-2.1	-4.8	2.9	2.6
CO13	47.2	15.8	76.9	3.5	81.4	16.1	0.0	9.1	0.0	11.3	9.5	6.1	6.7
CH13	16.0	6.6	8.3	39.3	34.3	9.5	59.8	5.0	66.0	9.4	16.1	6.4	6.9
N13	31.2	9.1	68.6	-35.7	47.2	6.6	-59.8	4.1	-66.0	2.0	-6.6	-0.4	-0.3
CO14	44.8	24.2	65.4	5.3	68.8	20.3	0.0	7.0	0.0	7.1	9.3	5.2	8.0
CH14	9.1	3.5	7.8	36.4	26.3	9.3	81.3	4.7	48.5	11.3	15.2	5.1	7.1
N14	35.7	20.6	57.6	-31.0	42.5	11.0	-81.3	2.3	-48.5	-4.1	-5.9	0.1	0.9
CO15	41.4	14.9	72.9	5.8	84.1	16.0	0.0	6.4	0.0	6.3	11.8	5.5	8.8
CH15	9.1	2.9	9.1	35.0	22.1	11.8	73.9	6.0	61.2	13.6	16.0	7.3	5.9
N15	32.3	12.0	63.8	-29.2	62.0	4.2	-73.9	0.4	-61.2	-7.4	-4.2	-1.8	2.8
CO16	44.4	12.8	66.8	10.8	57.5	20.0	0.4	8.7	0.0	7.4	7.3	6.8	4.0
CH16	14.9	4.2	6.1	31.0	30.6	7.3	53.6	6.8	54.9	6.3	16.7	4.9	9.6
N16	29.6	8.6	60.7	-20.3	26.9	12.6	-53.2	1.9	-54.9	1.1	-9.4	1.9	-5.6
CO17	39.3	22.2	9.9	11.8	35.8	27.6	0.0	3.9	0.0	3.3	3.8	4.3	5.9
CH17	10.3	2.2	10.1	21.6	21.2	3.8	38.1	5.6	7.1	11.6	24.0	4.4	7.9
N17	29.0	20.0	-0.2	-9.8	14.6	23.8	-38.1	-1.7	-7.1	-8.3	-20.2	-0.1	-2.1
CO18	38.4	10.7	39.1	14.3	31.2	28.7	3.1	5.0	0.0	5.0	14.3	5.3	6.4
CH18	11.5	3.0	5.5	20.2	26.3	14.5	39.7	7.5	25.6	6.8	25.1	7.2	8.6
N18	26.9	7.7	33.6	-5.8	4.9	14.2	-36.6	-2.5	-25.6	-1.8	-10.8	-1.9	-2.2
CO19	41.3	12.0	58.9	12.1	82.5	26.8	1.4	10.5	0.0	18.9	11.0	7.3	1.8
CH19	17.9	14.4	11.9	31.4	29.2	11.4	66.2	1.6	50.4	7.2	17.1	6.3	19.5
N19	23.4	-2.4	47.0	-19.3	53.3	15.5	-64.7	8.9	-50.4	11.7	-6.1	1.0	-17.6
CO20	45.2	16.1	72.3	12.6	63.3	24.5	0.0	6.9	0.0	7.4	11.4	8.0	3.9
CH20	14.7	3.5	11.9	32.7	35.5	11.4	59.7	2.1	54.6	7.5	15.7	8.3	13.9
N20	30.6	12.6	60.4	-20.0	27.7	13.2	-59.7	4.8	-54.6	-0.2	-4.3	-0.3	-10.1
CO21	50.8	17.2	62.8	12.1	63.6	26.6	0.0	7.5	0.0	6.7	15.3	8.7	3.7
CH21	18.2	3.3	11.9	35.1	28.6	15.3	60.3	2.4	49.7	9.0	18.5	7.0	15.5
N21	32.6	13.9	50.9	-23.0	34.9	11.3	-60.3	5.0	-49.7	-2.3	-3.2	1.6	-11.9
CO22	40.5	14.0	54.0	15.9	55.1	23.1	0.2	6.8	0.0	6.0	8.0	6.5	3.1
CH22	5.8	4.6	10.0	26.0	26.3	8.1	60.5	1.7	50.9	5.0	14.5	3.3	16.5
N22	34.7	9.4	44.0	-10.2	28.8	15.1	-60.3	5.1	-50.9	0.9	-6.5	3.2	-13.4
CO23	19.5	10.0	21.8	20.6	81.5	39.8	5.2	3.3	0.0	4.2	10.1	8.0	2.8
CH23	17.4	1.8	15.4	28.1	21.8	11.3	46.3	1.0	13.8	24.0	30.7	2.3	13.0
N23	2.1	8.3	6.4	-7.5	59.6	28.5	-41.1	2.3	-13.8	-19.8	-20.5	5.7	-10.2
CO24	23.7	13.6	21.0	17.9	75.8	29.2	3.2	4.4	0.0	5.2	10.6	6.4	2.8
CH24	16.3	2.1	13.6	28.8	21.6	11.1	47.1	1.0	13.1	19.8	22.9	2.9	13.2
N24	7.4	11.4	7.3	-10.9	54.2	18.1	-43.9	3.4	-13.1	-14.6	-12.4	3.6	-10.5

Table 8: Compensations, charges and net payments for each one of the 24 scenarios obtained with the APT method

Results for the inter-TSO payments because of network use

Table 8 show the compensations, charges and net payments obtained with APT for the 24 scenarios. Table 9 is the traditional matrix of compensations and charges obtained for the average scenario when the APT method is used.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	96.2	0.0	0.0	2.8	5.9	0.0	0.0	1.2	0.0	0.0	0.0	3.4	0.6
B	0.0	134.5	0.0	0.0	0.5	0.0	0.1	0.0	0.0	3.3	0.0	0.0	0.0
CH	0.7	0.0	106.8	0.0	8.5	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
CZ	12.0	0.0	0.0	158.2	14.4	0.0	0.0	0.8	0.0	0.0	0.0	0.3	2.7
D	9.9	0.4	8.9	3.7	1248.8	0.0	0.1	0.0	0.0	4.2	0.0	0.1	0.0
E	0.0	0.0	0.0	0.0	0.0	806.9	0.4	0.0	0.0	0.0	11.9	0.0	0.0
F	0.0	11.8	17.1	0.0	22.8	5.4	1197.3	0.0	0.1	0.0	0.0	0.0	0.0
H	1.7	0.0	0.0	0.4	0.0	0.0	0.0	74.9	0.0	0.0	0.0	0.0	2.4
I	8.4	0.0	24.3	0.0	4.5	0.0	0.3	0.0	516.1	0.0	0.0	3.5	0.0
NL	0.0	2.3	0.0	0.0	8.8	0.0	0.0	0.0	0.0	231.4	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	17.8	0.0	0.0	0.0	0.0	138.7	0.0	0.0
SLO	6.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	16.2	0.0
SK	1.4	0.0	0.0	4.0	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	62.9
	136.4	149.0	157.1	169.3	1314.3	830.1	1198.8	81.6	516.2	239.0	150.6	23.6	68.5
	110.1	138.4	116.7	188.3	1276.2	819.2	1254.5	79.4	557.1	242.5	156.4	22.5	73.0
	26.3	10.6	40.4	-19.0	38.1	10.8	-55.8	2.2	-40.8	-3.5	-5.8	1.1	-4.5
	40.3	14.5	50.3	11.1	65.5	23.2	1.5	6.7	0.1	7.6	11.9	7.4	5.7
	14.0	3.9	9.9	30.1	27.4	12.3	57.3	4.5	41.0	11.1	17.8	6.3	10.1

Table 9: Annual compensations, charges and net payments because of network use with the APT method

Results for the inter-TSO payments because of network losses

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	14.5	0.0	0.0	0.2	0.7	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.1
B	0.0	22.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
CH	0.0	0.0	21.5	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CZ	1.6	0.0	0.0	10.9	2.7	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.4
D	1.2	0.0	2.0	0.7	156.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	103.6	0.0	0.0	0.0	0.0	1.3	0.0	0.0
F	0.0	1.5	2.7	0.0	3.7	0.8	256.5	0.0	0.0	0.0	0.0	0.0	0.0
H	0.1	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.5
I	1.6	0.0	8.3	0.0	0.6	0.0	0.1	0.0	82.5	0.0	0.0	0.9	0.0
NL	0.0	0.8	0.0	0.0	2.1	0.0	0.0	0.0	0.0	26.6	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	22.0	0.0	0.0
SLO	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
SK	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	6.9
	20.3	24.8	34.6	12.2	167.2	106.6	256.8	8.1	82.5	27.3	23.3	4.3	7.9
	16.1	23.0	22.4	15.7	160.9	104.9	265.3	8.2	94.1	29.6	24.2	3.9	7.8
	4.2	1.9	12.3	-3.5	6.3	1.8	-8.6	-0.1	-11.5	-2.3	-1.0	0.4	0.1
	5.8	2.4	13.1	1.3	10.7	3.0	0.3	0.6	0.0	0.7	1.3	1.5	1.0
	1.6	0.5	0.8	4.8	4.4	1.3	8.8	0.7	11.6	3.0	2.2	1.1	0.9

Table 10: Annual compensations, charges and net payments because of network losses with the APT method

The same comments can be made about these results as for the corresponding ones presented about the AP and WWT methods in the two preceding sections. In this case, however, they are quite similar to the ones obtained for use, always bearing in mind that they are much smaller in size.

3.2.4 Results for the Provisional method (PM)

Table 11 shows the compensations, charges and net payments obtained with PM for the 24 scenarios. Table 12 is the traditional matrix of compensations and charges obtained for the average scenario when the PM method is used.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
C01	76.0	16.7	66.3	29.7	142.8	23.6	1.5	32.6	0.0	26.9	15.7	14.5	17.3
CH1	3.9	15.0	20.9	21.9	5.2	28.8	177.5	0.5	145.1	19.1	5.5	9.0	11.1
N1	72.1	1.7	45.4	7.8	137.6	-5.3	-176.1	32.1	-145.1	7.8	10.2	5.5	6.2
CO2	58.4	23.6	62.1	38.3	109.5	25.5	2.2	23.0	0.0	17.0	13.6	11.7	23.0
CH2	7.8	11.6	17.1	14.6	21.2	18.9	152.6	5.0	115.1	26.1	2.8	6.0	9.0
N2	50.7	11.9	45.0	23.6	88.2	6.6	-150.3	18.0	-115.1	-9.1	10.7	5.7	14.0
CO3	57.5	14.7	57.8	36.3	109.7	29.9	0.6	23.0	0.0	13.9	15.2	11.5	24.8
CH3	5.9	14.5	9.2	13.8	16.5	18.3	149.2	4.7	110.9	34.6	4.5	4.7	8.2
N3	51.7	0.2	48.6	22.6	93.2	11.6	-148.6	18.3	-110.9	-20.7	10.7	6.7	16.6
CO4	59.0	15.8	66.4	42.8	113.4	25.5	0.0	25.6	0.0	12.5	13.4	13.2	20.3
CH4	10.2	14.3	14.7	18.0	15.7	19.7	154.5	9.1	115.5	24.2	1.8	4.0	6.1
N4	48.8	1.5	51.7	24.8	97.6	5.9	-154.5	16.5	-115.5	-11.7	11.6	9.1	14.2
CO5	36.1	21.4	46.5	49.7	112.8	31.9	3.4	13.0	0.0	3.3	13.0	12.3	23.7
CH5	19.4	10.7	15.5	6.2	3.4	16.5	144.9	11.2	88.1	38.7	5.5	2.5	4.8
N5	16.6	10.7	31.1	43.5	109.4	15.5	-141.5	1.9	-88.1	-35.3	7.5	9.9	18.9
CO6	39.9	14.4	49.4	48.0	108.3	39.1	1.6	23.0	0.0	4.2	14.7	12.5	21.7
CH6	15.0	14.2	10.9	6.2	7.0	17.9	156.9	4.1	94.8	37.3	5.0	2.4	5.3
N6	24.9	0.2	38.5	41.8	101.3	21.2	-155.3	19.0	-94.8	-33.1	9.7	10.1	16.5
CO7	57.9	16.9	65.9	22.7	142.8	22.4	10.5	26.3	0.8	12.9	10.2	13.1	21.4
CH7	5.4	9.0	19.2	23.3	5.7	7.7	129.3	5.4	149.4	49.5	6.2	5.6	8.0
N7	52.6	7.9	46.7	-0.6	137.1	14.7	-118.8	20.8	-148.6	-36.6	3.9	7.5	13.3
CO8	47.5	20.3	63.9	20.6	118.0	25.8	0.4	23.3	3.7	8.5	12.5	13.3	21.3
CH8	10.1	14.1	20.3	17.5	13.0	2.3	138.4	2.2	105.9	43.0	1.6	4.9	5.8
N8	37.3	6.2	43.7	3.1	105.0	23.5	-138.0	21.1	-102.3	-34.5	10.8	8.4	15.6
CO9	39.6	15.1	61.3	21.0	126.3	22.5	0.9	20.7	2.3	7.3	11.6	13.1	24.3
CH9	12.1	10.1	16.4	17.1	2.2	3.7	135.3	7.9	98.8	49.6	2.2	5.4	5.4
N9	27.5	5.0	45.0	3.9	124.1	18.8	-134.4	12.9	-96.5	-42.3	9.4	7.7	18.9
CO10	39.7	12.3	60.2	29.8	113.4	22.1	1.3	22.2	1.4	11.8	12.5	11.1	21.6
CH10	7.3	12.9	16.3	22.7	13.2	13.5	133.3	6.1	87.9	36.3	1.1	4.8	3.9
N10	32.4	-0.6	43.9	7.0	100.1	8.6	-132.0	16.1	-86.5	-24.5	11.4	6.3	17.7
CO11	48.9	19.6	30.5	35.7	76.2	28.6	7.8	9.9	0.0	4.0	15.1	13.3	23.8
CH11	7.6	9.9	29.2	14.7	41.1	8.0	90.2	9.3	59.6	33.9	1.8	5.5	2.6
N11	41.3	9.8	1.3	21.0	35.1	20.6	-82.4	0.5	-59.6	-29.8	13.3	7.8	21.2
CO12	40.6	13.3	44.1	34.3	63.8	18.9	3.0	14.2	0.7	5.5	13.4	9.8	28.6
CH12	2.8	6.9	21.3	16.9	36.2	11.4	91.6	9.2	59.2	26.9	0.9	4.8	2.1
N12	37.8	6.4	22.7	17.5	27.6	7.5	-88.6	5.0	-58.5	-21.4	12.5	5.0	26.4
CO13	52.8	18.7	80.7	29.9	142.8	12.7	0.0	28.6	0.0	13.1	8.6	13.6	21.9
CH13	15.1	2.4	0.8	44.1	5.1	14.2	141.2	9.6	131.7	34.1	8.9	5.4	10.6
N13	37.8	16.3	79.8	-14.2	137.7	-1.6	-141.2	18.9	-131.7	-21.0	-0.3	8.2	11.3
CO14	55.0	27.5	72.9	28.9	118.0	22.1	0.0	24.9	0.0	9.0	12.1	13.2	21.4
CH14	4.7	14.5	4.9	33.9	12.6	13.4	162.7	6.9	98.3	37.1	3.4	4.5	8.0
N14	50.3	13.0	68.1	-5.0	105.5	8.6	-162.7	18.0	-98.3	-28.1	8.7	8.7	13.3
CO15	47.8	15.4	75.0	26.0	126.3	12.8	0.0	21.8	0.0	8.2	10.0	13.1	25.6
CH15	9.7	8.5	1.8	31.3	2.0	8.4	148.1	12.1	95.6	47.7	5.1	4.9	6.9
N15	38.1	6.9	73.2	-5.2	124.3	4.4	-148.1	9.7	-95.6	-39.5	5.0	8.2	18.8
CO16	54.2	15.0	77.2	44.8	113.4	18.4	1.3	25.6	0.0	9.9	8.4	12.5	20.1
CH16	13.2	9.6	13.6	33.1	15.0	13.4	144.1	8.7	101.7	37.4	2.3	3.7	5.1
N16	41.0	5.4	63.6	11.8	98.4	5.0	-142.8	16.9	-101.7	-27.5	6.1	8.8	15.1
CO17	50.8	20.0	23.5	50.1	76.2	30.2	0.0	13.0	0.0	3.7	5.0	10.1	23.9
CH17	1.0	13.3	34.9	14.6	39.0	7.0	82.7	8.3	60.7	34.5	4.1	3.4	3.0
N17	49.8	6.7	-11.4	35.5	37.2	23.3	-82.7	4.7	-60.7	-30.8	0.9	6.6	20.9
CO18	43.7	10.9	53.9	52.7	63.8	28.4	3.0	15.6	0.0	6.2	11.9	10.0	24.6
CH18	5.7	13.1	16.7	17.1	41.1	5.0	100.8	9.6	71.8	34.4	3.1	2.4	3.8
N18	38.0	-2.2	37.3	35.6	22.7	23.4	-97.9	6.0	-71.8	-28.2	8.8	7.6	20.7
CO19	52.8	19.1	57.2	29.7	142.8	47.9	3.6	32.6	0.0	16.8	14.8	12.9	10.6
CH19	8.4	18.8	33.0	21.3	5.0	6.9	165.7	0.5	140.6	9.7	8.9	4.5	17.4
N19	44.4	0.2	24.2	8.4	137.8	41.0	-162.1	32.1	-140.6	7.1	5.9	8.4	-6.8
CO20	51.9	16.1	69.6	38.3	93.1	35.0	0.0	23.0	0.0	7.3	16.7	12.4	14.5
CH20	6.2	11.1	11.2	11.5	38.3	13.0	146.5	3.9	90.5	28.0	4.3	2.8	10.6
N20	45.7	5.0	58.5	26.8	54.8	22.0	-146.5	19.1	-90.5	-20.6	12.4	9.6	3.8
CO21	59.1	17.6	59.5	36.3	94.1	37.9	0.0	23.0	0.0	6.7	15.8	13.8	13.1
CH21	0.3	12.3	11.8	11.1	39.8	11.7	143.9	3.8	88.5	37.5	0.9	4.5	10.9
N21	58.8	5.3	47.6	25.2	54.3	26.2	-143.9	19.3	-88.5	-30.8	14.9	9.4	2.2
CO22	58.1	15.8	60.0	42.8	113.4	37.1	0.4	25.6	0.0	7.1	11.8	12.3	18.0
CH22	0.4	17.3	29.7	17.0	14.9	12.6	157.1	8.6	108.5	13.7	7.7	4.6	10.2
N22	57.7	-1.6	30.2	25.8	98.5	24.4	-156.7	17.0	-108.5	-6.5	4.1	7.7	7.8
CO23	37.6	9.0	37.5	49.7	112.8	34.3	8.5	13.0	0.0	6.2	12.8	12.8	15.4
CH23	14.2	17.9	34.8	5.8	3.1	0.9	125.1	10.5	81.8	41.1	2.8	2.9	8.8
N23	23.4	-8.8	2.7	43.9	109.6	33.4	-116.6	2.5	-81.8	-34.9	10.1	9.9	6.6
CO24	35.7	14.7	37.5	48.0	108.3	36.2	4.9	15.6	0.0	7.6	12.2	11.2	14.0
CH24	10.6	15.0	35.8	5.2	5.7	1.7	123.2	10.3	82.5	39.8	2.4	5.2	8.4
N24	25.1	-0.3	1.7	42.8	102.5	34.5	-118.4	5.3	-82.5	-32.2	9.8	6.0	5.6

Table 11: Compensations, charges and net payments obtained with PM for each one of the 24 scenarios

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	90.5	0.4	1.4	0.9	2.8	0.7	0.1	0.5	0.0	0.2	0.3	0.3	0.5
B	1.7	133.6	1.9	1.3	3.8	1.0	0.1	0.7	0.0	0.3	0.4	0.4	0.7
CH	2.7	0.9	104.9	2.3	6.2	1.7	0.3	1.1	0.0	0.5	0.7	0.7	1.1
CZ	2.6	0.9	3.2	146.4	6.0	1.3	0.1	1.2	0.0	0.6	0.6	0.6	1.1
D	3.1	1.1	3.4	2.5	1228.9	1.8	0.2	1.2	0.0	0.5	0.8	0.7	1.3
E	1.6	0.5	1.9	1.2	3.6	803.9	0.1	0.7	0.0	0.4	0.4	0.4	0.7
F	17.8	6.1	21.3	13.5	40.8	10.1	1196.8	7.8	0.2	3.7	4.5	4.4	7.3
H	0.9	0.3	1.1	0.8	2.1	0.5	0.1	78.1	0.0	0.2	0.2	0.2	0.4
I	12.9	4.3	15.3	9.4	29.5	7.1	0.9	5.7	516.0	2.7	3.1	3.1	5.2
NL	4.4	1.5	5.3	3.5	10.3	2.5	0.3	1.9	0.1	232.3	1.1	1.1	1.9
P	0.5	0.2	0.6	0.4	1.2	0.3	0.0	0.2	0.0	0.1	138.2	0.1	0.2
SLO	0.6	0.2	0.7	0.4	1.4	0.3	0.0	0.3	0.0	0.1	0.1	14.3	0.2
SK	1.0	0.3	1.2	0.7	2.3	0.6	0.1	0.4	0.0	0.2	0.2	0.2	62.3
	140.6	150.5	162.4	183.3	1339.0	831.8	1199.1	99.8	516.4	241.9	150.7	26.7	83.0
	98.7	146.0	123.2	164.7	1245.6	815.4	1334.1	85.1	615.3	266.2	142.1	18.8	69.7
	41.8	4.4	39.1	18.6	93.3	16.4	-135.0	14.7	-98.9	-24.3	8.7	7.9	13.3
	50.0	16.8	57.5	36.9	110.1	27.9	2.3	21.6	0.4	9.6	12.5	12.4	20.6
	8.2	12.4	18.3	18.3	16.8	11.5	137.3	7.0	99.3	33.9	3.9	4.5	7.3

Table 12: Annual compensations, charges and net payments because of network use with the PM method

Quite understandably, the results obtained for the provisional method resemble most those of the WWT method. After all, in both methods the compensation to be paid to a country are related to the transit through the grid of the country, which is computed in the same way in WWT and PM. Besides, both methods follow the same procedure to allocate the compensation due to a country among all the others. But, when comparing the results for WWT and PM in more detail we can see how the negative net payments are concentrated in less countries in PM than in WWT. Thus, for example, in PM France has to pay € 135 million and Italy € 98.9 million whereas in WWT France has to pay € 76 million and Italy € 56.6 million. Consequently, there are some countries whose net result is positive for the PM method and negative for the WWT method. This is the case of Spain, the Czech Republic or Portugal. These differences are obviously explained by the different ways in which the impact of the transit on the use made of the grid of a country is determined in each method. The WWT method allows for the existence of negative compensations when the removal of the transit reduces the total use made of the grid. On the contrary, the compensations obtained with the PM method are always positive. In other words, the PM method does not provide for the possibility that a transit may actually reduce the utilization of the grid of a country instead of increasing it.

Results for the inter-TSO payments because of network losses

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	13.3	0.1	0.3	0.1	0.4	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1
B	0.2	22.2	0.4	0.1	0.5	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1
CH	0.4	0.2	22.9	0.2	0.8	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1
CZ	0.4	0.1	0.7	10.8	0.7	0.2	0.0	0.1	0.0	0.0	0.1	0.1	0.1
D	0.4	0.2	0.7	0.2	156.6	0.3	0.0	0.1	0.0	0.1	0.1	0.1	0.1
E	0.2	0.1	0.5	0.1	0.4	103.1	0.0	0.1	0.0	0.0	0.1	0.1	0.1
F	2.7	1.0	4.8	1.1	5.1	1.4	256.3	0.8	0.0	0.3	0.7	0.8	0.8
H	0.1	0.1	0.2	0.1	0.3	0.1	0.0	8.3	0.0	0.0	0.0	0.0	0.0
I	2.0	0.7	3.5	0.7	3.6	0.9	0.2	0.6	82.5	0.2	0.5	0.6	0.5
NL	0.6	0.3	1.1	0.3	1.3	0.4	0.1	0.2	0.0	26.6	0.2	0.2	0.2
P	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	21.3	0.0	0.0
SLO	0.1	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
SK	0.1	0.1	0.3	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	6.4
	20.8	25.1	35.8	13.8	170.3	106.8	256.8	10.6	82.5	27.5	23.3	4.8	8.6
	14.5	23.9	25.3	13.4	159.1	104.7	275.8	9.3	96.6	31.4	21.9	3.2	7.5
	6.3	1.1	10.5	0.3	11.3	2.1	-19.0	1.3	-14.0	-4.0	1.4	1.6	1.1
	7.5	2.9	12.9	3.0	13.7	3.7	0.5	2.3	0.1	0.9	2.0	2.2	2.1
	1.2	1.8	2.4	2.7	2.5	1.6	19.5	1.0	14.1	4.8	0.6	0.6	1.1

Table 13: Annual compensations, charges and net payments because of network losses with the PM method

There are obvious similarities between the results obtained for the compensations among TSOs because of network losses (see Table 13) and the ones because of network use (see Table 12). The sign of the net payment for any country is the same in both cases and those countries that pay and receive most are also the same. As happened with the other methods, the volume of the compensations for network losses is far less important than that for network use. It is also clear that the results for losses cannot exactly match those for network use because of several reasons. The relation between the losses over a line and the flow is not linear but quadratic. Additionally, when we compute compensations for network use the total cost of the lines is being assigned regardless of the level of utilization of each particular line. Thus, a long line whose flow is very small compared to its capacity would give rise to a small payment because of network losses (due to the fact that the flow is small) but probably a large payment because of network use. On the contrary, when the line is heavily used, the payment for losses will be much more important whereas the total payment for network use will remain unchanged.

3.3 Comments and conclusions

Table 14 is a summary of the compensations, charges and net payments because of network use that have been obtained with the four different methods examined. Some general conclusions that can be drawn from these numerical results were already commented in the final report of Phase I of this project. Those methods that link compensations to the use made by the transit of the grid of each country tend to favor heavily transited countries, like Germany or Switzerland, at the expense of others with large imports or exports, like France, Italy or The Netherlands. The compensation due to mainly importing or exporting countries with these methods is smaller than the amount they would receive if total cross border flows were taken into account instead of just transits. At the same time, when using the WWT method, countries importing or exporting heavily are the ones that are significantly charged to pay for these compensations. In this respect, a method like AP, which uses all cross border flows and not only part of them, seems to be more neutral to all types of countries.

Some results, however, look surprising at first sight. For example, the net payment to Spain when the WWT method is used is negative and large (i.e. Spain is assigned a large net payment). By contrast, both the AP and the APT methods yield positive net payments for Spain. This seems to be at odds with the fact that the transit through Spain is not particularly important. Results obtained with the WWT method, however, are difficult to predict since they critically depend on the internal distribution of flows in the country and how eliminating the transit affects them. In this case, the flow over many Spanish lines increases once the transit has been removed. Consequently, the transit reduces the global use made of the Spanish grid and Spain has to compensate others for this reduction. In short, both AP and APT methods respect the actual pattern of physical flows and therefore yield much more similar results for Spain that the WWT method, which forces an artificial transit across the Spanish grid.

The results for The Netherlands look quite shocking too. While the corresponding inter-TSO payment is large and positive with AP, it turns out to be negative both with APT and WWT. Since The Netherlands is a heavy importer with a very small transit flow, the compensation due to The Netherlands is much smaller when a method based on the transit is used than when all cross border flows are considered. Similar considerations apply to the cases of Italy and France.

The reason why AP results in large payments for The Netherlands is that, despite being a heavy importer, the use that the Dutch agents are making of the grid of neighboring countries (such as Belgium and Germany) is small. This is probably related to the fact that there are important generation centers in Belgium and, specially, in Germany that are very close to the Dutch border. Therefore, the Netherlands imports do not seem to result in a significant use of the grids of neighboring countries.

Countries with large transits and comparatively smaller net imports or exports tend to have much larger positive net payments with WWT, and also with APT, than with AP. This is for instance the case of Switzerland or Germany. The same type of conclusions can be drawn, in general, from the results for compensations because of network losses.

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
AP_CO	49.5	25.3	62.2	22.3	79.7	38.4	73.3	10.2	48.1	38.3	17.2	8.8	8.3
AP_CH	23.5	18.7	39.2	36.7	68.9	31.8	110.1	7.3	81.4	12.4	27.2	9.5	14.8
AP_N	26.0	6.6	22.9	-14.4	10.8	6.6	-36.8	3.0	-33.3	25.8	-10.0	-0.7	-6.5
WWT_CO	41.6	9.3	64.6	-19.0	77.2	-18.1	0.8	29.0	0.3	14.0	-4.2	4.1	8.2
WWT_CH	4.1	6.6	7.4	12.4	5.6	7.5	76.8	3.0	56.9	18.1	2.3	2.6	4.4
WWT_N	37.5	2.7	57.2	-31.4	71.6	-25.6	-76.0	25.9	-56.6	-4.0	-6.5	1.5	3.8
APT_CO	40.3	14.5	50.3	11.1	65.5	23.2	1.5	6.7	0.1	7.6	11.9	7.4	5.7
APT_CH	14.0	3.9	9.9	30.1	27.4	12.3	57.3	4.5	41.0	11.1	17.8	6.3	10.1
APT_N	26.3	10.6	40.4	-19.0	38.1	10.8	-55.8	2.2	-40.8	-3.5	-5.8	1.1	-4.5
PM_CO	50.0	16.8	57.5	36.9	110.1	27.9	2.3	21.6	0.4	9.6	12.5	12.4	20.6
PM_CH	8.2	12.4	18.3	18.3	16.8	11.5	137.3	7.0	99.3	33.9	3.9	4.5	7.3
PM_N	41.8	4.4	39.1	18.6	93.3	16.4	-135.0	14.7	-98.9	-24.3	8.7	7.9	13.3

Table 14: Summary of the results of inter-TSO payments among countries for the AP, WWT, APT and PM methods

4 Further examination of the preferred methods

4.1 Background

This chapter explores some less common features of the preferred methods to compute inter-TSO payments that were not addressed in the preceding chapter. In principle this will finalize the comparative evaluation of the three methods, adding new elements to what was presented in Phase I of the project.

Each one of the three methods for computation of inter-TSO payments that were analyzed in the last chapter has some degrees of freedom regarding its application. This is a consequence of ambiguities or not entirely justified assumptions in the definition of every method. Each one of them will be examined individually in sections 4.2, 4.3 and 4.4. The meaning of the numbers in the tables shown in this chapter has been already explained in Chapter 3 for Table 3 with the AP method.

4.2 Variants of the Average Participations method (AP)

A) The "basic" AP method.

In the basic AP method, -as it has been used in last chapter and in Phase I of this project-, all the demand in each node of the network is aggregated on one side, and the generation is also separately aggregated, but they are not netted out as a single net demand or a net generator. This appears to be the most consistent choice with the principles of the Florence Forum and the EU Regulation. Why? Because otherwise we would be incurring into some kind of "transaction based" network cost allocation approach. Assume that the aggregated generation of node k is GAk, the aggregated demand DAk and also that GAk > DAk. If we treat the node as having only a generator with an input to the network of GAk – DAk, this amounts to considering that a volume of generation DAk serves locally a load DAk, without using the transmission network, and therefore without paying for it. And this is certainly transaction based.

Compensations, charges and net payments for the first scenario of the 24 provided by ETSO, -when using the AP basic method-, are shown in Table 15.

	AT1	BE1	CH1	CZ1	DE7	ES1	FR1	HU1	IT1	NL1	PR1	SI1	SK1
AT1	73	0	0	3	5	0	0	0	4	0	0	2	0
BE1	0	168	0	0	2	0	7	0	0	6	0	0	0
CH1	0	0	77	0	10	0	21	0	9	0	0	0	0
CZ1	19	0	0	150	18	0	0	0	1	0	0	1	1
DE7	12	1	15	6	1208	0	7	0	5	23	0	0	0
ES1	0	0	0	0	0	769	18	0	0	0	21	0	0
FR1	0	20	25	0	27	22	1122	0	29	0	0	0	0
HU1	1	0	0	0	0	0	0	64	0	0	0	0	4
IT1	20	0	31	0	9	0	36	0	456	0	0	7	0
NL1	0	1	0	0	6	0	0	0	0	183	0	0	0
PR1	0	0	0	0	0	32	0	0	0	0	128	0	0
SI1	5	0	0	0	0	0	0	0	4	0	0	12	0
SK1	1	0	0	4	0	0	0	7	0	0	0	0	59
	131	190	149	164	1285	823	1211	72	509	212	149	22	64
	88	183	118	190	1277	809	1244	69	561	190	160	22	71
	43	6	31	-26	8	14	-33	3	-52	22	-11	0	-7
	58	22	72	13	77	54	88	8	53	29	21	10	5
	15	15	40	39	69	39	122	5	104	7	32	10	12

Table 15: Compensations, charges and net payments for the first scenario with the AP basic method

B) Variant 1: Generation and Load at each node are netted out before the AP method is applied.

Assume that the aggregated generation of node k is Gak and the aggregated demand is Dak. Then, if GAk > DAk the node will be treated as just having a generator GAk – DAk. On the contrary, if DAk > GAk, then the node will be handled as having just a demand of DAk – GAk.

As indicated before, one can argue that this is a transaction-based approach, since the procedure actually amounts to assuming that the network users that are in a minority position at any given node k, -for instance, the aggregated demand DAk, if DAk <GAk-, do not have to pay any transmission network charges. This variant of the AP method assumes that the demand at node k is supplied by the local generation, even if some of the lines connected at node k are feeding power to this node from external generation. This criticism appears to be solid, but one has to realize that this variant has a strong resemblance with the answer to the claim about the comparatively small but heavily transited countries that motivated the creation of the APT method (see report on Phase I, section 3.1.6).

Given that this variant is transaction based, it has been considered as inferior to the basic AP method and hence it has not been programmed and no numerical results have been obtained for it.

C) Variant 2) Only the cost of the fraction of the capacity of each line that is actually used is taken into account in the inter-TSO payment algorithm

In the basic AP method, the total cost of each line is allocated to the network users, regardless of the level of utilization of the line. In principle this appears to be correct, since the purpose of the network cost allocation exercise is to assign the total cost of the transmission network so that it will be fully recovered through the network tariffs.

However, one could claim that the principle of cost allocation based on responsibility in network development should not be taken that far. Why? In the first place, we are using "electric network use" as a proxy for "responsibility in network development", and therefore we should leave some margin for error. In the second place, it is not clear how the unused fraction of the line can be attributed to any network user on the basis of "use". Therefore, an option is to leave the cost corresponding to the unused part of the lines to be assigned via a less engineering-like procedure. Ramsey pricing principles could be applied here, as well as more pragmatic considerations such as charging the entire unused part to consumers. This variant provides justification to avoid the 50/50 split rule that is implicit in the basic AP method, so that a smaller G charge can be accepted. In this study the unused part of the grid has been assigned to the load of the country.

There is still the problem of determining the actual "capacity" of a line. It happens that the amount of flow that a given line can take depends on the operating conditions of the power system. For the sake of simplicity we could assume that the capacity of any line is the one given by its thermal rating at some agreed temperature (see Chapter 2).

	A	B	CH	CZ	D	E	F	H	I	NL	P	SLO	SK
A	127	0	0	1	1	0	0	0	1	0	0	1	0
B	0	191	0	0	1	0	1	0	0	1	0	0	0
CH	0	0	135	0	2	0	5	0	3	0	0	0	0
CZ	4	0	0	178	3	0	0	0	0	0	0	0	0
D	2	0	4	2	1291	0	2	0	2	3	0	0	0
E	0	0	0	0	0	816	5	0	0	0	3	0	0
F	0	2	5	0	4	3	1188	0	9	0	0	0	0
H	0	0	0	0	0	0	0	92	0	0	0	0	1
I	5	0	11	0	2	0	12	0	499	0	0	3	0
NL	0	0	0	0	2	0	0	0	0	234	0	0	0
P	0	0	0	0	0	4	0	0	0	0	146	0	0
SLO	1	0	0	0	0	0	0	0	1	0	0	22	0
SK	0	0	0	1	0	0	0	2	0	0	0	0	80
	139.6	192.2	156.0	181.5	1305.4	824.0	1211.8	93.2	514.5	237.9	149.1	25.7	81.3
	130.3	193.5	144.5	185.4	1305.3	823.8	1211.0	92.7	531.7	236.5	150.8	24.3	82.4
	9.3	-1.3	11.5	-3.9	0.1	0.2	0.8	0.5	-17.2	1.4	-1.7	1.3	-1.1
	12.9	1.7	21.0	3.1	14.9	7.8	24.2	1.7	15.7	3.6	2.8	3.8	1.3
	3.6	2.9	9.6	7.0	14.8	7.6	23.4	1.2	32.8	2.2	4.5	2.4	2.5

Table 16: Compensations, charges and net payments for the AP method when only the cost of the fraction of the grid that is actually used is allocated

As with all the other variants considered here, the results have been obtained only for scenario number 1 in order to provide a first insight in the results that should be expected with each variant. By computing the results only for one scenario, we avoid having to repeat the same calculation process for all the scenarios and then process the results to obtain matrixes representative of the whole year. Results for one scenario are more than enough to show that their computation is perfectly possible and the kind of results yielded by each method. The results are shown in Table 16. As one could have easily anticipated, both compensations and charges obtained with this variant of the method are smaller than when the cost of the entire grid is allocated. The net compensation for some countries changes notably. For instance, France had a considerable positive net payment with variant 1 of AP whereas now it receives a small amount. This may suggest that the French grid has a higher level of utilization than the networks of its neighbors.

4.3 Variants of the With-and-Without Transits method (WWT)

Two alternatives to the original algorithm can be considered here. The first one allocates only the fraction of each line that is actually used. The second variant considers only the positive increments in the line flows that are caused by transits. ETSO has already obtained results with the later. It does not seem necessary to show the results for the variants of WWT in this report since they present the same drawbacks as the basic approach.

4.4 Variants of the Average Participations applied to Transits method (APT)

The same considerations that have been used when defining variants for the AP method can now be used to define variants for the APT method. No results are presented for either of the variants since it has been considered better not to go backwards from the basic APT method, neither is it advisable to make the existing mechanisms more complicated.

5 The horizontal network and the concept of transit

5.1 Background

This chapter examines two elements in the considered inter-TSO payment mechanisms that appear to be easy to understand, when first encountered, and that happen to be difficult to deal with in practical terms when it is necessary to obtain concrete results. These two elements, so difficult to define precisely, are transits and the horizontal network.

The final report of Phase I explained the difficulties that exist in the definition of transit (see section 3.1 “family 2”). The same arguments are revisited in section 9.2 of this report, when making a final evaluation of the methods. The numerical analysis of section 5.2 makes explicit some of these difficulties.

The quantitative evaluations associated to the mechanisms of inter-TSO payments need to be applied to a transmission network of the IEM that has to be defined previously. This is the “horizontal network”. Depending on the method of network cost allocation being considered, this definition may have more or less influence on the final results of compensations and charges.

During the realization of this study, it has been explored the possibility of having an objective and independent procedure of determining the true impact of transits on the utilization of the network, and also of helping out in the definition of the horizontal network. This procedure could consist of a series of statistical analysis of any existing correlation between cross-border flows and the flows at the internal lines of a country or TSO. Much has been learned in the process, but no definite results have been reached so far. Consequently, no results or conclusions are presented in this report.

5.2 The definition of the horizontal network

The horizontal network is the network whose lines could be affected by cross-border flows in a non negligible form or, in other words, the network formed by the lines whose utilization might correspond, up to a significant degree, to external users. The challenge is to define this network *a priori,* i.e. before the responsibility in the allocation of flows to external users has been assigned.

The provisional mechanism for the computation of inter-TSO payments that has been used during 2002 and, with some minor improvements, also in 2003 (see section 2.1.2 in the final report of Phase I of this project), is very sensitive to the definition of the horizontal network. The reason is very simple: Once the fraction f (in %) of external network utilization is somehow determined for a given country or TSO, then the compensation that is due to this country is just the percentage f of the cost of the network that has been previously defined to be the horizontal network.

The situation may be different when more sophisticated methods that make use of real network flows are used for network cost allocation in the inter-TSO payments mechanism. The reason is that these methods may be able, just by themselves, to identify which components of the transmission network should be included in the horizontal network and which ones should not.

In the remainder of this section we shall explore the role of the horizontal network in the different methods of interest for network cost allocation, in the context of the search for a suitable inter-TSO payment mechanism in the long-term.

The horizontal network in the provisional mechanism.

As explained before, the definition of the horizontal network has much influence on the final result that will be obtained in the provisional mechanism. This is why ETSO has proposed an interesting method of determination of this network, see [www.etso-net.org].

This method proposed by ETSO basically consists of checking the flows, in an empty network model of the considered country, when 100 MW are input at one of the interconnectors in the border of the country and 100 MW are withdrawn from any other interconnector at the border. The process is repeated for all possible pairs of interconnectors. Then, all lines whose flow has been equal or larger than a certain threshold value (e.g. 1 MW) are considered to belong to the horizontal network.

This method will certainly exclude any lower voltage lines whose flows are basically not affected by cross-border flows, because higher voltage lines exist that better accommodate these flows. But it may include lines that should not belong to the horizontal network Consider, for instance, an extreme case of a country with a small interconnector that typically carries a very small flow, but which is located at a place in the border very far away from the rest of the interconnectors. This is not such an uncommon case: think, for instance, of the weak interconnection of Italy with Greece, which is very distant from the much more important interconnectors with France, Switzerland, Austria and Slovenia. In this case the algorithm will include many lines in the middle of Italy that should not belong to the horizontal network. One could say that the method is reliable in eliminating lower voltage lines and not excluding any line that should be a part of the horizontal network. But it may include too many high voltage lines. When this is the case, the provisional method will compute more compensations for the country than necessary.

The horizontal network in the WWT method.

The ETSO method for the provisional mechanism plus the WWT method to determine the external network utilization is a good combination. There is no problem if more lines than those strictly needed are included in the horizontal network, since the WWT method will detect by itself that there is no difference in the flows in those lines between the with transit and the without transit cases, and there will be no economic consequences.

The horizontal network in the AP method.

This is a slightly more complex case than with the WWT method. While AP has no difficulty in identifying which lines are used by external agents and which are not, *within a certain voltage level,* whenever a lower voltage network is added in the transmission network representation, the downstream tracking procedure of AP will continue tracking the flow until final loads are reached. In this way AP could continue tracking flows downstream until the low voltage level of the distribution network.

There are several possibilities to solve this dilemma. The first one is to trust that the present algorithm of ETSO to identify the horizontal network (the one currently used with the provisional approach) is correct when not including lower voltage lines in the horizontal network. Once the horizontal network can be trusted in this respect (i.e. the algorithm has not included any lower voltage lines by mistake), then AP can also be trusted to identify which fraction of every line in the horizontal network is subject to external utilization.

Another possibility is to go to the root of the problem. We could compare the differences in flows between situations that are as similar as possible in demand but that have different flow patterns because of cross-border flows. Only the lines that show non negligible differences in the flows can be considered to belong to the horizontal network. The practical difficulty is to have available enough snapshots of flows to make the comparison without the interference of other external factors, such as the generation pattern or some lines unavailability. If this approach is selected, it may be better to produce the snapshots by simulation (running cases with the computer) instead of taking them out of actual system behavior.

Still another possibility is to make use of statistical correlation methods to identify those lines whose flows show some correlation with the actual flows at the interconnectors, or with the magnitude that is defined as "transit". This possibility has been explored but without being able to reach any definite conclusions so far. Therefore, no results are reported here.

5.3 The concept of transit

Section 3.1 of the final report of Phase I of this project discusses in detail the concept of transit and the logic of any method of network cost allocation that is based on this point of view. Some strong points, difficulties and pitfalls of this approach were already identified in this previous report and will not be repeated here (see, however, section 9.2 of this report for a summary of the strong and weak points of the WWT method).

The objective in this section is to verify and to evaluate, by means of numerical simulations, some of the weaknesses and strong points in the concept of transit and its utilization in the context of the computation of inter-TSO payments.

Basic difference between WWT and AP regarding the external use of individual lines

WWT forces the removal of the transit between the entry and the exit points at the border of the considered country, therefore causing changes in all intermediate lines to accommodate this change. Note that, on the contrary, AP tracks the cross-border flows, following the prevalent flow pattern. Therefore AP only computes an impact on a limited amount of lines, until the flows that are being tracked die in generators or loads. Conceptually both WWT and AP have some points of coincidence. Note that WWT will encounter intermediate lines where the flows have decreased with the transit and, therefore, will not count them in the computation or their impact will be negative (the compensation due to the country will be reduced because of them, something equivalent to charging for the use of external networks in AP). While the global result of WWT will make sense in general, the changes in the flows of individual lines, -because of the several reasons indicated above-, may not make much physical sense in some cases. This has adverse implications when seen from the viewpoint of the allocation of costs of individual investments, as indicated elsewhere. Table 17 compares the external impact on the individual lines of two countries, Spain and France, with the WWT and AP methods for scenario number 4. Table 18 shows equivalent results for scenario number 18.

	WWT E	AP E	WWT F	AP F
n_lin_10-30%	63(62)	22	0(0)	90
n_lin_30-50%	25(29)	25	0(0)	31
n_lin>=50%	22(34)	16	0(0)	36

Table 17: Impact of cross-border flows on the Spanish and French grids when applying the WWT method and the AP method to the snapshot corresponding to scenario number 4

	WWT E	AP E	WWT F	AP F
n_lin_10-30%	39(85)	30	10(13)	50
n_lin_30-50%	23(23)	9	1(4)	34
n_lin>=50%	38(60)	15	7(7)	38

Table 18: Impact of cross-border flows on the Spanish and French grids when applying the WWT method and the AP method to the snapshot corresponding to scenario number 18

The interpretation of the numbers in these tables differs slightly depending on the applied method. Columns 1 and 3 correspond to the WWT method and two different numbers are shown at each matrix location in these two columns. The first figure is the number of lines whose flow decreases when the transit is removed and the figure in brackets is the number of lines whose flow increases in the same case. Numbers in columns 2 and 4, however, refer to the number of lines participated up to a certain extent by external agents according to the AP method.

Rows correspond to different degrees of impact of cross border flows on the flows over the lines. The first row beginning from the top represents the number of lines for which cross border flows have an impact of between 10 and 30% of the flow in the line. The second one corresponds to those for which the impact is between 30 and 50% of the original flow and the third and last row shows the number of lines for which this impact is above 50% of the flow. Therefore ‘39’ in row 1 column 1 of Table 18 means that there are 39 lines in the Spanish grid whose flow decreases by more than 10% and less than 30% when the transits are removed in scenario number 18. Also in this row and column, ‘85’ means that there are 85 lines which show a 10 to 30% increase in their flow when removing the transit. On the other hand, ‘31’ in column row 2 column 4 of Table 17 means that there are 31 lines in

France for scenario number 4 whose degree of external utilization lies between 30 and 50% of the total use made of the line.

These results show that, even in a country like Spain where the transit is relatively small in size, the removal of this transit has a large impact on the flow of many of the lines in the country (column WWT E). Contrary to this, only those lines close to each of the borders with France and Portugal present some degree of external use with AP (column AP E).

The case of France is somewhat the opposite. Due to the fact that France is a purely exporting country in scenario number 4, WWT yields no external impact on the flow of any of the French lines as can be seen in Table 17. For scenario number 18, the external participation in the use made of the French grid is also very small according to WWT (see Table 18). On the other hand, results that are obtained with AP mean that countries importing from France are making a non-negligible use of its grid as can be seen in column labeled AP F in both tables.

6 Allocation of the cost of new network investments

The main objective of this section is to show the impact that the three main approaches that have been considered in this Phase II of the project, -namely AP, WWT and APT-, will have in the allocation of the cost of new investments in the transmission network.

This is a very relevant issue in the allocation of the cost of new network investments. Why? Because, implicit in the inter-TSO payment mechanism, is the fact that any new relevant transmission investment will be included in the horizontal network and its costs will be allocated following the same rules that apply to any other network asset. In conclusion, the cost of any new relevant network investment will be allocated to the different countries via the inter-TSO payment mechanism.

In this section the rules of cost allocation of the three considered methods (AP, WWT and APT) will be applied to several case examples of individual lines. These lines are located in different locations in the IEM and they have different roles. This quantitative comparison will provide a different perspective from which to contemplate the several methods that have been considered for the long-term mechanism to determine inter-TSO payments.

The expected implications of using each one of the three considered methods are discussed next.

The AP method

With AP the consideration of a new network investment is a trivial matter. Once the line is built and in operation the flows in the line will be recorded hourly (for instance), as it is also done for all other existing lines. Then the new line is treated as any existing line and its cost is assigned to the different network users individually, as with any other line, regardless of the political borders and taking into account only the real network flows. Therefore, the resulting inter-TSO compensations and charges automatically include the cost allocation of the new line to the different TSOs. Therefore, without any special action, the assignment of the cost of the new line is precisely accomplished according to the rules of the AP method.

The cost of the new line is a given data input to the model. A standard cost may be used or any other regulated cost. If the construction plus operation & maintenance costs of a line are assigned by a competitive auction, this is the value of the cost to be used for this line.

The WWT method

Once the line is built and in operation, the WWT method will determine the difference in the flow in the considered line when the transit is removed. This information may now be used to evaluate how much of the utilization of the line corresponds to external utilization, by using some simple pro rata assignment. Two difficulties appear:

- The WWT method does not provide any guidance on how to charge the cost of the external utilization of the line to the external network users, either individually at the different nodes or at country level. One has to recur to another allocation method or to a more or less arbitrary assignment rule.
- The difference in the flow of the new line that is caused by the transit may depend critically on the arbitrary pro rata assignment that the WWT method uses to distribute the value of the transit flow among the different interconnections of the considered country. This is very clear when the new investment is precisely an interconnector. Then, the WWT method itself arbitrarily determines how much of the transit corresponds to the considered line, without any more technical evaluation.

The APT method

From the point of view of the treatment of a new network investment, the APT method shares the strong and weak points of the WWT method. However, APT automatically solves the first difficulty of WWT that has just been described above.

6.1 The case examples.

Case example #1

The first case is that of a line located in Spain, not particularly close to any border, whose flow decreases when the transit through the Spanish grid is removed. The line is located between the nodes of 'Vandellós' and 'La Plana' in the north-eastern part of Spain and the snapshot corresponds to scenario number 1. Results of the application of the AP, WWT and APT methods to the allocation of the cost of this line are shown in Table 19. All numbers represent percentages of the total cost of the line. Thus, in row I column WWT '6.6' means that, according to the WWT method, Italy should pay for 6.6% of the cost of the line.

It can be seen that removing the transit in the WWT method forces the flow over lines located far from the borders to change substantially. At the same time, due to the procedure used in WWT to allocate the compensation own to a country, the recovery of the cost of this Spanish line is spread all over Europe with countries like Italy having to pay up to 6.6 % of the total cost. Both with AP and with APT the complete cost of the line is born by the Spanish system.

Case example #2

The second example is about a line located in the north-central part of Spain between the nodes of 'Garoña' and 'Herrera' also for scenario number 1. Results are presented in Table 20. In this case, however, the removal of the transit causes the flow over the line to increase. In other words, according to the WWT philosophy, the transit through the country would be reducing the flow over the line and, therefore, other countries should be compensated for the construction of this line. When recovering the investment cost of the new line, Spain would have to pay Italy for 9.9% of the cost of the line and France for 12.3 % of this cost. This does not seem to make much sense. As in the previous example, both AP and APT indicate that there should be no external participation (either positive or negative) in the recovery of the cost of the line.

	AP	WWT	APT
A	0	0.2	0
B	0	0.7	0
CH	0	1.1	0
CZ	0	1.1	0
D	0	0.3	0
E	100	79.6	100
F	0	8.2	0
H	0	0.0	0
I	0	6.6	0
NL	0	0.9	0
P	0	0.3	0
SLO	0	0.4	0
SK	0	0.5	0

Table 19: Allocation of the cost of an internal line in Spain. Case example 1

	AP	WWT	APT
A	0	-0.3	0
B	0	-1.1	0
CH	0	-1.7	0
CZ	0	-1.6	0
D	0	-0.5	0
E	100	130.7	100
F	0	-12.3	0
H	0	0.0	0
I	0	-9.9	0
NL	0	-1.4	0
P	0	-0.4	0
SLO	0	-0.7	0
SK	0	-0.8	0

Table 20: Allocation of the cost of an internal line in Spain. Case example 2

Case example #3

Now the cost of a line in Switzerland is allocated among the different countries. Results for this line are shown in Table 21. The line is located between ‘Innertk’ and ‘Robiei’ and the considered flows are from snapshot number 5. Less than 40% of the cost of the line would be recovered from Switzerland with the WWT method. Other countries would pay for most of the line. France would be paying for 25.4% of the cost of the line, Italy would pay for 15.1% and The Netherlands for 6.9% of it.

Again, a significant part of the line would be paid by other countries with the WWT method. Given that Switzerland has very important cross-border exchanges of electricity with other countries, it may make sense for these countries to pay a considerable part of its grid. What does not seem to be cost reflective is the dispersion of the charges all over the IEM countries, instead of relying on some serious procedure to estimate the participation of each country in the flow in the line.

Tracking of the flow over the line leads to Italy having to pay part of the cost of the line either with AP (20.2%) or with APT (13.3%). No other country apart from Switzerland and Italy has to pay anything for this line in these two methods.

	AP	WWT	APT
A	0	3.8	0
B	0	2.0	0
CH	76.4	37.1	84.6
CZ	0	1.3	0
D	0	0.8	0
E	0	3.2	0
F	0	25.4	0
H	0	2.0	0
I	20.2	15.1	13.3
NL	0	6.9	0
P	0	1.0	0
SLO	0	0.5	0
SK	0	0.9	0

Table 21: Allocation of the cost of a line in Switzerland

Case example #4

Finally, the last example is that of a Belgian line located quite near the border with France, between the nodes of 'Achen1' and 'Ac Lo11'. Results for this example are shown in Table 22. Given its geographical situation, it is reasonable to expect that most of the line should be paid by France as it happens both with AP (50.2%) and APT (23%). The WWT method, however, establishes that ,not only France (17%), but Italy (11.2%), Switzerland (5.6%) and The Netherlands (4.3%) should pay a significant part of the cost of the line, with all the remaining countries paying some smaller fraction too.

	AP	WWT	APT
A	0	1.6	0
B	49.8	54.3	77.0
CH	0	5.6	0
CZ	0	0.8	0
D	0	1.2	0
E	0	0.2	0
F	50.2	17.0	23.0
H	0	1.5	0
I	0	11.2	0
NL	0	4.3	0
P	0	0.3	0
SLO	0	0.7	0
SK	0	1.2	0

Table 22: Allocation of the cost of a Belgian line on the border with France

7 The number of scenarios

7.1 Background

Since 1-1-2003, ETSO is collecting hourly snapshots for most IEM countries, so that 8760 data sets of real network flows will be available by the end of 2003. Despite the availability of this data, the same question as in Phase I still remains: We want to know how many snapshots are needed to obtain a reasonable estimate of the compensations, charges and net inter-TSO payments within an acceptable margin of error. It is not a trivial matter to handle, verify, and process 8760 bulky data sets. If we could be convinced that acceptable results could be obtained with a significantly smaller number of scenarios, the practical advantage in the implementation of the long-term Inter-TSO payment mechanism would be very substantial.

24 snapshots of the flows in the network of 13 countries of the IEM have been made available for Phase II of this project. This is much more information than what was available in Phase I of the project, but not as much as to allow an statistical evaluation and a reliable prediction of the number of cases that would be needed to obtain the desired results within a prescribed margin of error.

However, it is possible to evaluate the available information in such a way that some useful preliminary conclusions with respect to the desired number of scenarios can be drawn.

7.2 Evaluation of the results

Each one of the series in Figure 1, Figure 2 and Figure 3 represents the geographical distribution of the net inter-TSO payments for a certain scenario. Figure 1 corresponds to AP, Figure 2 to WWT and Figure 3 to APT. The first conclusion one can draw from these figures is that inter-TSO payments are much more stable from one scenario to another with AP or APT than with WWT. For instance, inter-TSO payments for Germany range from –18.4 to 33 million euros in AP, depending on the scenario, whereas values with WWT range between –53.7 and 170.2 million euros. Those in APT range from 4.9 to 63.8 million euros. Similar results hold for other countries.

However, the three figures show that there are broad similarities between the different studied scenarios. Net payments to France and Italy are always negative, regardless of the method used to compute them, whereas those for Switzerland are mostly positive and those for the Czech Republic are mostly negative. Despite being very different in the two methods, compensations due to Slovenia, Hungary or Belgium do not change significantly from one scenario to another. All this seems to suggest very preliminarily that a number not too far from 24 scenarios will probably be enough to compute quite accurately annual inter-TSO payments.

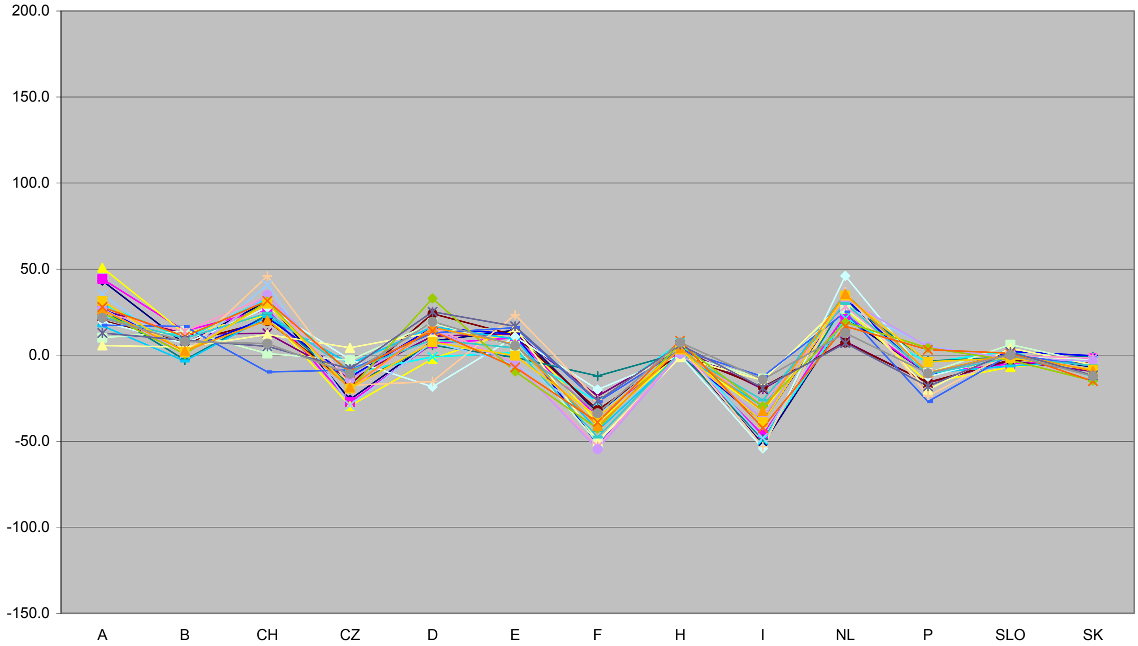

Figure 1: Geographical distribution of the net inter-TSO payments with AP

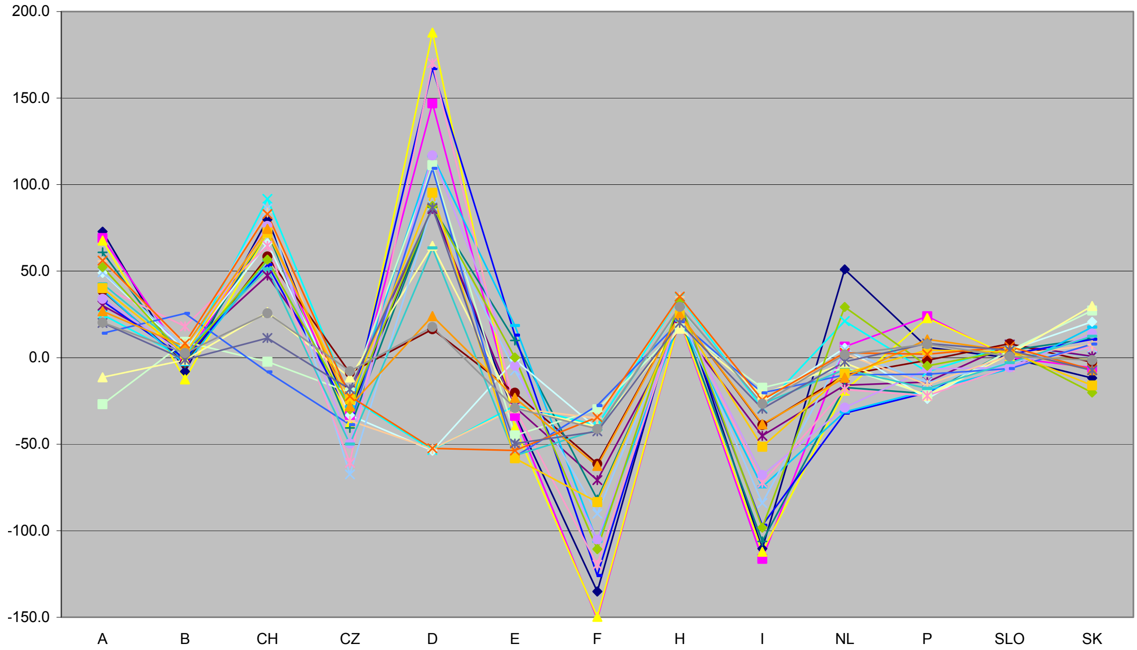

Figure 2: Geographical distribution of the net inter-TSO payments with WWT

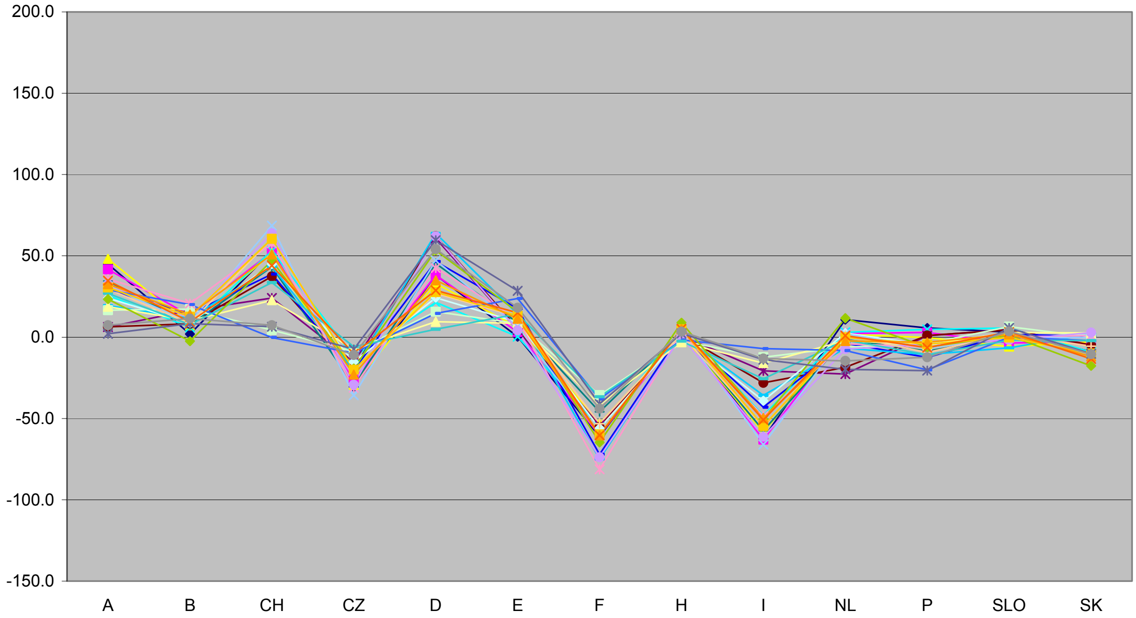

Figure 3: Geographical distribution of the net inter-TSO payments with APT

Figure 4, Figure 5 and Figure 6 show the geographic distribution of the compensations to be received by the different countries. A separate series represents this distribution for each one of the scenarios. Compensations show more clearly defined patterns of behavior than the net inter-TSO payments, especially with the AP and APT methods. This is very logical, taking into account that inter-TSO payments are the difference between two different variables, compensations and charges.

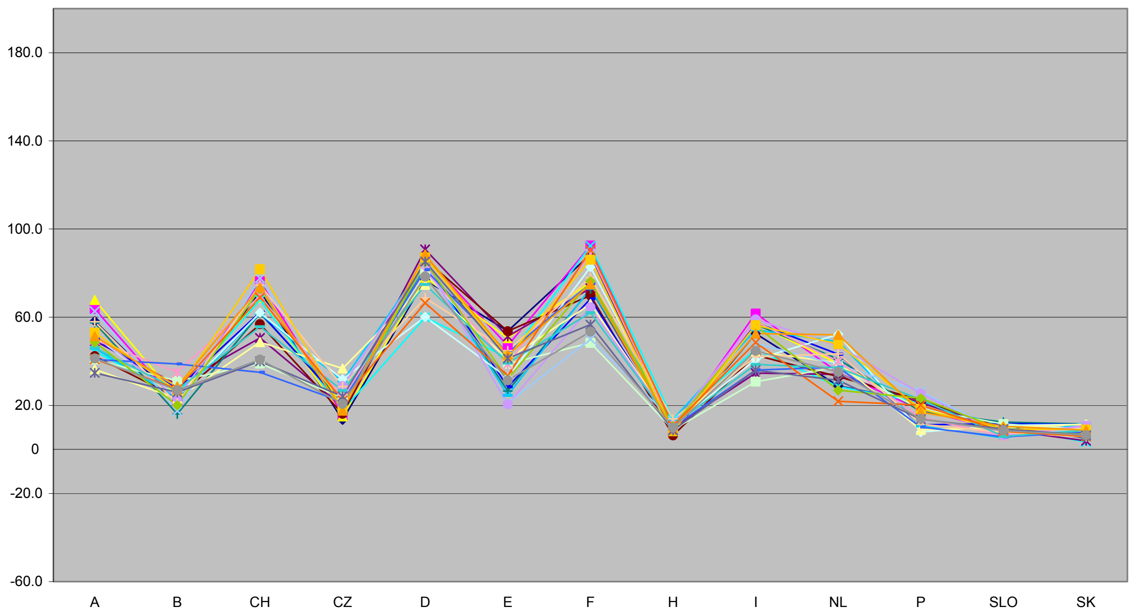

Figure 4: Geographical distribution of compensations to countries with the AP method

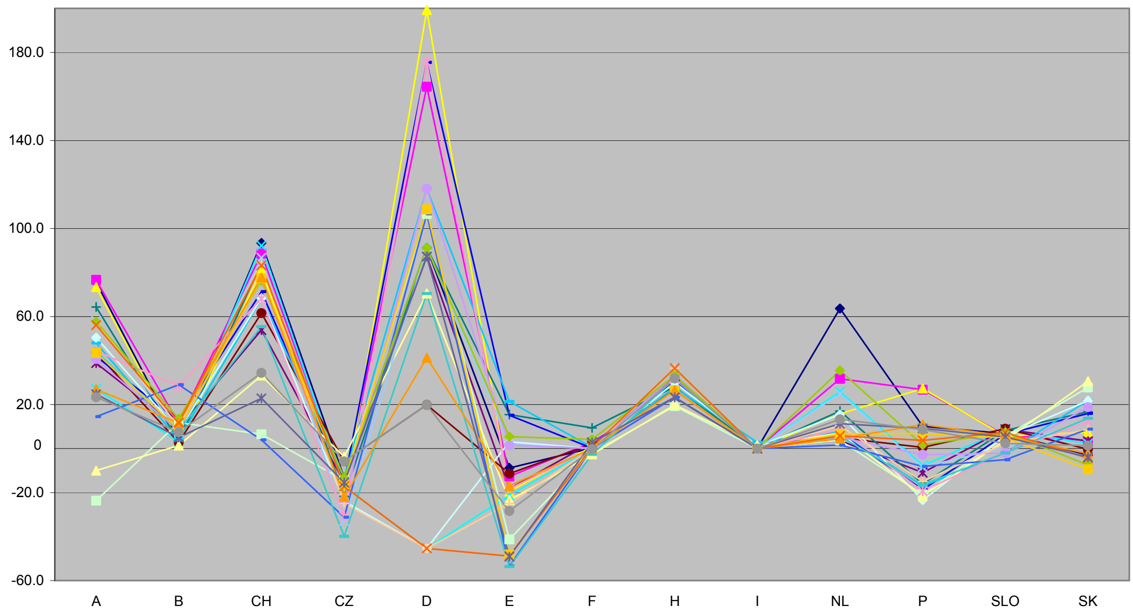

Figure 5: Geographical distribution of compensations to countries with the WWT method

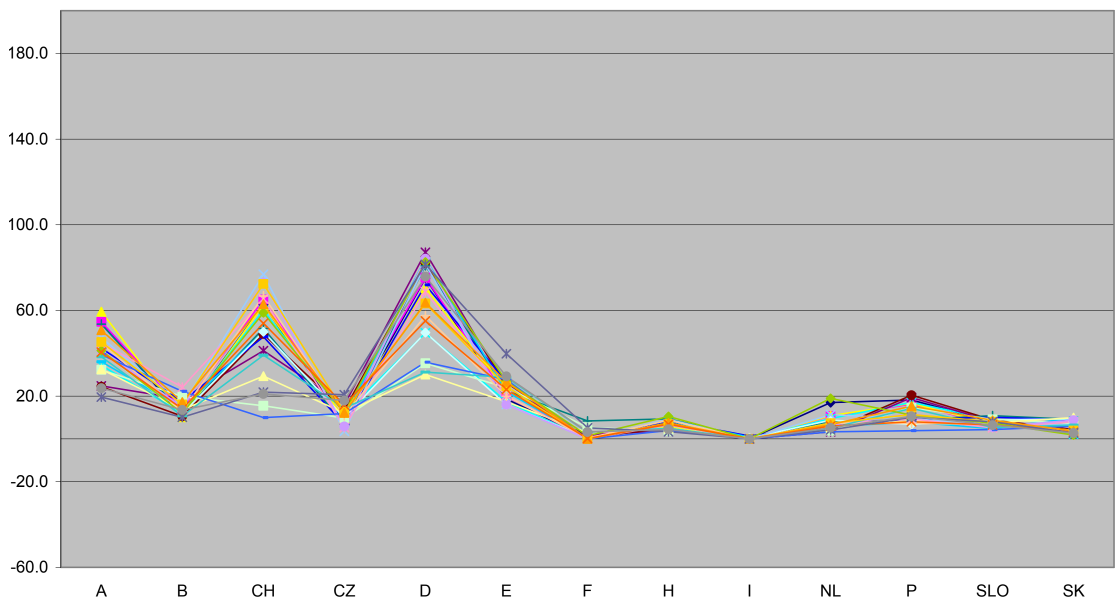

Figure 6: Geographical distribution of compensations to countries with the APT method

Finally, Figure 7, Figure 8 and Figure 9 represent the corresponding geographical distribution of charges. Charges computed with AP show again a clear pattern. Charges paid with the WWT method are quite low for all countries except for France, Italy and The Netherlands, since they are the ones with a larger volume of net imports or exports. Charges obtained with the APT method resemble those for the AP method though they are smaller.

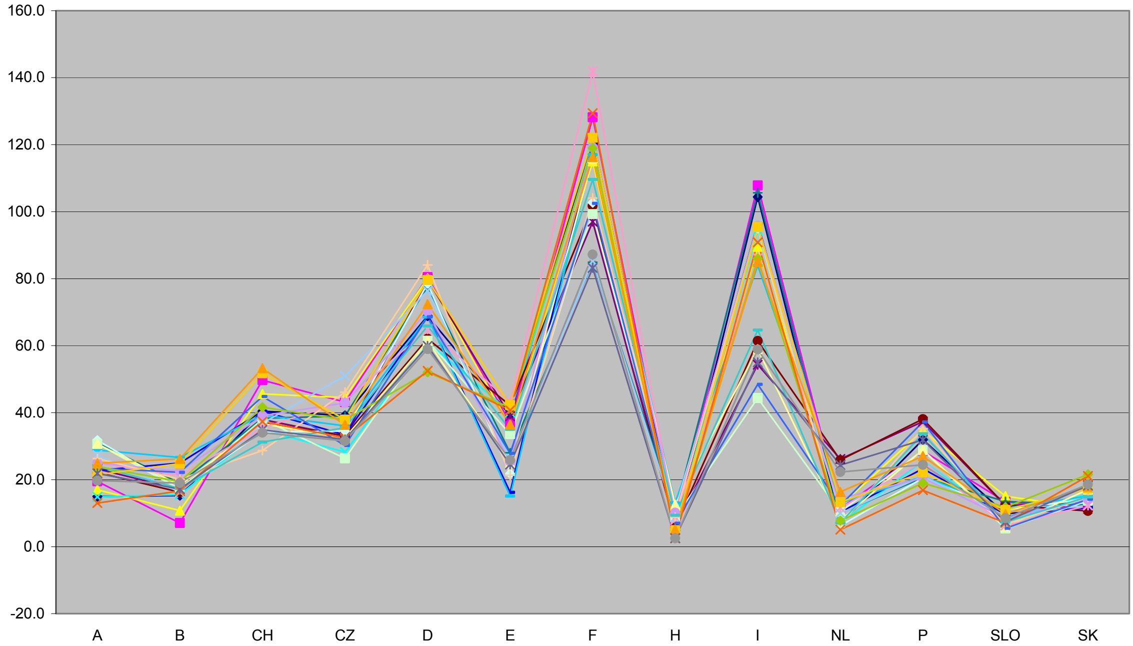

Figure 7: Geographical distribution of charges to be levied on countries with the AP method

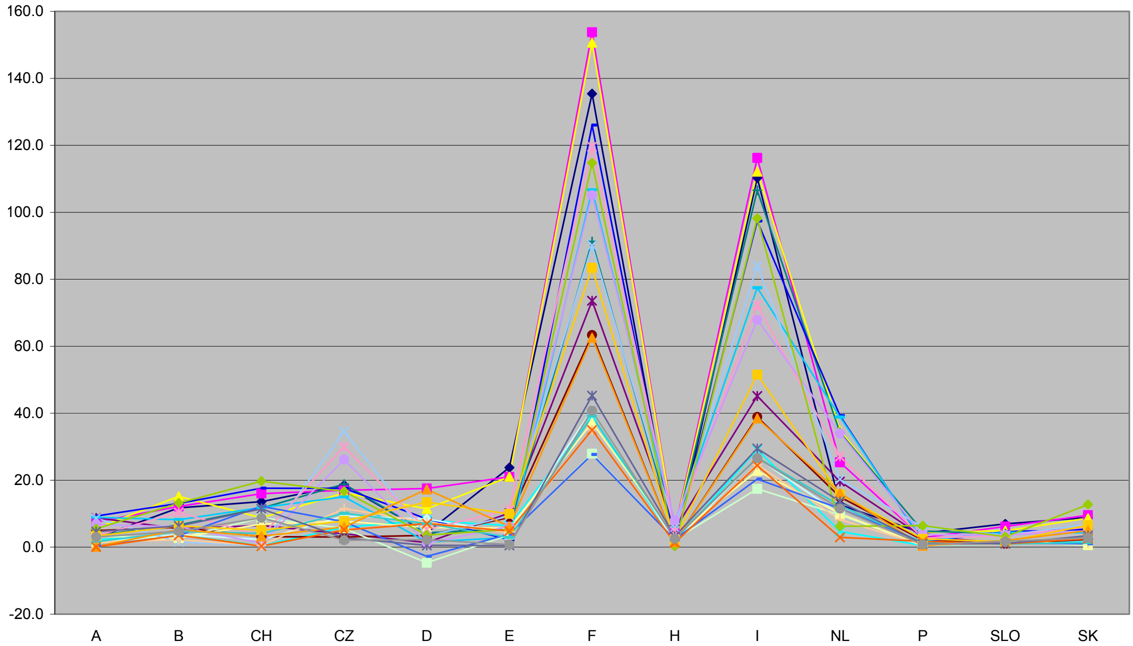

Figure 8: Geographical distribution of charges to be levied on countries with the WWT method

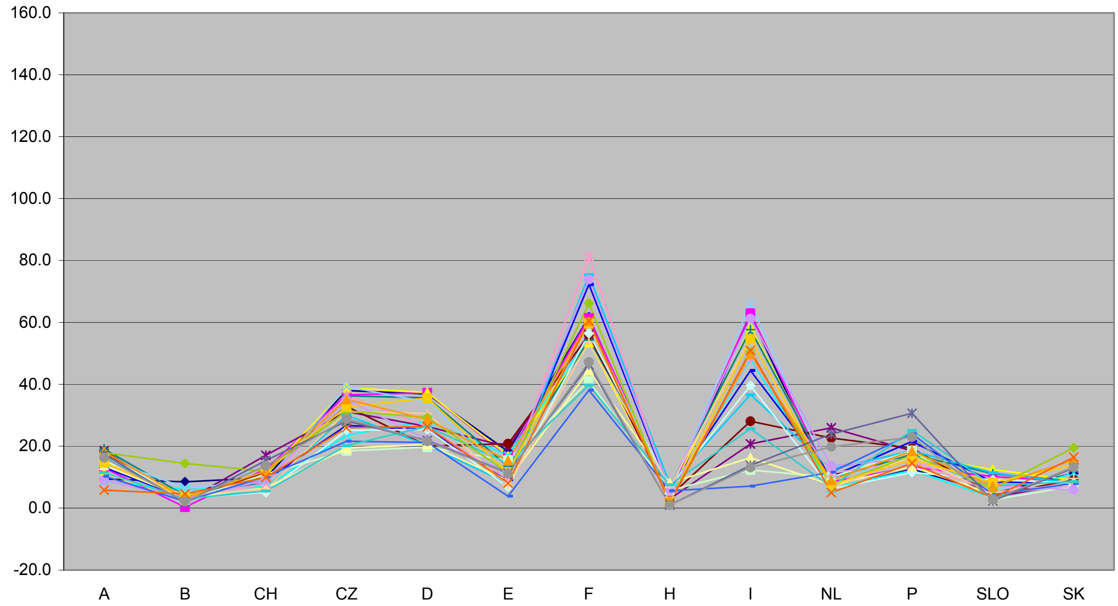

Figure 9: Geographical distribution of charges to be levied on countries with the APT method

Figure 10 to Figure 18 show the same results that have just been commented, but in a different format. In this case the figures represent the evolution of net inter-TSO payments, compensations and charges throughout the year. Again the same conclusions can be drawn. There is a stable pattern in the distribution of these payments. Note that the reason for some of the identical repetitions of some values (notably Germany) resides in the fact that some scenarios for a few countries had to be used more than once, in order to replace missing scenarios in the data that were provided by ETSO (see Chapter 2).

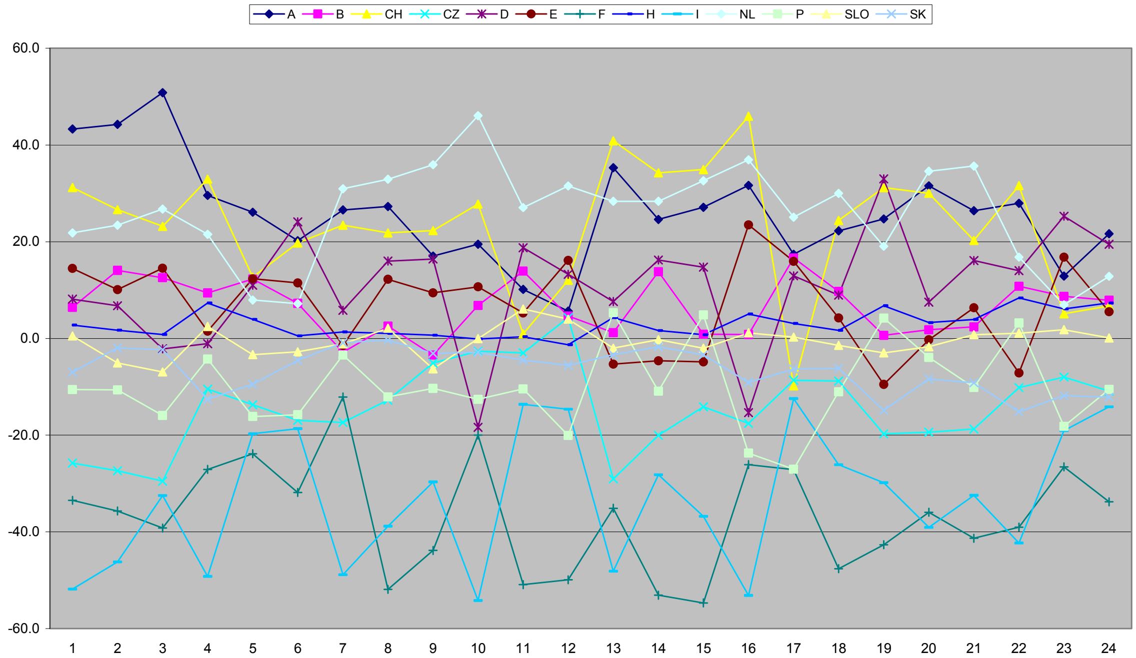

Figure 10: Evolution of inter-TSO payments with the number of the scenario for the AP method

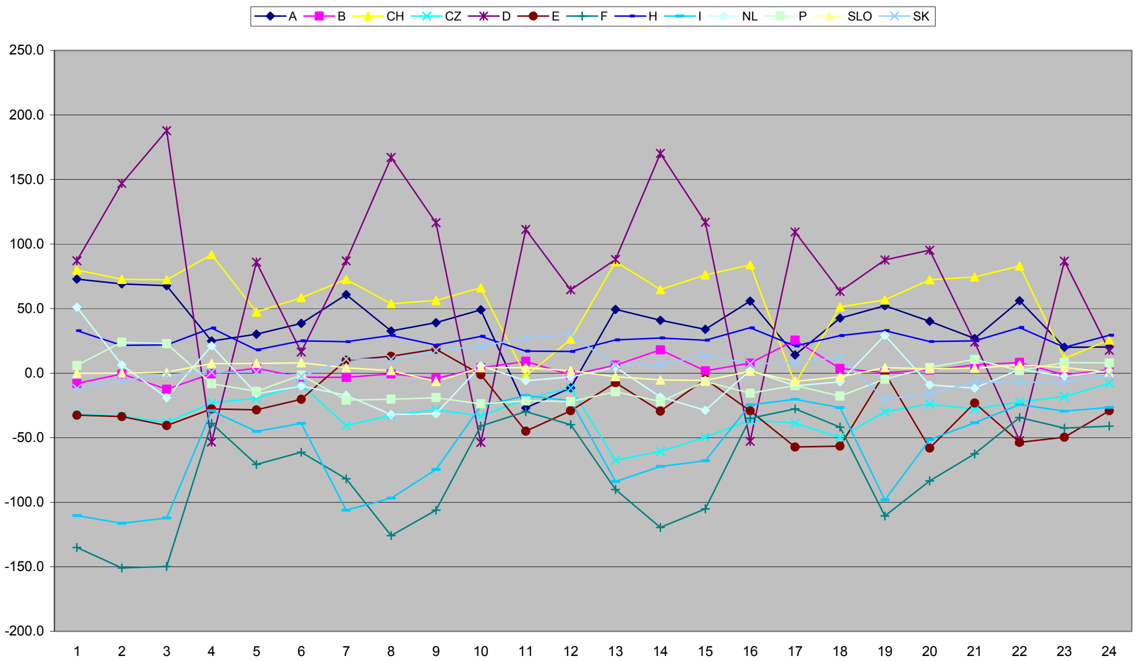

Figure 11: Evolution of inter-TSO payments with the number of the scenario for the WWT method

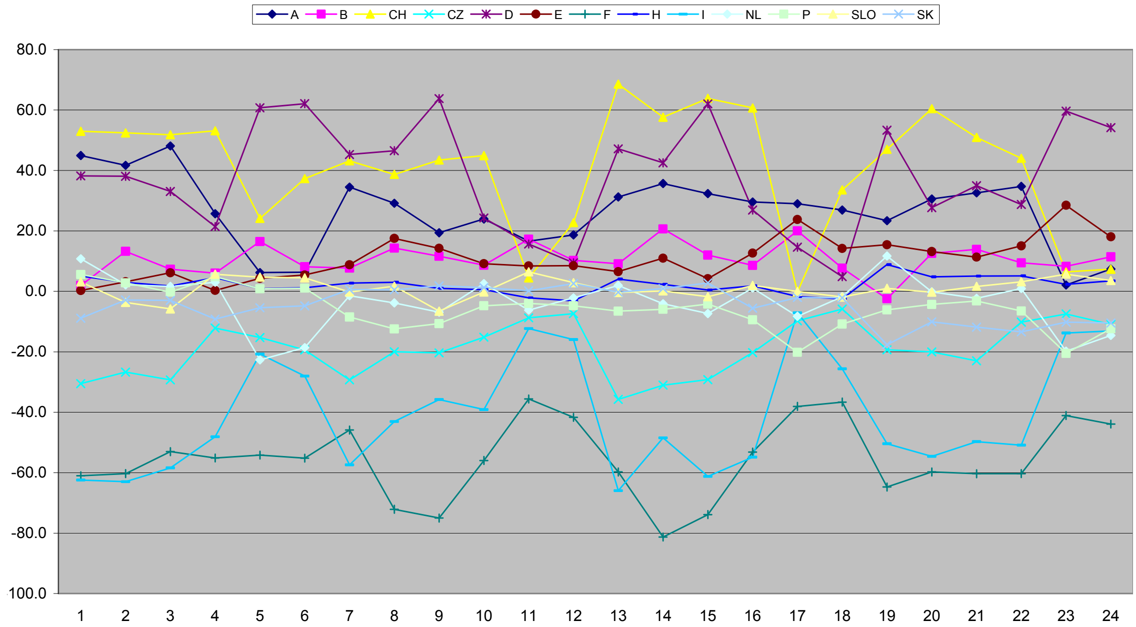

Figure 12: Evolution of inter-TSO payments with the number of the scenario for the APT method

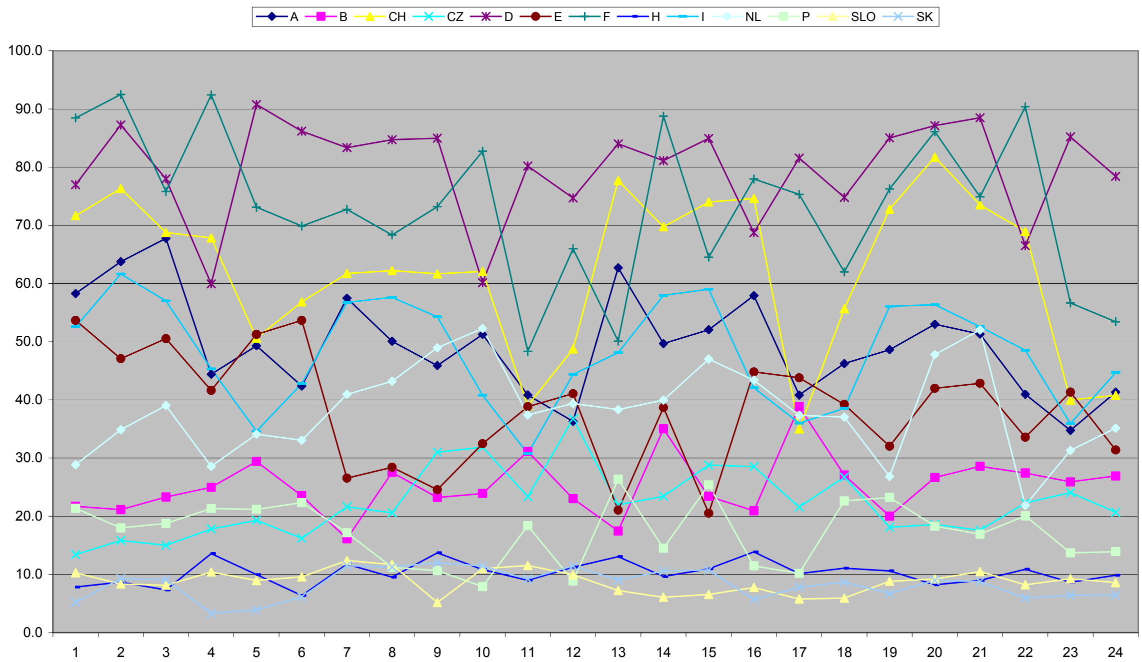

Figure 13: Evolution of compensations to countries with the number of the scenario for the AP method

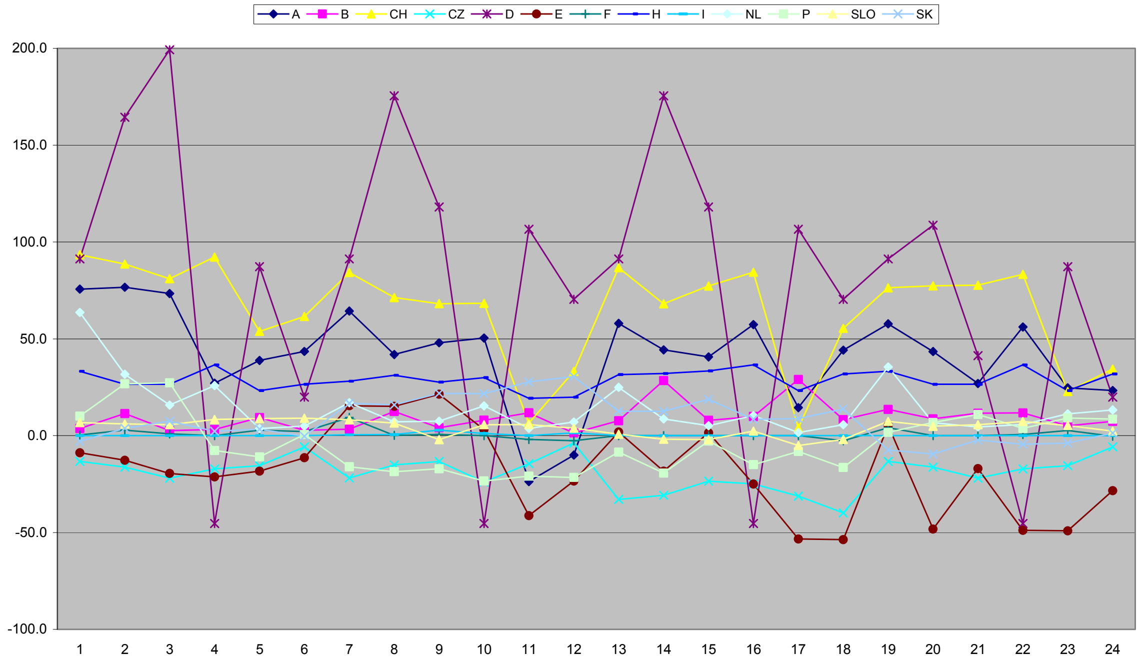

Figure 14: Evolution of compensations to countries with the number of the scenario for the WWT method

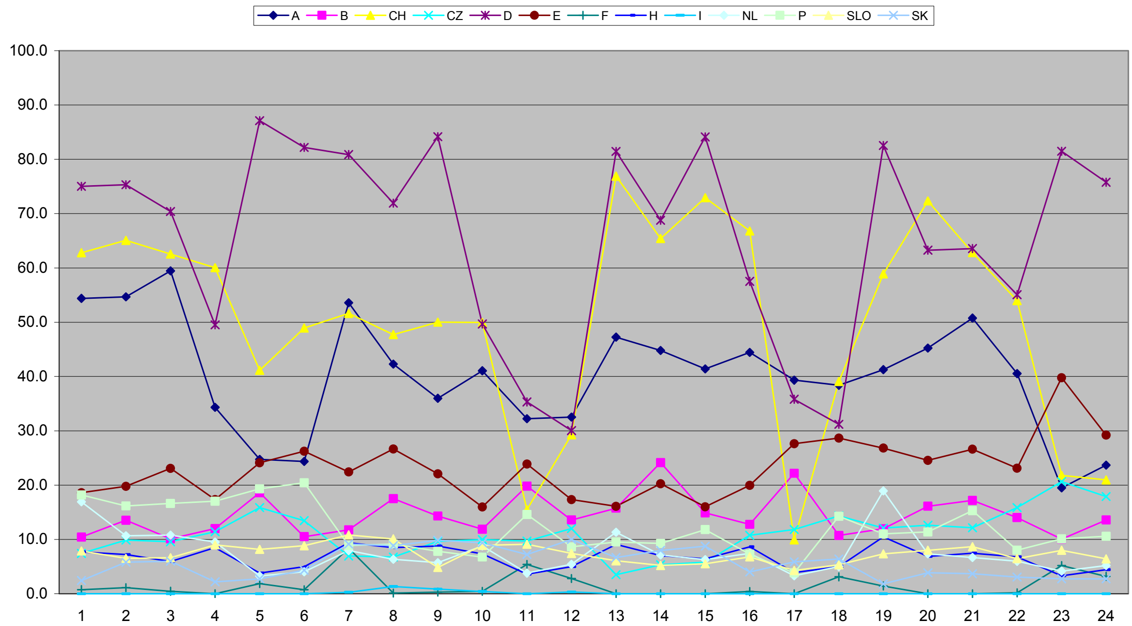

Figure 15: Evolution of compensations to countries with the number of the scenario for the APT method

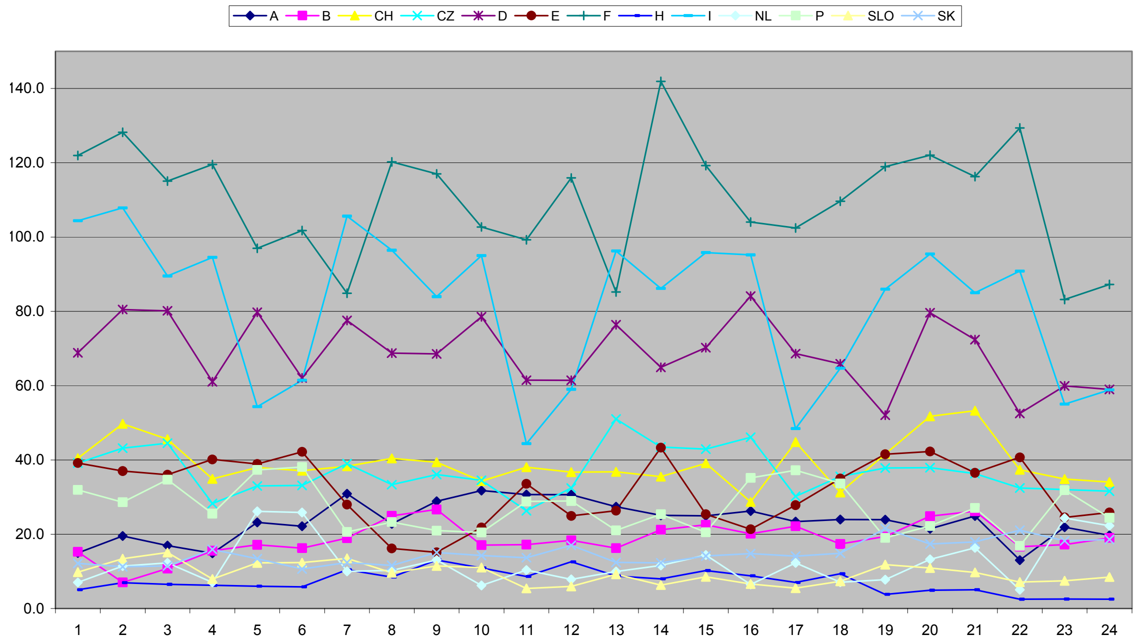

Figure 16: Evolution of charges on countries with the number of the scenario for the AP method

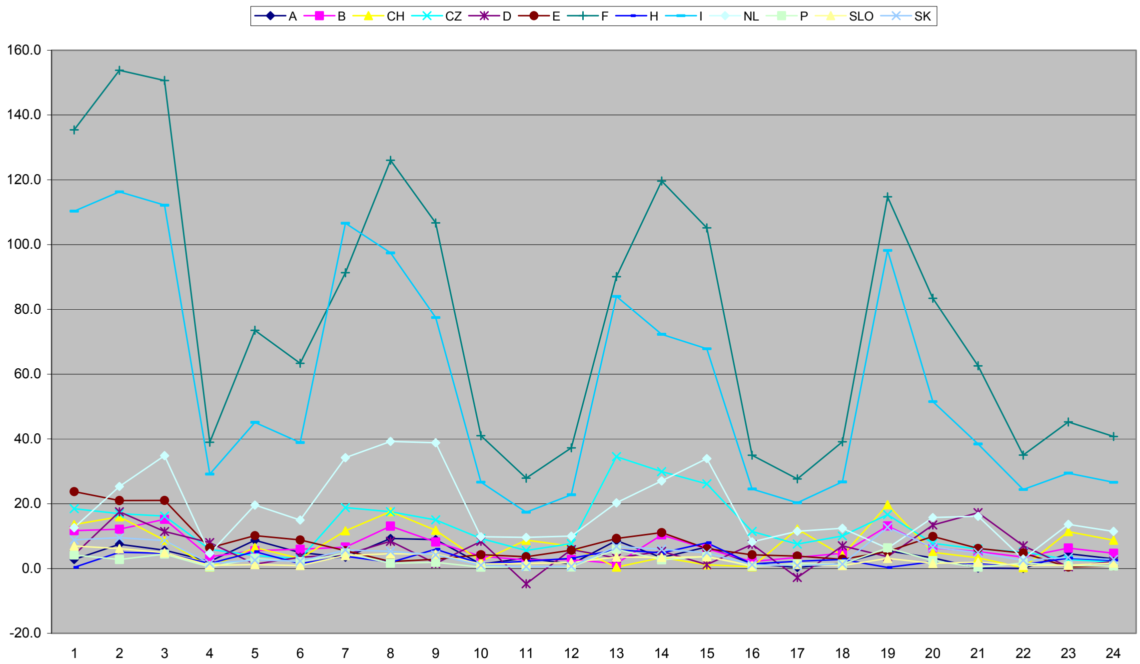

Figure 17: Evolution of charges on countries with the number of the scenario for the WWT method

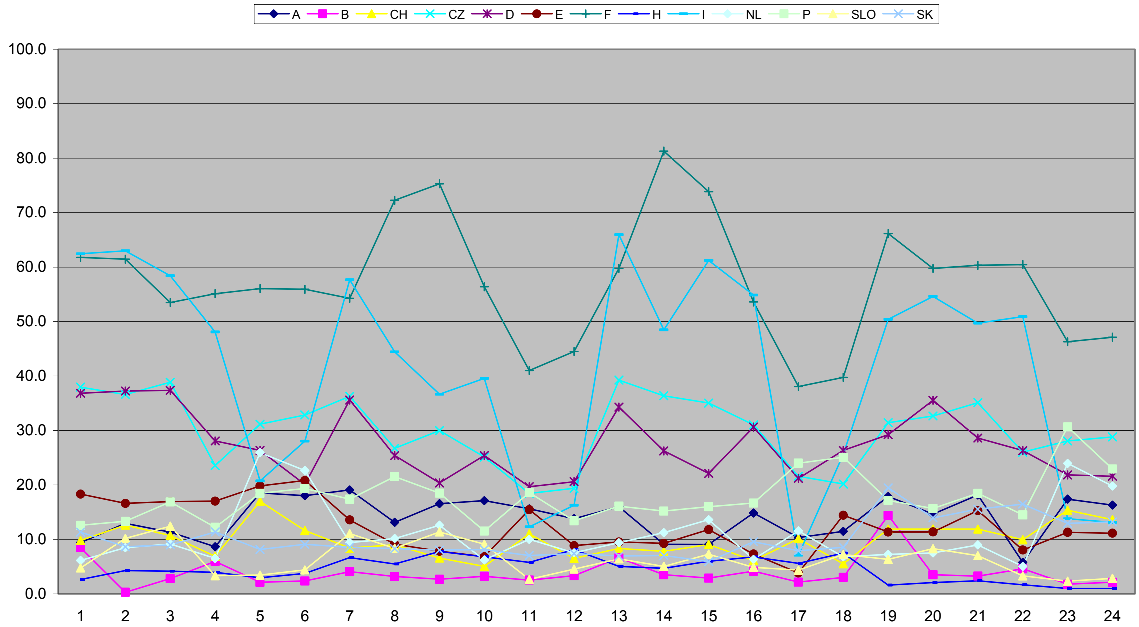

Figure 18: Evolution of charges on countries with the number of the scenario for the APT method

8 Assessment of locational signals produced by AP

In the IEM we start from a situation where well established and complete EU-wide locational signals for transmission do not exist, and this situation may remain so for some time. There are no EU-wide energy nodal prices and there are no pan-European transmission network tariffs, which could include any locational component. The only existing mechanisms that provide some sort of locational signals at IEM level are the two following ones[11]:

A. *Congestion management.* Still in its infancy at European level. Some uncoordinated auction mechanisms are already in place. The EU Regulation asks for the implementation of market based mechanisms. CEER has worked in the development of practical guidelines that any implementation of a congestion management scheme should meet. ETSO and other stakeholders are working on the development of coordinated congestion management schemes.

B. *Inter-TSO payments.* The principle of local G and L charges providing full access to the IEM network, supplemented by a scheme of inter-TSO compensations has been already adopted and implemented with a transitory mechanism for the computation of compensations and charges. The locational content of inter-TSO payments is small, as the compensations and charges are computed and applied at TSO level.

This chapter tries to provide some additional knowledge that may help in finding an answer to the following basic question: What kind of additional locational signals should be reasonably incorporated in the future into the IEM for the sake of efficiency, while taking into account the practical issues in achieving any harmonization in this area?

Section 8.1 presents the theoretical background supporting the implementation of locational signals, with particular attention to the potential role of inter-TSO payments and its consistency with any potential scheme of EU-wide transmission tariffs[12]. Section 8.2 presents quantitative results that have been obtained with the new available data and discusses the method that has been used for this purpose. The implications of these results on tariff harmonization are examined in section 8.3.

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[11] A few EU countries have adopted various schemes to provide locational signals at national level. Some use transmission tariffs with geographical differentiation, while others establish locational signals at operation level by applying zonal energy prices when congestions occur or by introducing loss factors to account for losses at nodal level.

[12] The current draft of the Strategy Paper of the European Commission for the implementation of the IEM says that: “Regarding tariffs, it is clear that for the medium term, an approach whereby tariffs for cross border trade are a combination of different national tariffs schemes and where TSOs are compensated for transit and/or other cost inducing flows is the most sensible. However in the longer term, a pan-European tarification mechanism, would contribute to the further integration of markets.”

8.1 Background on locational signals

The basic principles of regulation of transmission network pricing were presented in Annex 2 of the final report of Phase I of this project. A review of the cross-border tarification principles that have been adopted for the IEM as an outcome of the Florence Regulation process were also described in section 2.1.1 of this same report. In this section we shall summarize the relevant concepts around the idea of locational signals and we shall borrow some material from section 5.4 of the final report of Phase I of the project.

Short and long-term locational signals.

Short-term economic locational signals are a result of network losses and constraints that happen during system operation. They are energy charges, i.e. they are applied to MWh that are produced or consumed. The most characteristic and sophisticated of these signals are nodal energy prices, not to be confused with the long-term nodal transmission network tariffs. These short-term signals are needed to achieve an efficient operation of the system, i.e. that the generators with the lowest variable costs are used and that consumers may respond to the actual costs of supplying electricity to each location. However, in many actual markets the energy prices do not contain these signals at all, or only in some crude way, with the subsequent loss of efficiency. These short-term signals also have a long-term impact, since the expectation of their values in the long-term has an influence in guiding long-term decisions of the network users, in particular the location of new facilities of generation or demand.

Transmission tariffs have the primary objective of recovering whatever fraction of the regulated transmission costs (most of them, actually) that has not been recuperated by short-term signals. Transmission tariffs can be considered as *long-term economic signals*, since the allocation scheme should be primarily based on the responsibility of the agents in network investment. Therefore, transmission tariffs should promote an efficient use of the network that reduces the need for new investments and also appropriate location of new generation and consumption facilities.

Cross-border tarification, -and the mechanism of *inter-TSO payments* that for this purpose has been adopted in the Florence Forum-, result in modifications of *transmission tariffs*, the long-term signals.

We have to recall that in the conclusions of the Florence Regulatory Forum it has been accepted an almost complete separation in the procedures to deal with the economic signals for operation -which are inherently short-term related- and network costs recovery -which are inherently long term related-. This separation of the roles of the signals for operation and network cost recovery is explained now:

- *Operation:* Short-term locational signals are intended to maintain the efficiency in the dispatch of generation and load in the IEM. These signals must internalize the effect of congestions and losses in the network. Therefore adequate congestion management procedures must be adopted with the purpose of achieving maximum efficiency in the utilization of the limited network capacities. Some progress has been already made in the IEM in this respect. The resulting locational signals will be strong if systematic congestions take place in the system. Any revenues (congestion rents) that might be obtained from the application of the short-term signals should be deducted from the total network costs that need to be recovered.

The procedure to deal with loss signals in the short-term is far less advanced, since losses do not have security implications and an IEM-wide scheme of computation of loss factors for operation purposes still appears to have significant practical difficulties. The dilemma between charging marginal or average costs of losses remains an open issue, in order to obtain an appropriate short term economic signal. The only progress that has been made in the IEM so far has been the agreement whereby the extra cost of losses that a country incurs because of cross-border transits must be compensated and it will be a component of the inter-TSO payments. Note that this compensation takes place annually and therefore the short-term effect of the economic signal is completely lost.

- *Network cost recovery:* Longer-term (typically annual) charges are used to pay for the regulated transmission network cost. Since any locational signal that might be intended with these charges has a long-term nature, these charges must not be transaction-based, since transactions typically vary much with time and only the position of each agent in the network remains. National transmission tariffs, —the domestic G and L charges, which could include locational signals at national level—, serve this purpose, since they provide full access to the entire IEM, they totally recover the regulated transmission costs and they are not transaction based. Inter-TSO payments introduce some adjustments (minor modifications of the original G and L national charges) into the mechanisms for network cost recovery at national level and therefore contribute a certain locational component.

Fully locational transmission tariffs and the contribution of the inter-TSO payment mechanism.

Inter-TSO payments are primarily meant to compensate economically those countries whose networks are being used by external users and not as a means to send precise locational signals to the individual agents of the market. However, the inter-TSO payment mechanism that has been adopted in the Florence Forum can also play a role with respect to sending correct locational signals. Inter-TSO payments in the end will result in a correction to the basic rule of using the local G and L charges as the basis for the access charge to the IEM transmission network. How significant could this correction be as a provider of locational signals?

Let us assume that a method, *-"the network cost allocation method"-,* exists that is able to assign the total cost of a transmission line to each one of its users. Let us also assume that the method for the assessment of costs for all transmission lines within the IEM has been harmonized, so that all Member States agree on the regulated annual cost of each one of the lines and other transmission facilities. Transmission tariffs must fully recover these costs. Then, application of "the network cost allocation method" to all lines in the IEM would result in a complete set of nodal transmission tariffs: a Gk tariff and an Lk tariff for generators and consumers located, respectively, at each transmission node k in the territory of the IEM. Political borders have been ignored in the computation. These are perfect *long-term* locational signals. No more could be asked for in terms of location and tariff harmonization.

What is the role of inter-TSO payments in all this? The "network cost allocation method" for the computation of inter-TSO payments starts precisely from a full allocation of standardized transmission costs of all lines in the IEM transmission network to all the transmission nodes in the IEM territory, as indicated in the previous paragraph. However, instead of using nodal transmission tariffs, the agreed procedure for inter-TSO payments aggregates the tariffs Gk and Lk for each country and determines how much each country has to be compensated or to be paid according to its usage of other networks and the usage of its network by others. The net amount of charges or compensation resulting from all this for each country should be applied to modify in a certain way its internal G and L charges. It should be noted that this inter-TSO payment scheme deliberately undoes the nodal tarification that had been achieved previously, turning it into a scheme of aggregate compensations. Obviously it is up to the individual countries to apply internally the net inter-TSO payments so that nodal differentiation is maintained, although this would not be consistent with the current practices in most IEM countries, where tariffs have no geographical discrimination.

Summing up, any mechanism of inter-TSO payments that is based on the allocation of the use of each transmission facility to its individual users can provide correct long-term locational signals at an aggregated country or TSO level. To be consistent, these signals must be based on standardized transmission costs at EU level.

The allocation key of the net inter-TSO payment to the internal tariffs G and L in any given country j can be directly obtained from the outcome of the "network cost allocation method". This method precisely determines how much the generators in country j are using of the network external to j, and also how much of the network of country j is being used by generators from outside country j. The excess of the first amount over the second one is the extra payment (or credit, if the amount is negative) that should be charged to the generators in country j. These locational signals ignore any geographical differentiation within each country, since the average value for country j is used instead of the individual value for each generator. The same reasoning should be used for consumers.

In conclusion, the inter-TSO payment mechanism, if properly defined and implemented correctly, contributes adequate long-term aggregated locational signals at TSO or country level to the transmission network tariffs that are locally implemented by countries or TSOs. The mechanism of inter-TSO payments, as agreed in Florence, does not provide detailed long-term locational economic signals per se -as it was not the agreed purpose of this mechanism-, since it aggregates charges and compensations at TSO level, although this does not prevent the individual countries or TSOs from recovering the individual nodal signals if they wish.

While the present lack of harmonization in the computation and design of transmission network tariffs in the IEM persists, the impact of the contribution of the inter-TSO payments mechanism, -even if it is applied with full attention to the locational effect-, is expected to be low in general. This is confirmed by the quantitative results that are presented later.

8.2 Computation of long-term locational signals

In this section it is shown that long-term locational signals (nodal transmission tariffs) can be preliminary computed from the available data that has been gathered by ETSO. The locational content of these tariffs is evaluated in order to assess if it is strong enough to be worth the effort and complexity of establishing IEM-wide transmission tariffs and harmonization procedures.

Methods that are based on the assignment of the network utilization to individual generators and consumers (such as the AP method) can be used in the computation of nodal transmission tariffs (this is the "family 1" type of methods, see the Final Report of Phase I of this project, section 3.1). On the other hand, algorithms that are based on the impact of transits on each considered country (the "family 2" of methods, such as WWT and APT) cannot be used for the calculation of transmission tariffs.

Only the AP method has been used in this evaluation. The main purpose of Phase II of the project is to use the new data that have been made recently available, in order to improve the comparative evaluation of the competing methods for the long-term mechanism of inter-TSO payments. Therefore, the main interest here is to check if the AP method, as a serious contender to be used in the long-term mechanism, could also be of any help in providing locational signals, perhaps within a wider scheme of transmission tariff harmonization.

The results to be presented are obtained from the analysis of the 24 snapshots corresponding to the year 2002 that were made available by ETSO.

Nodal transmission tariffs

The AP method has been used to obtain nodal transmission charges for each one of the 3965 nodes of the IEM-13 network model, in each one of the 24 scenarios for the year 2002 that have been provided by ETSO. These would be the annual transmission tariffs to be levied on the different agents if the corresponding scenario were the only one available to compute them. From these nodal tariffs for each agent and scenario an average annual tariff has been obtained for every agent. In order to calculate the average tariff for an agent its nodal tariff in each scenario has been weighted with the amount of power either produced or consumed by the agent. Whenever the nodal tariff for an agent is zero in a particular scenario (because it is not using the grid according to the AP method) the amount of power produced or consumed by the agent in this scenario has not been taken into account when computing its average transmission charge. Those tariffs of agents whose transmission charge is always zero regardless of the scenario have not been included in the results presented below[13].

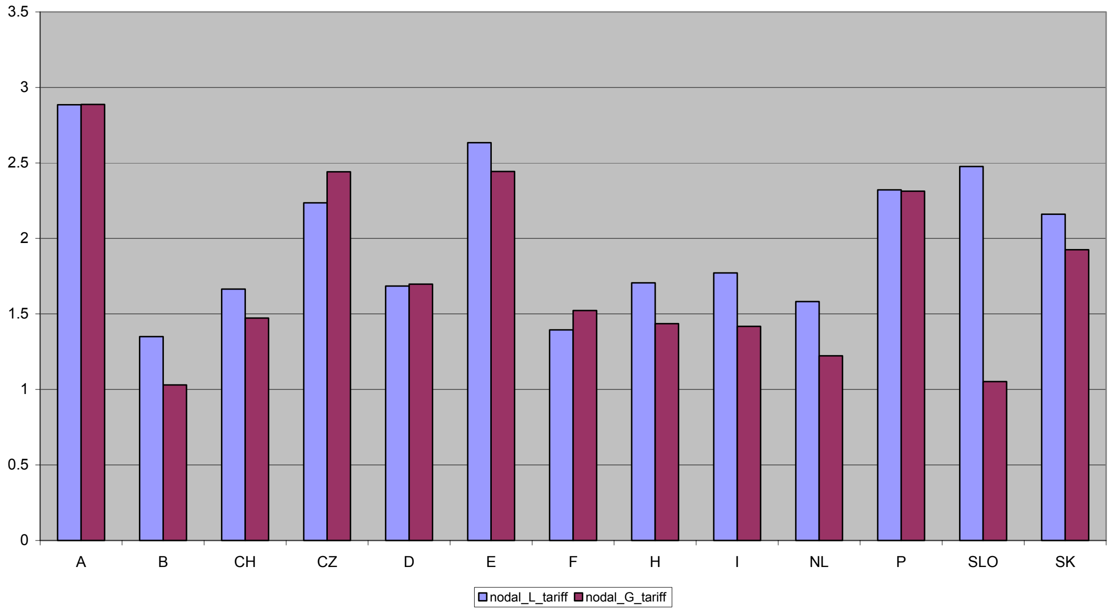

Figure 19: Average nodal L and G tariffs for the 13 countries in the IEM network

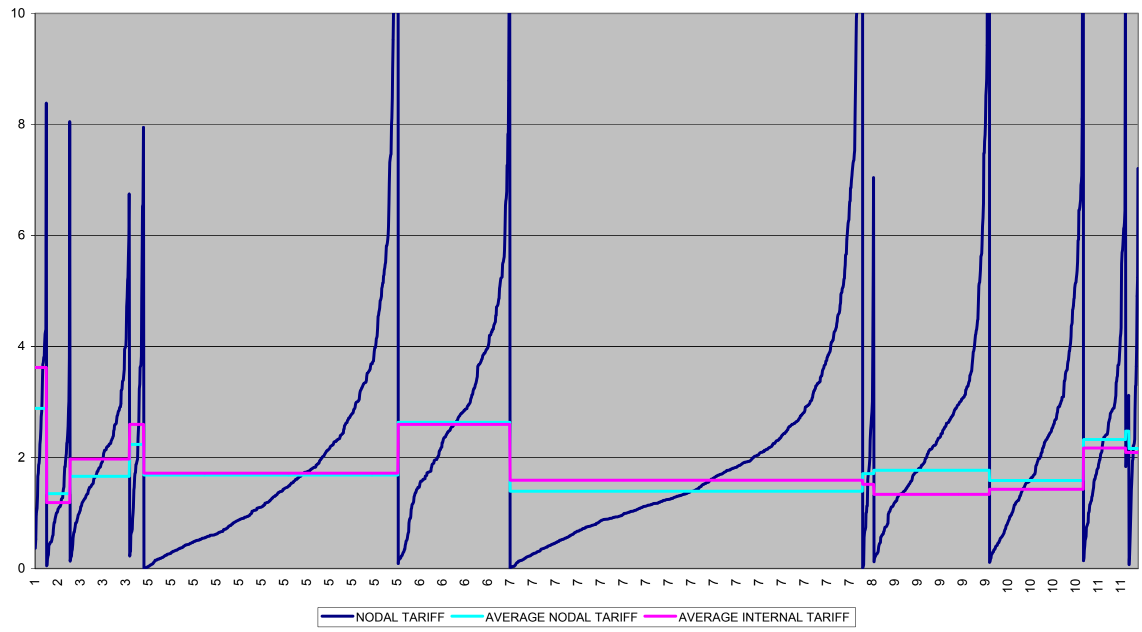

Figure 20: Nodal L tariffs for all the nodes in the IEM-13 network. Information on the highest tariffs (not shown in the figure) for eachone of the countries can be found in Figures 15 to 40.

[13] The true average transmission charge is obtained when also the agents with zero transmission charges are included in the computation of the average value.

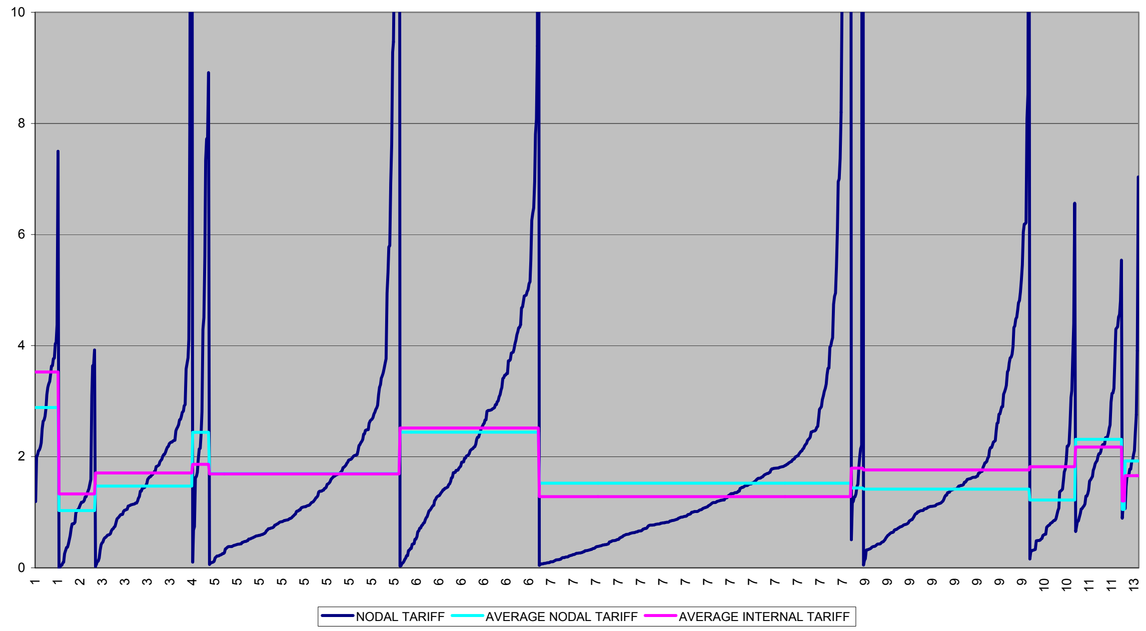

Figure 21: Nodal G tariffs for all the nodes in the IEM-13 network. Information on the highest tariffs (not shown in the figure) for each one of the countries can be found in Figures 15 to 40.

Figure 19 presents the average nodal L and G tariffs for the 13 countries in the IEM network as a bar chart. Numbers are expressed in Euros / MWh. Figure 20 and Figure 21 show the nodal L and G transmission tariffs, respectively, for all the nodes in the IEM-13 network. The average values for G and L for each country have been represented with a blue line, whereas the average internal tariffs for each country (resulting from dividing half of the cost of the national grid by the total amount of load or generation in the country; this is the internal average transmission tariff for each country before the application of inter-TSO payments) are represented with a solid pink line. The difference between both horizontal lines in each country indicates the significance of the impact of the inter-TSO payment mechanism on the transmission tariffs of each country.

ETSO has not been able to provide the geographical coordinates of each node in the network and therefore it has not been possible to show a map with the spatial distribution of the tariffs in the IEM. However, we can appreciate from the figures that the distribution of the average values is quite uniform in all countries (the average values for G range between 1.03 €/MWh and 2.89 €/MWh, with an average value for the IEM of 2.02 €/MWh; in the same way, the average values for L range between 1.35 €/MWh and 2.89 €/MWh, with an average value for the IEM of 2.33 €/MWh). The significant differences among the average transmission charges in different countries are not only due to the different pattern of flows existing in each part of the grid but also to the fact that the amount of transmission assets per MWh varies widely from one country to another. In this sense, inter-TSO payments among countries account for the difference between the average transmission charge that would exist in each country if there were not cross border exchanges of electricity (pink line in Figure 20 and Figure 21) and the computed average transmission charges per country (blue line). Thus, for example, the positive inter-

TSO payment of 26 million euros for Austria represents the amount that other countries have to pay Austria, because of the difference between the cost of the Austrian grid (represented by the average internal tariffs on G and L) and the total cost of the whole grid used by the Austrian generators and consumers (represented by the actual average G and L tariffs).

The distribution of transmission charges within every country shows a large dispersion with respect to the average value. This is related to the different ways in which the same pattern of flows can affect the transmission charge computed with average participations for two agents located not very far one from the other. Due to the non-linear nature of the method, the unitary participation in the use made of the grid by an agent may critically depend on the size of G and L at the nodes[14].

Focusing on one country like Spain, we can see how there are areas where generation and / or load nodal tariffs are similar. Thus, for example, in the Basque Country region, L tariffs range between 1.3 and 7.3 €/MWh with an average of 2.63 €/MWh and a standard deviation of 1.22 €/MWh. As far as G tariffs are concerned, they range between 0.03 and 2.85 €/MWh with an average of 0.82 €/MWh and a standard deviation of 0.79€/MWh. Outliers above the average can be explained as corresponding to agents that either produce or consume a small amount of power and are connected to the rest of the grid through a dedicated line or lines. Values well below the average are normally generators in a node where demand is predominant or conversely loads in a node where generation is much more important. Even within the Basque region, different areas can be distinguished where tariffs are much more homogeneous. One possibility to avoid the problem of dispersion of the tariffs is to compute and apply zonal tariffs. In order to compute them each nodal tariff would be weighted with the amount of power either consumed or produced by the corresponding agent and an average for predefined geographical regions would be obtained. In this way, those extreme values would have a small influence in the resulting tariff to be applied to every generator or load in the area. It is also possible to design methods to smooth out the individual nodal tariffs by taking into account the values of nearby nodes.

Smoother and perhaps more acceptable results than the ones presented in this report can be obtained if the cost of the non-used part of the network is assigned to all the demand in the country as a flat charge (variant 2 for AP, see section 4.2), since a significant fraction of the costs of the network are now socialized.

The results that have been obtained are not conclusive with respect to the usefulness of AP as an aid in the computation of nodal transmission tariffs with a locational content. The average values that have been obtained and the volatility of the results for the 24 snapshots appear to be normal. It will be necessary a detailed examination, -once some geographical data regarding the position of each node is obtained-, of the reasons behind the large dispersion of values of the G and L charges for each country, and also the relationship with the values at nearby nodes in the neighboring countries.

[14] See section 5.4.1 of the final report for Phase I of the project for a more detailed explanation.

8.3 Implications on tariff harmonization

A suggested procedure

A sound transmission tarification procedure at IEM level should be based on the responsibility of each network user, regardless of political borders, in the utilization or the development of each one of the elements of the transmission network of the IEM. The implementation of such a tarification procedure would consist of the three following steps:

- Assign the responsibility of every network user in the development or the utilization of each one of the facilities of the transmission network, regardless of political borders.
- Use standard transmission costs across the IEM in order to make the conversion from the responsibility factors in step (i) to assignment of costs.
- Translate the assigned costs into transmission tariffs G and L (i.e. charges per kWh, per kW or per customer) using some harmonized procedure.

The procedures to calculate the remaining transmission charges in the Member States, beyond the G and L charges above, should be harmonized. For instance, the remaining charges (or credits) that are needed for complete transmission cost recovery of a given country or TSO could be totally assigned to consumers, either uniformly or in such a way that total charges to demand may become uniform, if this is required by the national regulation. The advantages of this harmonization approach are:

- All generators within the IEM receive totally correct long-term locational transmission signals that are meant to convey correct siting incentives.
- The total amount of regulated remuneration of the transmission activity within each country or TSO is left entirely to subsidiarity. This appears to be reasonable, because of the large disparity of values and procedures that have been adopted in each country or TSO, which correspond to well established commitments of the regulatory authorities with the owners of transmission assets within the IEM.
- It is left to the regulatory authorities of each Member State how to allocate to their consumers the difference between the revenue collected within a country or TSO by the IEM-wide G and L tariffs that apply to the network users within that country or TSO and the regulated value of the remuneration of the transmission activity. In general this will distort the long-term locational signals to consumers. However, it is deemed to be an acceptable compromise, since:
    - a) the potential for market distortion of incorrect locational transmission signals for consumers is considered to be lower than it is for generators, in particular if the extra charge is applied so that the loss of economic efficiency is minimized, as it is the case when Ramsey-like tarification methods are employed;
    - b) some Member States have long standing commitments to maintain uniform tariffs for consumers within their territories;

- c) the economic value of the difference in the preceding bullet point has to be assigned somehow and this appears to be the least damaging option.

The procedure to compute IEM-wide transmission tariffs that has just been presented implicitly contains an inter-TSO compensation scheme. In fact, political borders have been ignored when the allocation of transmission responsibility and cost has been performed. Therefore the G and L tariffs so computed already contain the compensations and charges (evaluated using standard costs) that are required because of the external use of the networks of other countries or TSOs.

A simplified version

In the absence of an agreed upon method to compute harmonized nodal transmission charges, the European Commission and the Tarification Task Force of CEER have been working on a simplified approach for tariff harmonization. This approach basically amounts to leave each country to set a value for the G tariff, -either uniform or with geographical differentiation, for each country-, such that the associated revenues represent a small percentage of the regulated costs of the horizontal network of each country. The remaining regulated cost of transmission for each country, -including any net TSO payments-, will be recovered for each country by the L charges.

Since the G charge is so small, there is no problem that it is applied as a €/MWh charge, since the distortion that it may introduce in the short-term operation of the power system, with energy prices in the vicinity of 35 €/MWh, will be negligible.

9 Comprehensive evaluation & conclusions

The availability of new data, the experience obtained so far in the application of the transitory approach of cross-border tarification and the development of new European Regulation for cross-border trade has provided a new perspective, from which to address the extension of the report on "Cost components of cross-border exchanges of electricity"[15].

This report of Phase II of the project has examined a few selected methods of network cost allocation under different perspectives and for different applications. A reduced set of real network flow scenarios, corresponding to 24 selected snapshots for different instants of time during 2002, have been used for this purpose. This last chapter takes advantage of what has been learned during the preceding chapters, and defines in section 9.1 a comprehensive set of criteria to evaluate any method of network cost allocation that may be proposed as the core of the cross-border tarification scheme in the EU Internal Electricity Market. Then, in section 9.2, this set of criteria is applied to the few methods that were selected during Phase I of the project and that have been carefully examined in the preceding chapters of this report.

9.1 Criteria to be met by a method of network cost allocation in the context of the IEM

The importance of a sound regulation of the transmission activity should not be underestimated. Although the cost of transmission is not of much relevance when compared to the total cost of electricity, a poor solution to any of the three basic aspects of transmission regulation: investment, access and pricing, may well result in a significant loss of efficiency in the functioning of the power system. Transmission regulation is, by far, the most contentious issue when trying to implement any kind of multinational market.

The success of the regulatory framework of transmission for cross-border trading of electricity in a multinational market depends on several factors. Here we shall concentrate only on the method of network cost allocation that is needed to implement a mechanism of inter-TSO payments, since, in broad terms, this is the approach of cross-border tarification that has been adopted within the IEM. As we shall see, the choice of this method has different implications and this decision should not be taken lightly.

In this section we shall define the criteria that such a method of network cost allocation has to meet. The application of these criteria to a few selected methods will be addressed in the following section. Both tasks will draw from the knowledge

[15] See the final report for Phase I of this project: "Cost components of cross-border exchanges of electricity", prepated by the Instituto de Investigación Tecnológica (Universidad Pontificia Comillas de Madrid) for the Directorate-General for Energy and Transport of the European Commission, November 2002. See http://europa.eu.int/comm/energy/electricity/publications/index_en.htm.

that has been gathered during the realization of this study, as described in the preceding chapters of this report.

The criteria that have been identified can be classified into three groups.

A. The broader context.

This first set of criteria look at the consistency of the network cost allocation method with the underlying paradigm of the IEM that is contained in the EC Regulation and the methodological decisions already made within the context of the Florence Forum.

- *Criterion #1: The method for network cost allocation must be consistent with the fundamental approach inspiring the construction of the IEM*: As stated in a recent EU Commission staff working paper, "The overall goal is for the IEM to function in the same way as a national market … In the long term a pan-European tarification mechanism would contribute to the further integration of markets"[16]. These are elements of what has been often termed the "single system paradigm", which expresses the ideal objective of achieving rules for the IEM so that it approaches the functioning of a single system as much as possible, without that implying that there is any purpose or objective aimed at merging TSOs, power exchanges or national regulators into single pan-European organizations.
- *Criterion #2: The method for network cost allocation must be consistent with the overall framework of transmission regulation, so that any mutual implications with other aspects of transmission regulation do not create undesirable conflicts, now or in the future*. Is the method consistent with the remaining elements of cross-border transmission regulation?
    - a) investment in new infrastructures;
    - b) locational signals for operation and investment;
    - c) network tariff harmonization and potential pan-European or at least regional transmission tariffs.

  One example for this need of consistency is the relationship between the inter-TSO payment mechanism and transmission investment. The inter-TSO payment mechanism, -regardless of the actual method for network cost allocation that might be used-, automatically allocates the cost of any new network investment that belongs to the so called "horizontal network" to the different countries or TSOs, according to a prescribed procedure. Therefore, the implications of this procedure on the mechanisms to be adopted for transmission network expansion have to be examined very carefully.

[16] EU Commission staff Working Paper, "Strategy Paper: Medium term vision for the Internal Electricity Market (IEM)", draft, October 2003.

B. Economic, technical and legal soundness of the method.

Soundness of the method in all relevant aspects, -economic, technical or legal-, will facilitate its understanding and minimize potential conflicts in its application, therefore contributing to its acceptance.

- *Criterion #3: Economic soundness.* Is the method based on sound economic principles or does it have economic justification? Does the method promote economic efficiency (productive efficiency, allocative efficiency)? Does the method at least not distort efficiency? Do the results of application of the method make economic sense? Can relevant counterexamples be found?
- *Criterion #4: Technical and logical soundness.* Is the method based on sound engineering principles or does it have technical justification? Does it rely on non justified hypotheses or definitions? Is there any technical inconsistency in the algorithms that are needed for the application of the method? Do the results of application of the method make engineering sense? Can relevant counterexamples be found?
- *Criterion #5: Legal soundness.* Does the method have any kind of incompatibility with the existing regulation? Will be the method perceived as fair?

C. Implementation issues.

The practical aspects in the implementation of the method can sometimes be decisive in the final choice of one method or another. Excessive complexity in the algorithms, difficulties in data acquisition and handling or lack of robustness in the results may dissuade from choosing one particular method.

- *Criterion #6: Data availability, acquisition and handling.* Volume and availability of required data, difficulty in obtaining or processing the data.
- *Criterion #7: Availability and complexity of procedures or commonly agreed definitions that are required to apply the method. Experience with its utilization.* This includes: Definition of transit, definition and determination of the horizontal network, algorithms and computer models, commonly agreed standard costs of network infrastructure and losses.
- *Criterion #8: Ability to be easily understood and verified.* Is the method easy to understand and to apply? Is the basic concept of the method easy to explain and communicate? Are there any special difficulties in the practical implementation of the method or in the interpretation of the results? Can the results be verified or replicated easily?

9.2 Evaluation of the three proposed methods of network cost allocation

The three groups of criteria that were defined in the previous section will be applied here in the evaluation of the three methods that have been examined in detail in the preceding chapters of this document. The three considered methods are real network flow methods, that is, methods that take as the starting point the actual physical flows that exist in the transmission networks. These methods, whose detailed description can be found in the final report of Phase I of this project, are:

d) The "with-and-without-transits" method (WWT), a simplified version of which has been used by ETSO during 2001 and 2003 in the computation of inter-TSO payments for a large number of countries participating in the IEM.

e) The "average participations" method (AP).

f) The "average participations applied to transits" method (APT) that was proposed during Phase I of this project.

A. The broader context.

This first set of criteria look at the consistency of the network cost allocation method with the underlying paradigm of the IEM that is contained in the EC Regulation and the methodological decisions already made within the context of the Florence Forum.

- *Criterion #1: The method for network cost allocation must be consistent with the fundamental approach inspiring the construction of the IEM*:

  WWT:

  WWT is an extension of the traditional method of evaluation of the impact of a transaction between two parties on a third –typically vertically integrated- system. These transactions were termed "wheeling transactions" in the US regulation and the US Federal Energy Regulatory Commission (FERC) has approved thousands of tariff terms for these transactions during the last thirty years. The "wheeling" philosophy is well adapted to the world of vertically integrated utilities and voluntary transactions, but this paradigm significantly differs from the "single system paradigm" that prevails in advanced multinational markets in a context of liberalization, as it is the case of the IEM. The most recent documents of the European Commission and the CEER do not leave any doubt about the choice of paradigm.

  AP:

  AP traces the flow in each line, both upstream and downstream, in order to determine the responsibility of generators and loads in that flow. By simple aggregation it is determined the charge that corresponds to each generator and load in the use of the total network of the system and, again by aggregation, how much corresponds to all agents in a country and how much each country has to compensate any other country for the use of its network. Political borders are totally ignored in the network cost allocation process and they are only used when performing the aggregations of charges of the agents of each country.

  This is completely consistent with the "single system paradigm", since the charges to individual network users are computed as if only a single power system existed, where all network users share a common transmission network and the charges are based on the magnitude of utilization of this network by each agent.

APT:

APT shares the same philosophy of design as WWT, -namely, that only "transits" may cause external use in a network-, and therefore it is subject to the same criticism. APT tries to improve upon WWT by tracking the transit flows both upstream and downstream, and therefore by being able to assign these transits to the agents –and by aggregation to the countries- that are responsible for them. Thus, when compared to the AP method, APT is at a clear disadvantage because the results depend on the borders considered as opposed to the AP method, which produces the same results at node level regardless of the existing political borders.

- *Criterion #2: The method for network cost allocation must be consistent with the overall framework of transmission regulation, so that any mutual implications with other aspects of transmission regulation do not create undesirable conflicts, now or in the future*. Three major components of transmission regulation that may be related to the method of network cost allocation for inter-TSO payments have been identified. Each one of them will be now examined for each one of the three methods being considered.
  - a) Investment in new infrastructures.

  The inter-TSO payment mechanism automatically determines the fraction of the cost of the horizontal network of a country that is subject to external use and, also automatically, it charges this cost to those countries that appear to be responsible for this external utilization. Any new transmission investment that is added to the horizontal network of a country is subject to the same procedure. Therefore, we can conclude that the network cost allocation method that is adopted for the inter-TSO payment mechanism determines who is going to be charged for any new transmission investment in the IEM. Let us now examine the performance of each one of the three considered methods under this perspective.

  WWT:

  In the allocation of costs of new investments WWT frequently provides results that are difficult to accept. This has to do with two major reasons.

  The first one is a consequence of the basic concept of the WWT method, when contemplated from the perspective of a single line in the transited country. Removal of the transit in the "without transit" case forces changes in flows in all lines situated in between the interconnections with import flows and the ones with export flows. These changes in flows may not have much to do with the actual pattern of distribution of import and export flows in the considered country. WWT and AP differ widely in this respect, as shown in section 5.3. For instance, in example

1 of section 6.1, 20.4% of the flow in an assumed new transmission line in Spain (Vandellós – La Plana) is attributed to external agents by WWT, while AP considers that 100% of the use of this line corresponds to internal utilization. As explained in chapter 5, the result provided by WWT is consistent with its logic, whereby having import flows in one side of a country and export flows on the other side means that there is a transit that crosses the country, with an impact on all lines in between the entry and exit points of the transit.

According to the logic of WWT, it will frequently happen that the flow in the new line being considered happens to increase when the transit is removed. Application of the standard WWT method results in a *negative* compensation to the country where the line is located, i.e. the country must pay others because of this line. This is, for instance, the case in example 2 of section 6.1, with line (Garoña – Herrera) in Spain. WWT determines that the transit reduces the flow in this line by 31% and, therefore, Spain will have to compensate a total amount of 31% of the cost of the line to all countries in Europe a pro rata of their net imports or exports. Again, in this case AP determines that the entire use of the line is internal to Spain. The result of WWT is unreasonable when applied to infrastructure costs, since the questionable concept of "transit" cannot be a determining factor to reduce investment in a network. This notion of benefit because of the existence of a transit makes more sense with losses, which can really decrease at a given time because of an actual transit flow.

In order to eliminate this anomaly, one could think of making use of the variant WWT-2 in section 4.3 of this report, where negative compensations to individual lines are not taken into consideration. However, the quantitative results provided by this variant are totally unacceptable, as shown in the numerical example. The WWT method forces the flows so widely across the networks that only the netting of the positive and negative results makes possible to obtain results of a reasonable order of magnitude.

The second reason why the results of WWT for the allocation of costs of individual lines are difficult to accept has to do with the second step in the inter-TSO payment method: the allocation of the charges. Let us examine the procedure by which the WWT method allocates the cost of a new transmission investment by means of the inter-TSO payment mechanism. Consider first the situation that can be expected to be more typical, when the flow in the considered line in the "with transit" situation happens to be larger than in the "without transit situation". In WWT this increment in the flow is attributed to network users in external countries, who should be charged for the proportional fraction of the cost of the line. How much should each external country be charged? The internal logic of the WWT method does not provide a reasonable answer to this question. WWT, as it is currently implemented now, allocates the cost to every country, in direct proportion to the sum of the absolute values of the net imports and next exports of the country during a given year.

The problem with this network cost allocation rule is that the allocation of the cost of the external use of a line in a country k is dispersed among all countries with any imports or exports. Examples of this are shown in Chapter 6. While a certain level of socialization in the costs of network reinforcements across Europe may seem initially tolerable, it does not seem acceptable (see example 4 in section 6.1) that Italy, because of its large volume of imports, has to pay 11% of the cost of a line at the border between Belgium and France, or Switzerland –because of its large exports- has to pay 6%, while the reasonable thing to do, as AP rightly determines, is to charge only and 50/50 to France and Belgium. Even worse, if the standard WWT method is used, then it may happen (see example 2 in section 6.1) that Spain has to pay an extra 31% of the cost of a new Spanish line to countries with the larger imports and exports: France (12%), Italy (10%), Switzerland (2%), Czech Republic (2%), The Netherlands (1%), etc.

AP:

The results that have been obtained with AP appear to be reasonable in all cases. This has to do with the internal logic of the method: track the flow of each line, both upstream and downstream, to determine who are the individual agents (countries) that are responsible for this flow. Therefore, the AP method is perfectly suited to allocate the cost of a new transmission investment, since this is exactly what the method does: to individually allocate the cost of each investment.

Depending on the situation of the considered line with respect to the dominant patterns of flow in the IEM, when tracking upstream or downstream the flow in a this line sometimes the sinks and sources of the flow happen to be near to the line and sometimes are far away, perhaps crossing one or more political boundaries. This behaviour has been examined for a sample of lines. Some representative cases are reported in section 6.1 and the results have been found to be reasonable in all the considered examples.

APT:

APT provides a solution to the two major problems of WWT that were identified above. On one hand, APT tracks the transit flows at the borders of each country, both upstream and downstream, in order to determine the external use of the network of the country and who is responsible for this external use, but it does not force an incremental flow (the transit) across the country. Therefore the impact of the transit on the individual lines is closer to the AP philosophy and the results appear to have the same physical meaning as with AP.

On the other hand, the allocation of the charges (step 2 in the inter-TSO payment mechanism) takes into account the topology of the network and the pattern of flows, therefore avoiding the quasi arbitrary allocation of the WWT method.

In conclusion, APT provides results for the allocation of costs of individual network investments that are similar to those obtained with AP, although typically with a lower allocation to external use, as can be verified in the examples shown in Chapter 6. The reason is that APT only tracks transit flows, instead of the complete cross-border flows that are considered by AP.

- b) Locational signals for operation and investment.

The adopted method should be able to provide locational signals in the allocation of network costs. It will depend later on the specific transmission regulations, -both at national and EU levels-, whether these locational signals will be properly used or not.

WWT:

WWT is unable to provide any locational signals at nodal level.

In step 2 of the inter-TSO payment mechanism (allocation of charges) WWT ignores any locational concept and socializes the charges taking only into account the net imports and exports of each country.

AP:

AP starts by allocating the costs of the entire network of the IEM to all nodes of this network. Assuming that the network allocation logic is correct, AP achieves a fully locational assignment of network costs.

The inter-TSO payment mechanism aggregates the compensations and charges at country or TSO level, therefore losing most of the original locational content of the AP nodal charges. Some locational content is preserved, as shown in the figures of individual tariffs for each country in section 8.2.

Section 8.2 of this report also shows the results that are obtained when AP is applied to the computation of long-term locational signals. The large variation in nodal charges that is obtained for each country when the basic AP method is employed is a somewhat surprising result that deserves further analysis. The difficulty in performing this analysis is the lack of geographical information on the nodes of the network, so they cannot be placed on a map.

More acceptable results are obtained when variant AP-2 is used and the cost of the non-used part of the network is assigned to all the demand in the country as a flat charge.

APT:

APT only tries to allocate the responsibility of transits to individual nodes of generation and demand. APT does not allocate the cost of the complete network. Therefore it cannot be used in the determination of pan-European nodal tariffs or any other kind of locational signal related to the entire transmission network.

- c) Network tariff harmonization and potential pan-European or at least regional transmission tariffs.

From what has been said in the previous bullet point (c), it is clear that only **AP** –or any other reasonable method that is based on the assignment of the responsibility in the use of each network investment-, has any chance to be useful in a process of regional or pan-European network tariff harmonization where one wants to preserve any locational content.

B. Economic, technical and legal soundness of the method.

- *Criterion #3: Economic soundness.* Is the method based on sound economic principles or does it have economic justification? Does the method promote economic efficiency (productive efficiency, allocative efficiency)? Does the method at least not distort efficiency? Do the results of application of the method make economic sense?

All three methods rely on a basic assumption: use is tantamount to responsibility in investment or economic benefit, which should be the sound criteria for the allocation of network costs[17]. Once the utilization of "network electrical use" has been accepted as the criterion to allocate the network costs, the discussion is mostly transferred to the area of electrical engineering: Which is the best method to determine electrical usage of a network?

A second economic criterion has to do with the capability of sending long-term locational signals. These signals can then be used to create incentives for location of new agents or to stimulate network reinforcements. But if these signals do not exist, it will be later impossible to make use of them.

WWT:

Instead of attempting to assign the cost of the entire IEM network among the groups of users of each country or TSO, WWT relies on the concept of transit as a measure of electrical utilization. Then, it is further assumed that the entire impact of all external network users on the network of a given country can be expressed by the concept of transit. The use of transits will be examined under criterion #4.

No locational signals are provided by the WWT method, as explained before under criterion #2.b.

AP:

Once it is accepted that electrical use is an acceptable proxy to responsibility in network cost, the only remaining key point is whether the tracking method of AP is a reasonable scheme for the allocation of responsibility in network use. This will be commented later, in criterion #4.

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[17] SeeAnnex 2 in the Final Report of Phase I of this project.

But, once it is assumed that AP is a good method to determine network utilization, AP has all the good properties for economic soundness, in particular the property of additivity of charges. In fact, AP allows one to allocate the cost of each line individually to each one of the nodes of the network. Then it is possible to bundle these charges at TSO or country level or to use them at nodal level, so that locational signals with any level of aggregation can be used.

APT:

APT is a pragmatic combination of the WWT and AP methods, as shown by the numerical results that have been shown in this report. Under a viewpoint of economic soundness it shares the basic assumptions of both methods. As in the WWT method, APT assumes that any compensation between countries must be related to the use the transit through a country makes of the grid of this country. However, the way of computing the impact of the transit on the flows of the grid is the same as the one applied in the AP method to all the cross-border flows.

- *Criterion #4: Technical and logical soundness.* Is the method based on sound engineering principles or does it have technical justification? Is there any technical inconsistency in the algorithms that are needed for the application of the method? Do the results of application of the method make engineering sense? Do the numerical results make sense according to the rationale of the method? Do the results make sense intuitively?

WWT:

The central idea of the WWT method is that "external" flows cross the border of a country without intervention of the agents of this country. The distinction between which of the flows crossing the border are "external" and which ones are related to the internal agents of the country is achieved by means of the definition of "transit", whereby the minimum of the total amount of imports and exports, at any moment in time, is adopted as the value of the transit. The results that have been obtained with WWT appear to be consistent with what could be expected according to the characteristics of the method. However, a considerable number of criticisms can be identified for the WWT method:

- The concept of transit is very intuitive, but imprecise when we try to express it in mathematical terms, since there is no possible method to ascertain, only from the knowledge of the values of the cross-border flows at all interconnections, which flows at the border of a country go through it and which ones are just associated to the internal agents.
- WWT is implicitly accepting that only when there is a transit there is any utilization of the network of a country by external agents. A broader view of "external use" should contemplate that, when a country is importing, then the exporter is using the network of this country to export as much as this country is using it to import. And vice versa.

- The distribution of the transit flow among the several interconnections crossing the border of a country is arbitrary. In the current version of the method this allocation of the transit flow is done a pro rata of the actual flow at each interconnection.
- Regardless of the arbitrariness of the allocation of the transit flow among the interconnections, the removal of the transit results into a fictitious "without transit" situation, which may have a bizarre configuration of flows and losses with little resemblance with the physical reality of the power system.
- Since the definition of transit ignores the pattern of flows inside a country, counterexamples can be easily invented where there is a transit, according to the adopted definition, but it is clear that no physical flows are crossing the country from the entry points to the exit ones. However, this does not necessarily mean that WWT yields wrong results, as it is shown later.
- The whole idea of transit is based on the existence of political borders. If political borders change, so will do the compensations and charges associated to transits, as well as the final charges or credits corresponding to each individual agent. While the outcome of methods that are based on the allocation of the use of each individual network facility –such as AP-does not depend on the political borders, the set of compensations and charges resulting from the application of WWT will change if a new political border is introduced, for instance just by splitting any country k in two: k1 and k2. Then the sum of the compensations and charges of k1 and k2 in general will differ from the compensation and charge computed for k as a whole.

  This should not only be seen as a theoretical result that indicates lack of internal consistency in the WWT method. It may also have practical implications. For instance, numerical results on inter-TSO payments are different with WWT depending whether Northern Ireland is considered jointly with the UK or with the Republic of Ireland. This cannot happen with AP.
- WWT forces the removal of the transit between the entry and the exit points at the border of the considered country, therefore causing changes in all intermediate lines to accommodate this change. Note that, on the contrary, AP tracks the cross-border flows, following the prevalent flow pattern. Therefore AP only computes an impact on a limited amount of lines, until the flows that are being tracked die in generators or loads. However the results of WWT and AP do not have to be that different in the end, since WWT will encounter intermediate lines where the flows have decreased with the transit and, therefore, will not count in the computation or their impact will be negative (the compensation due to the country will be reduced because of them, something equivalent to charging for the use of external networks in AP). While the global result of WWT will make sense in general, the changes in the flows of individual lines, -because of the several reasons indicated above-, may

not make much physical sense in some cases. This has adverse implications when seen from the viewpoint of the allocation of costs of individual investments, as indicated elsewhere.

- It is not clear how to proceed with WWT regarding "direct current" (DC) lines. What happens to the flow in the DC line when the transits are removed? Was that flow a part of the transit? As the flow in a DC line is determined by the system operator and not by the load flow model itself, it is needed an additional assumption when running WWT concerning how the flows in DC lines will be in the "without transit" situation.
- There is not a unique measure of the impact of the removal of a transit. Three possible measures are:
    - a) compute a global measure of network utilization, such as the MW x km, and compare this measure in the "with transit" and "without transit" situations (this is the metric that is used in the variant WWT-1 in section 4.3;
    - b) compare the flows in each line in the "with transit" and "without transit" situations and compute only those flows that have increased because of the transit (this is variant WWT-2);
    - c) determine the volume of flows that is caused in the network of the considered country by the transit flow itself, in the absence of any other flows (this metric must be very close to the first one).

  But there is still more. Once it is known how much of the actual network utilization corresponds to the transit, we have the choice of sharing between external and domestic use only the fraction of the capacity of the lines that is currently being used or the total capacity of the lines. For instance, if a line has a transmission capacity of 1000 MW, its current flow (with transit) is 400 MW and the flow in the "without transit" condition is 300 MW, we have two choices:
    - a) charge to external use a fraction (400 – 300) / 1000 = 0.1 or 10% of the cost of the line.
    - b) charge to external use a fraction (400 – 300) / 400 = 0.25 or 25% of the cost of the line.

  The degrees of freedom in the choice of the metric indicate that the WWT method cannot provide an unambiguous answer to the question of measuring network utilization[18].
- Once the compensation that is due to a country has been computed with WWT, the logic of the "with and without transit" approach does not give any idea on how to charge this compensation to the agents or countries that are responsible for this external utilization. Several schemes have been used during the last years in the practical implementation of the WWT method for the calculation of inter-TSO payments in the IEM. The simplest, most fair and most logical one (once

[18] The second problem that has been indicated here is also common to the AP and APT methods.

it is admitted the impossibility of WWT to do better) seems to be to charge the total sum of compensations to the countries on a pro rata basis of their net flows, i.e. the absolute value of the difference between exports and imports of each country, for each one of the scenarios that are considered.

AP:

The basic idea behind the AP method, and also its weak point, is that AP assumes that it is possible to trace the origin and the end of the flows and applies a simple proportionality branching rule for this purpose. The nice thing about AP is that, if the flow tracing rule is accepted, everything else directly follows: compensations for external use, charges, inter-TSO payments, nodal transmission tariffs, allocation of the cost of new investments and so on. The following comments about the flow tracing rule are pertinent here:

- The flow branching rule cannot be proved on the basis of the laws of physics. The adopted pro rata hypothesis on the branching of flows is the simplest one, but it seems difficult to propose a better rule. The branching rule may be termed arbitrary, but the flows are physical ones. The tracing process starts from the actual pattern of existing network flows.
- AP is based on the average utilization of the network. Marginal signals are known to have interesting economic properties. However, average signals might be preferable when just trying to assign the total cost of the network and to design transmission tariffs to cover this total network cost. Marginal signals are certainly preferable in the short-term, for operation purposes.
- The AP method has degrees of freedom in its implementation, see Chapter 4, for instance regarding whether the total capacity of the lines should be allocated or just the fraction of that capacity that is actually used. This can be seen as a negative point, -since the method does not imply unambiguously how it should be implemented-. On the other hand, it allows flexibility in attaining other goals, such as tariff harmonization or a convenient split among generation charges and consumer charges.
- The results that have been obtained with AP in both Phases of the project appear to make physical sense and also seem to be consistent with what could be expected according to the characteristics of the method, except perhaps for the strong dispersion in the values of the nodal transmission tariffs that is commented below. No counterexamples or inconsistencies have been found. See in section 3.1.1 of the Final Report of Phase I of this project the discussion on the treatment of relatively small and heavily transited countries with the AP method.

Additional comments on the AP method:

- In AP a direct current (DC) line could be treated as any other line in the system: its flow will be tracked upstream and dowstream in order to determine where it originates and where it ends. Another possibility is to treat a DC line not as a transmission facility, but as a trading entity represented by a generator on one end and a load at the other end, who will have to pay transmission charges because of their utilization of the network. In both cases AP provides a simple answer without having to modify the method at all.
- The nodal transmission tariffs that have been computed in Chapter 8 with AP using the 24 snapshots of 2002 show a strong spatial differentiation that has not been fully explained yet. This feature could be an indicator of some kind of undesirable volatility in the results of AP. But nothing can be firmly stated until a thorough investigation is made and, for this investigation, the geographical coordinates of the network nodes (which have not been made available) are necessary.

  If a satisfactory explanation is found, and if it is desired to compute nodal transmission tariffs with a locational component, it is possible to make use of one of the variants of the AP method (allocate responsibility for external use only to the fraction of the total capacity of each line that is really used), so that the large range of variation of the tariffs that are obtained with AP is reduced significantly, as shown in section 4.2.
- The AP method shares with WWT the potential criticism -about the ambiguity in the dependence of the results-, on whether the total cost of the line should be allocated based on the outcome of the method or if only the cost of that part of the line that is actually used should be assigned according to AP, while the rest is socialized.

APT:

Obviously APT must combine the weak points of the assumptions behind both WWT and AP: the use of the concept of transit and the acceptance algorithm for tracking the flow of AP. The merit of APT is in trying to make more acceptable the use of transits, by introducing a locational component in the determination of charges and by avoiding the forcing of a transit across the entire network of the individual countries. The results that have been obtained with APT appear to be consistent with what could be expected according to the characteristics of the method.

Criticisms associated to the concept of transit are applicable to APT, as well as the pro rata distribution of the transit among the interconnections. But APT solves the problems of WWT in step 2 (allocation of charges) of the inter-TSO payment mechanism. APT also avoids forcing the transit to all intermediate lines between the entry and exit points, although it still favours heavily transited countries, as WWT does, and it also tends to mistreat purely exporting or importing countries.

APT uses the same proportionality rule as AP to trace the flows in the system. This branching rule is by no means indisputable and therefore neither is the way of computing how the transit affects the use of the grid. As with the other two methods, the results obtained depend on whether the cost of all the capacity of each line is assigned following the APT method or the cost of the unused part of the grid is socialized among the local demand.

Numerical results are typically in between those of WWT and AP and they appear to make engineering and economic sense.

- *Criterion #5: Legal soundness.* Does the method have any kind of incompatibility with the existing regulation?

  See Annex 1 for a selection of parts from the EU Regulation that may be relevant for the choice of the most suitable algorithm for the long-term inter-TSO mechanism.

  WWT:

  According to articles 2 and 3 of the EU Regulation, the inter-TSO mechanisms of compensations and charges are a consequence of the existence of cross-border flows. And "cross-border flows are those physical flows of electricity on the transmission network of a Member State that result from the impact of the activity of producers and/or consumers outside of that Member State". Who must pay the compensation to a Member State because of hosting cross-border flows? "The TSOs of national transmission systems from which cross-border flows originate or end".

  The text of the Regulation makes it difficult to escape to the interpretation that *all* physical flows at the border of a Member State must be examined to evaluate how much they use the network of this Member State (in order to determine the compensation) and where they originate or end (so that the charges could be attributed to the responsible Member States).

  WWT starts from the implicit assumption that a certain fraction of the total cross-border flows of a given Member State, -which obeys to a certain definition and is termed "transit"-, is the only one who gives right to compensations to the Member State. And then, in step 2 of the method, the responsibilities for this transit are assigned to all Member States, regardless of location, distance to the considered Member State and pattern of flows.

  Therefore, the following inconsistencies of WWT with respect to the EU Regulation can be identified:

  - Not only "transits", but also purely importing or exporting countries have flows that result from the impact of the activity of external producers or consumers, even if the flows originate or end inside the considered country.
  - WWT does not try to find out "where the flows originate or end" in order to assign responsibilities for the network use, when computing the charges that each country has to pay (step two in the inter-TSO mechanism). Instead, WWT socializes the charges a pro rata of the net volume of imports and exports. It is true that net imports and exports are one of the reasons for external utilization of networks, but not only. Besides, a flat socialization that totally ignores topology

cannot be considered to meet the requirement of determining "from which systems the cross-border flows originate and the systems where those flows end".

AP:

The writing of articles 3 and 8 of the Regulation appears to fit perfectly the logic of the AP method. There is, however, a statement whose interpretation from the viewpoint of AP is not immediate: "Benefits that a network incurs as a result of hosting cross-border flows shall be taken into account to reduce the compensation received".

We shall ignore here the reasons why this statement was made, which had much to do with the claim, by peripheral countries in the IEM, that they were not enjoying the benefits of being a part of the IEM because of their relative isolation. Being transited may create problems, but it is also a indication of a full participation in the IEM.

Taking the statement literally, one could argue that WWT identifies the benefits of hosting cross-border flows directly: If the removal of the "transit" increases network usage and losses in the transited country, these are the benefits that take place because of hosting the transit.

If we accept this narrow interpretation of "benefit", we can also show that AP takes also these beneficial effects of cross-border flows into account, but in a more *implicit* manner. The benefits that a network may incur by hosting cross-border flows are taken into account by AP, but *implicitly*. We have to remember that AP does not compare two situations ("with and without flows"), so that the beneficial or detrimental impact of external flows is explicitly shown. AP allocates flows and losses to those who are responsible for them, based on a unique map of physical flows, the only one that exists. If externally induced flows are counter to the internal flows in a country k, then the benefit that country k receives will also show in AP, because country k will have to pay more for the external losses and infrastructure than in the case where the externally induced flows reinforce the internal flows of country k. This can be easily proved with simple examples.

APT:

APT avoids one of the previous criticisms to WWT, since APT does search for the origin and end of flows. However APT makes use of transits instead of the complete cross-border flows (as the AP method does), and it cannot show the potential benefits of transits directly, since with APT, as with AP, the flows only appear to create positive losses and positive utilization of infrastructure.

C. Implementation issues.

The practical aspects in the implementation of the method can sometimes be decisive in the final choice of one method or another. Excessive complexity in the algorithms, difficulties in data acquisition and handling or lack of robustness in the results may dissuade from choosing one particular method.

- *Criterion #6: Data availability, acquisition and handling.* Volume and availability of required data, difficulty in obtaining or processing the data.

  Both methods, WWT and AP, basically require the same amount of data: the physical flows in every line of the IEM network. After the reprogramming of the AP and APT methods that has been carried out during this Phase II of the project, the three methods only need the collection of separate data bases for each one of the IEM countries and for each considered scenario. No interconnected network model for the entire IEM is needed in any of the three methods.

  There are still some minor differences among the three methods regarding data requirements:

  - AP needs also to know the separation of generation and demand at each node, which is typically available jointly with the flows.
  - AP only needs the values of the flows as they are provided by measurements or computation, while WWT needs that these data are compatible with a converged load flow model.
  - APT requires the same data as AP.

  There have been comments in some recent documents of the Florence Regulatory Forum about a potential modification of WWT, so that it could be applied to all cross-border flows and not only to transits. We shall not enter here into a detailed evaluation of this potential method, to whom most of the previous comments on WWT apply. Note, however, that the removal of all cross-border flows in any particular country implies that the internal balance between generation and demand has to be established again, by shutting down or starting up a certain volume of generation. The realization of these modifications, in order to be realistic, amounts to performing an optimal redispatch of generation, which needs economic (confidential) data of generators.

  The Regulation establishes that standard methodologies must be used in the determination of costs for which host networks should be compensated and that these methodologies should be based on forward looking long-run average incremental costs (LRAIC). The analysis in this report has been performed on the same basis as the current provisional inter-TSO payment mechanism, which is the regulated revenues of the involved TSOs. This makes no difference among the three considered methods, as all of them would need to adapt the cost data to the new Regulation.

  WWT:

  The computations that are required to apply the WWT method can be performed independently by each TSO, with a limited amount of external information: the annual aggregation of the absolute values of hourly net imports or exports for each one of the IEM countries or TSOs. This is a convenient feature of WWT, which is a consequence of the simplification introduced in step 2 of the process: the allocation of charges to the countries on the basis of their annual volume of net imports or exports.

AP:

The computations that are required to apply the AP method need to have available the individual data sets for all IEM countries. Although this information could be made available to all TSOs for verification and transparency reasons, it seems more convenient that a single organization is in charge of this computation, as the case has been during this period of experimentation and analysis (an internal Task Force of ETSO has been handling the complete data set and running the different algorithms).

The computation of the total compensation due to each country (step 1 in the 3 step mechanism of inter-TSO payments) with AP can be done on an individual basis and independently, just as with WWT. The difference is in step 2, namely, allocation of the compensation due to a TSO k to all other TSOs. For this step 2, AP needs all the network flows when trying to allocate the compensation due to a TSO k. The same would be true for WWT if the simple step 2 presently used in this method could be improved to take into account the origin and end of the transits, as in APT.

APT:

Since APT tracks the transits –both in step 1 and step 2 of the algorithm-, in order to find out the origin and end of the transit flows, then it also needs to have available the individual data sets for all IEM countries, as with the AP method. Therefore the data requirements for APT are the same as hose for AP.

- *Criterion #7: Availability and complexity of procedures or commonly agreed definitions that are required to apply the method. Experience with its utilization.* This includes: Definition of transit, definition and determination of the horizontal network, algorithms and computer models, commonly agreed standard costs of network infrastructure and losses.

  As indicated in criterion #6, there are no significant differences among the three considered methods regarding data requirements. However, differences exist with respect to procedures and experience.

  WWT:

  WWT only uses a computing tool that is currently employed in any energy control centre: a load flow model. Some simple extra programming is needed for processing the data that are provided by the load flow model, in order to compute the compensations and charges. Ample experience exists in the use of load flow models. However, the experience in the application of the WWT method of inter-TSO payment computations with real network flows is very limited (just the initial evaluations that have been performed by ETSO and this project) and it has not been confirmed that it has been successful. NORDEL has used the WWT method during more than one year, but only for losses.

WWT requires a precise definition of transit that allows the numerical computation of this magnitude, as well as its utilization. ETSO has proposed a definition, which has been used in the provisional method as well as in all the computations regarding WWT in this report. Nothing proves that this is the best possible definition of transit, but no alternative definition has been proposed.

WWT, as any other method for the computation of inter-TSO payments, needs the previous definition of a "horizontal network". As explained in section 5.2 of this report, the results that can be obtained with WWT are very robust with respect to the definition of the horizontal network. The reason is that WWT will detect by itself if there is any difference in the flows of the lines between the with transit and the without transit cases. Therefore, defining a horizontal network which is too large should not be a problem when the WWT method is applied since the results will not critically depend on this. However, if the defined horizontal network is not detailed enough the results of compensations and charges will change.

AP:

AP needs its own model to track the flows, which is only readily available at the institutions that have developed one, for whatever reason. It is a relatively simple model to develop and it is used exclusively for this purpose. ETSO developed last year its own AP model when performing numerical comparisons between AP and WWT. A new version of the model has been developed during this second Phase of the project. The new version allows to deal with separate data sets of network flows for each country or TSO, instead of a single data set for the connected IEM-wide complete network.

The AP algorithm has been used, or at least tried, in the past in several countries with the purpose of computing nodal transmission tariffs: It has been used in New Zealand during several years and at least test runs have been performed for several other countries during the last 10 years. The experience in the use of AP for the calculation of inter-TSO payments is similar to the experience in the use of WWT (except for the utilization of WWT by NORDEL for compensations related to losses).

AP is more sensible to the definition of the horizontal network that WWT, as explained in section 5.2. The simplest way of making sure that the results of AP do not depend on the definition of the horizontal network, as recommended in this section 5.2, is to trust that the present algorithm that ETSO employs to identify the horizontal network (the one currently used with the provisional approach) is not including unnecessary low voltage lines in the horizontal network. Once the horizontal network can be trusted in this respect , then AP can be trusted to identify which fraction of every line in the horizontal network is subject to external utilization.

APT:

APT has been developed during Phase I of this project. It completely relies in a blend of the WWT and AP methods. It requires a definition of the transit through a grid as WWT does. APT basically uses the same algorithms as AP, but with a different purpose. There is no experience in the utilization of APT outside the boundaries of this project.

The same comments as for AP apply also to APT regarding the horizontal network.

- *Criterion #8: Ability to be easily understood and verified.* Is the method easy to understand and to apply? Is the basic concept of the method easy to explain and communicate? Are there any special difficulties in the practical implementation of the method or in the interpretation of the results? Can the results be verified or replicated easily?

  WWT:

  The initial presentation of the basic WWT concept: "compare the use of the network with transits and when the transits are removed" is very intuitive and easy to understand. The difficulties only appear when one tries to go one step further: What is a transit? Why this arbitrary definition and not other? How do you "remove" transits? What does it mean the situation of an interconnected country when "transits" are removed? Then the initial simplicity is mostly gone.

  The complexity of the basic algorithm –the load flow- should not be underestimated. One thing is that the load flow is a very popular computer model among power engineers and other the internal complexity of the algorithm itself, which is significant. Not many people in a working group that develops regulation of cross-border trade would be able to explain the main features of the load flow algorithm.

  The results that have been obtained for compensations, charges and net inter-TSO payments with WWT have been presented and commented in chapters 3, 4 and 7. These results appear to be consistent with the internal logic of the WWT method. However, several reasons for concern have been identified:

  - The figures for compensations, charges and net payments with WWT are quite stable across countries and scenarios. However, they are larger and significantly more volatile than with AP.
  - Removal of the transit implies that many lines of the considered country are affected. When a transit is shown to reduce the utilization of infrastructure or the losses, the economic implications (the country should compensate others because of this fact) is not easy to accept. One could think of considering only positive increments of flow in the lines, but this may result in a huge volume of compensations.
  - As a consequence of what has just been said, the implications of WWT on the allocation of the cost of new network investments are not satisfactory, as explained in Chapter 6 and in the criterion #2.a above.

AP:

The initial presentation of the AP method is also easy to understand: “in order to assign the responsibility for the use of each line, track the flow in the line upstream until you reach the generators and downstream until you reach the loads”. Here the difficulties also appear when one tries to go into the specifics: How does the flow divide when you arrive at an intersection? Which is the justification of the adopted rule? Should we net out the generation and demand in the same node or it is preferable to treat generation and load separately?

The AP algorithm is relatively easy to explain. Certainly easier than the load flow algorithm. A complete description can be found in Annex 6 of the Final Report of Phase I of this project. But it is known to very few people, since it is a specialized topic of interest for just a minority.

The results that have been obtained for compensations, charges and net inter-TSO payments with AP have been presented and commented in chapters 3, 4 and 7. These results also appear to be consistent with the internal logic of the AP method. The following comments are pertinent here:

- The figures for compensations, charges and net payments with AP are quite stable across countries and scenarios. They are smaller and less volatile than with WWT.
- The implications of AP on the allocation of the cost of new network investments are in principle satisfactory, as explained in Chapter 6 and in the criterion #2.a above.
- There is one possible reason for concern and this is the strong spatial differentiation of the nodal transmission tariffs that were computed in Chapter 8 with AP, as indicated in the comments for criterion #4 above.

APT:

Understanding APT requires to be familiar with both AP and WWT. The complexity in understanding APT is therefore increased somewhat. But the basic idea is still simple and intuitive. APT combines most of the difficulties of AP and WWT when the method is examined at a deeper level. It does not require to run a load flow but the transit through each country must be precisely defined as in WWT. One advantage of this method over the WWT method is that we do not need to modify the flows in the system in order to compute inter-TSO payments since the algorithm of APT is basically the same as for AP. Therefore it shares all the criticisms of the AP method in this regard.

Table 23 is a more readable synthesis of the comparison just carried out among the different methods. In the table, ‘+ ‘means that the performance of the corresponding method, according to the concerned criteria, is satisfactory, ‘- ‘means that its performance is unsatisfactory and ‘~‘ that it could do better but it is not bad.

		AP	WWT	APT
The Broader Context	Consistency with Single System paradigm	+	-	-
	Consistency with other aspects of transmission regulation	+	-	-
Soundness of the method	Economic soundness	+	-	~
	Technical and logical soundness	~	-	~
	Legal soundness	+	-	-
Implementation Issues	Data availability, acquisition and handling	-	+	-
	Availability and complexity of procedures involved. Experience with the method	~	+	-
	Ability to be easily understood and verified	+	+	~

Table 23: Summary of the comparison between AP, WWT and APT

9.3 Conclusions

The thorough review of the three considered methods in the last section allows one to reach a firm conclusion: The average participations method (AP) is clearly preferable to the with-and-without transits method (WWT), with the average participations applied to transits method (APT) being only an alternative if, for some reason, it is decided to maintain the transit paradigm, but one wants to avoid some of the major problems of the WWT method.

AP is the clear winner in the "broader context" set of criteria (criteria #1 and 2). Neither WWT nor APT satisfy these criteria. In the category of “economic, technical and legal soundness of the method” (criteria # 3, 4 and 5) AP is again the winner, WWT performs the worst and APT is somewhere in the middle. WWT fares better than AP and APT in the implementation criteria # 6 and 7. The practical disadvantages of AP with respect to WWT are not critical nevertheless. Finally, both AP and WWT basically tie in criterion #8. APT is the worst method of the three according to the implementation criteria.

This conclusion is more drastic than the one that was reached in the Phase I of the project, where AP was considered to be the preferred method, but WWT was considered to be an interesting and acceptable alternative and APT a reasonable compromise between the two other methods. The lack of synchrony of WWT and APT with some aspects of the EU Regulation, the much better quality of the numerical results of AP over the two other methods, especially WWT, the inability of WWT and APT to provide any kind of locational signals and the poor performance of WWT in the implicit allocation of the cost of new network investments definitely tilt the balance towards AP as the preferred method for the long-term mechanism of inter-TSO payments in the Internal Electricity Market.

Annex 1. EU Regulation on cross-border tarification.

This section contains selected parts from legal EU documents that are relevant for deciding which method should be adopted for the long-term mechanism of inter-TSO payments.

REGULATION (EEC) No .../2003 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2003 on conditions for access to the network for cross-border exchanges in electricity.

In the exposition previous to the articles of this Regulation, it is expressed that:

- In an open, competitive market, transmission system operators should be compensated for costs incurred as a result of hosting cross-border flows of electricity on their networks by the operators of the transmission systems from which cross-border flows originate and the systems where those flows end.
- Payments and receipts resulting from compensation between transmission system operators should be taken into account when setting national network tariffs.
- The actual amount payable for cross-border access to the system can vary considerably, depending on the transmission system operators involved and as a result of differences in the structure of the tarification systems applied in Member States. A certain degree of harmonisation is therefore necessary in order to avoid distortions of trade.
- A proper system of long term locational signals would be necessary, based on the principle that the level of the network access charges should reflect the balance between generation and consumption of the region concerned, on the basis of a differentiation of the network access charges on producers and/or consumers.
- It would not be appropriate to apply distance-related tariffs, or, provided appropriate locational signals are in place, a specific tariff to be paid only by exporters or importers in addition to the general charge for access to the national network.

<u>Article 2</u>

Definitions

(b) "cross-border flow" means a physical flow of electricity on a transmission network of a Member State that results from the impact of the activity of producers and/or consumers outside of that Member State on its transmission network. If transmission networks of two or more Member

States form part, entirely or partly, of a single control block, for the purpose of the inter-transmission system operator (TSO) compensation mechanism referred to in Article 3 only, the control block as a whole shall be considered as forming part of the transmission network of one of the Member States concerned, in order to avoid flows within control blocks being considered as cross-border flows and giving rise to compensation payments under Article 3. The regulatory authorities of the Member States concerned may decide which of the Member States concerned shall be the one of which the control block as a whole shall be considered to form part of;

(d) "declared export" of electricity means the dispatch of electricity in one Member State on the basis of an underlying contractual arrangement to the effect that the simultaneous corresponding take-up ("declared import") of electricity will take place in another Member State or a third country;

(e) "declared transit" of electricity means a circumstance where a "declared export" of electricity occurs and where the nominated path for the transaction involves a country in which neither the dispatch nor the simultaneous corresponding take-up of the electricity will take place;

(f) "declared import" of electricity means the take-up of electricity in a Member State or a third country simultaneously with the dispatch of electricity ("declared export") in another Member State;

Article 3

Inter transmission system operator compensation mechanism

1. Transmission system operators shall receive compensation for costs incurred as a result of hosting cross-border flows of electricity on their networks.

2. The compensation referred to in paragraph 1 shall be paid by the operators of national transmission systems from which cross-border flows originate and the systems where those flows end.

3. Compensation payments shall be made on a regular basis with regard to a given period of time in the past. Ex-post adjustments of compensation paid shall be made where necessary to reflect costs actually incurred.

The first period of time for which compensation payments shall be made shall be determined in the guidelines referred to in Article 8.

4. Acting in accordance with the procedure referred to in Article 13(2), the Commission shall decide on the amounts of compensation payments payable.

5. The magnitude of cross-border flows hosted and the magnitude of cross-border flows designated as originating and/or ending in national transmission systems shall be determined on the basis of the physical flows of electricity actually measured in a given period of time.

6. The costs incurred as a result of hosting cross-border flows shall be established on the basis of the forward looking long-run average incremental costs, taking into account losses, investment in new infrastructure, and an appropriate proportion of the cost of existing infrastructure, as far as infrastructure is used for the transmission of cross-border flows, in particular taking into account the need to guarantee security of supply. When establishing the costs incurred, recognised standard-costing methodologies shall be used. Benefits that a network incurs as a result of hosting cross-border flows shall be taken into account to reduce the compensation received.

Article 4

Charges for access to networks

1. Charges applied by network-operators for access to networks shall be transparent, take into account the need for network security and reflect actual costs incurred insofar as they correspond to those of an efficient and structurally comparable network operator and applied in a non-discriminatory manner. Those charges shall not be distance-related.

2. Producers and consumers ("load") may be charged for access to networks. The proportion of the total amount of the network charges borne by producers shall, subject to the need to provide appropriate and efficient locational signals, be lower than the proportion borne by consumers. Where appropriate, the level of the tariffs applied to producers and/or consumers shall provide locational signals at European level, and take into account the amount of network losses and congestion caused, and investment costs for infrastructure. This shall not prevent Member States from providing locational signals within their territory or from applying mechanisms to ensure that network access charges borne by consumers ("load") are uniform throughout their territory.

3. When setting the charges for network access the following shall be taken into account:

– Payments and receipts resulting from the inter-transmission system operator compensation mechanism;

– Actual payments made and received as well as payments expected for future periods of time, estimated on the basis of past periods.

4. Providing that appropriate and efficient locational signals are in place, in accordance with paragraph 2, charges for access to networks applied to producers and consumers shall be applied regardless of the countries of destination and, origin, respectively, of the electricity, as specified in the underlying commercial arrangement. This shall be without prejudice to charges on declared exports and declared imports resulting from congestion management referred to in Article 6.

5. There shall be no specific network charge on individual transactions for declared transits of electricity.

Article 8

Guidelines

1. Where appropriate, the Commission shall, acting in accordance with the procedure referred to in Article 13(2), adopt and amend guidelines on the issues listed under paragraph 2 and 3 and relating to the inter-transmission system operator compensation mechanism, in accordance with the principles set out in Articles 3 and 4. When adopting these guidelines for the first time the Commission shall ensure that they cover in a single draft measure at least the issues referred to in paragraph 2(a) and (d), and paragraph 3.

2. The guidelines shall specify:

(a) details of the procedure for determining which transmission system operators are liable to pay compensation for cross-border flows including as regards the split between the operators of national transmission systems from which cross-border flows originate and the systems where those flows end, in accordance with Article 3(2);

(b) details of the payment procedure to be followed, including the determination of the first period of time for which compensation is to be paid, in accordance with the second subparagraph of Article 3(3);

(c) details of methodologies for determining the cross-border flows hosted for which compensation is to be paid under Article 3, in terms of both quantity and type of flows, and the designation of the magnitudes of such flows as originating and/or ending in transmission systems of individual Member States, in accordance with Article 3(5);

(d) details of the methodology for determining the costs and benefits incurred as a result of hosting cross-border flows, in accordance with Article 3(6);

(e) details of the treatment in the context of the inter-TSO compensation mechanism of electricity flows originating or ending in countries outside the European Economic Area;

(f) the participation of national systems which are interconnected through direct current lines, in accordance with Article 3.

3. The guidelines shall also determine appropriate rules leading to a progressive harmonization of the underlying principles for the setting of charges applied to producers and consumers (load) under national tariff systems, including the reflection of the inter-TSO compensation mechanism in national network charges and the provision of appropriate and efficient locational signals, in accordance with the principles set out in Article 4.

The guidelines shall make provision for appropriate and efficient harmonized locational signals at European level.

Any harmonisation in this respect shall not prevent Member States from applying mechanisms to ensure that network access charges borne by consumers (load) are comparable throughout their territory.

When adopting or amending guidelines, the Commission shall ensure that they provide the minimum degree of harmonization required to achieve the aims of this Regulation and do not go beyond what is necessary for that purpose.

When adopting or amending guidelines, the Commission shall indicate what actions it has taken with respect to the conformity of rules in third countries, which form part of the European electricity system, with the guidelines in question.

Annex 2. Charts of the locational signals produced by AP for each country

This annex presents the nodal transmission tariffs obtained with the AP method in more detail (see section 8). For each country, two separate figures are provided (see Figure 22 to Figure 47). The first one shows the distribution of G and L charges within the country (represented with a blue line), tariffs for loads appear on the left hand side of the graphic and tariffs for generators on the right hand side. Both L and G tariffs have been sorted according to their magnitude. Both the average G and L transmission charge (dark line) and the average G and L internal transmission charge (pale line) are presented as well (see explanation in section 8.2). The second figure for each country shows the distribution of the standard deviation of the transmission charge for every agent within the country. Agents have been sorted following the same order as in the figure of nodal tariffs that comes before it. The standard deviation for an agent has been computed from the nodal tariffs obtained for the agent in the different scenarios. The average standard deviation for G and L in the country has also been represented (blue line).

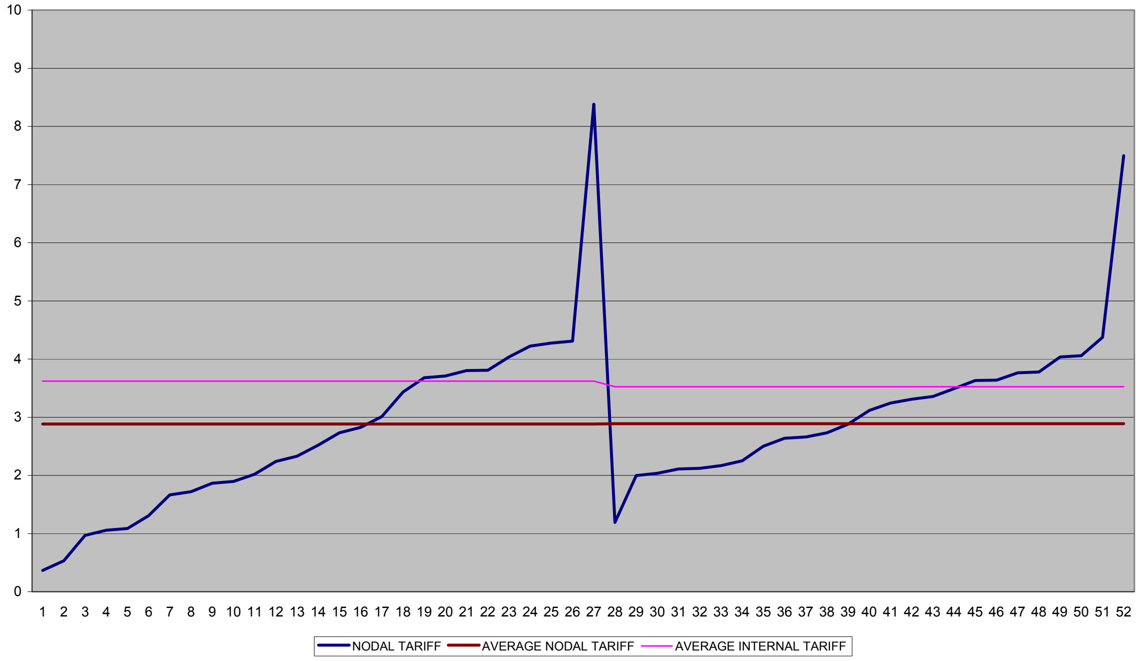

Figure 22: Nodal tariffs for Austria

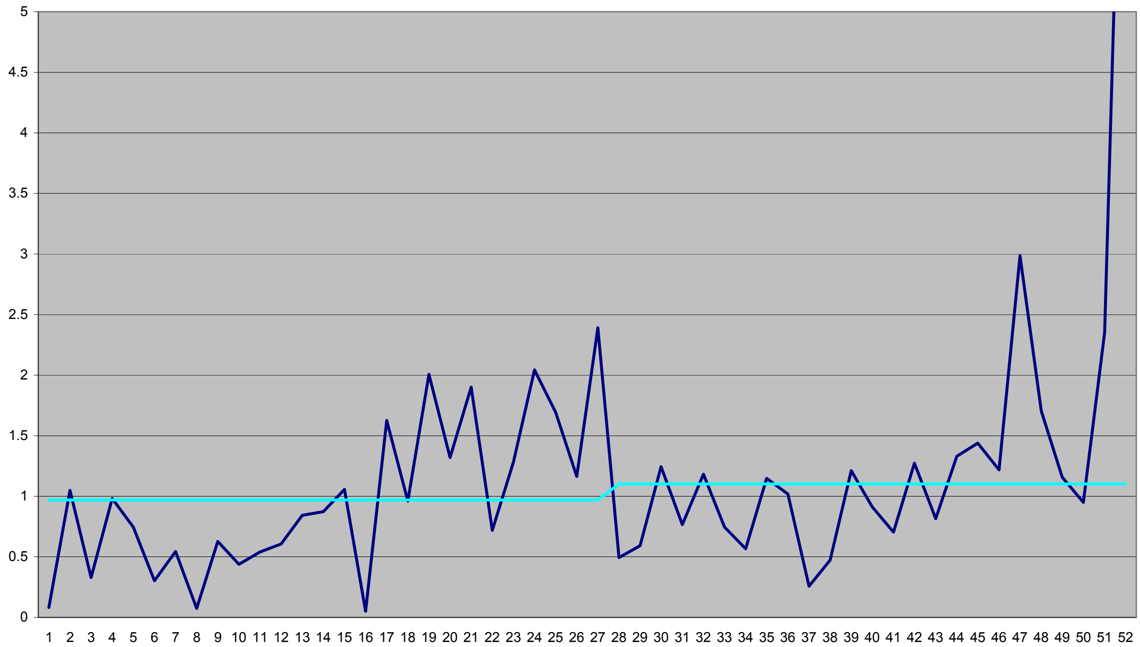

Figure 23: Standard deviation of the nodal tariffs for Austria (there is one generator with a standard deviation of 8.4 euros/MWh, which is not shown in the figure)

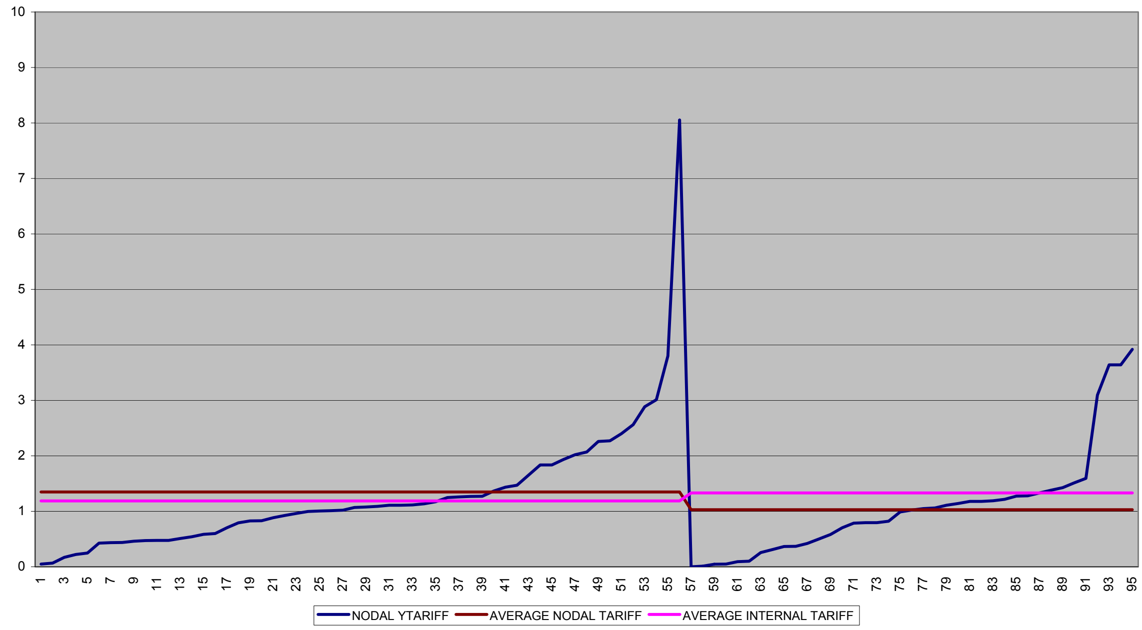

Figure 24: Nodal tariffs for Belgium

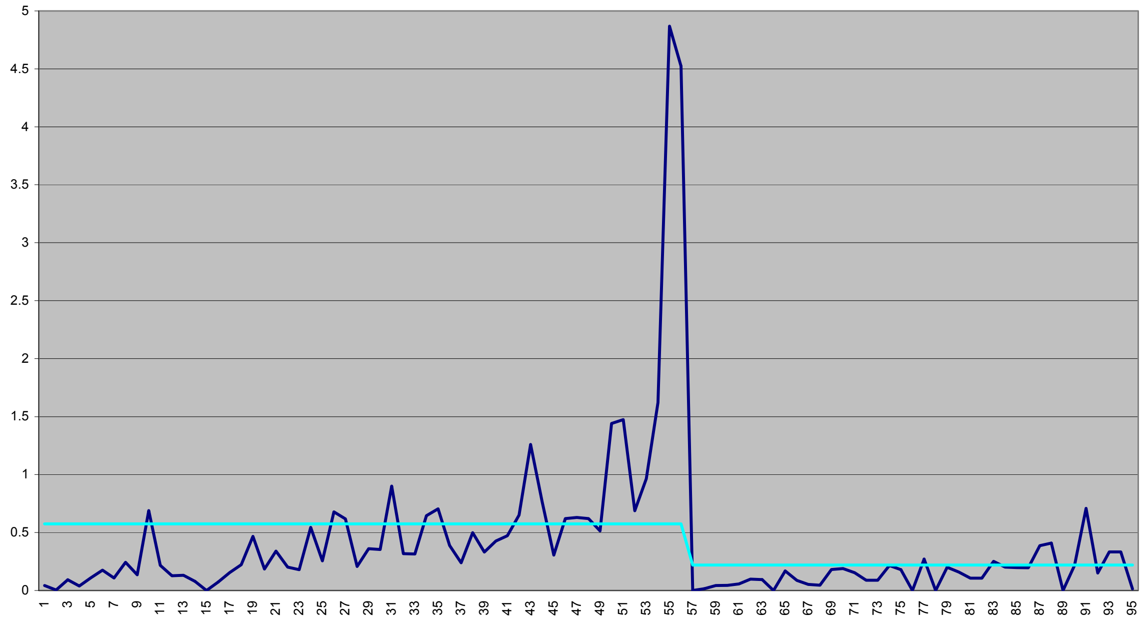

Figure 25: Standard deviation of the nodal tariffs for Belgium

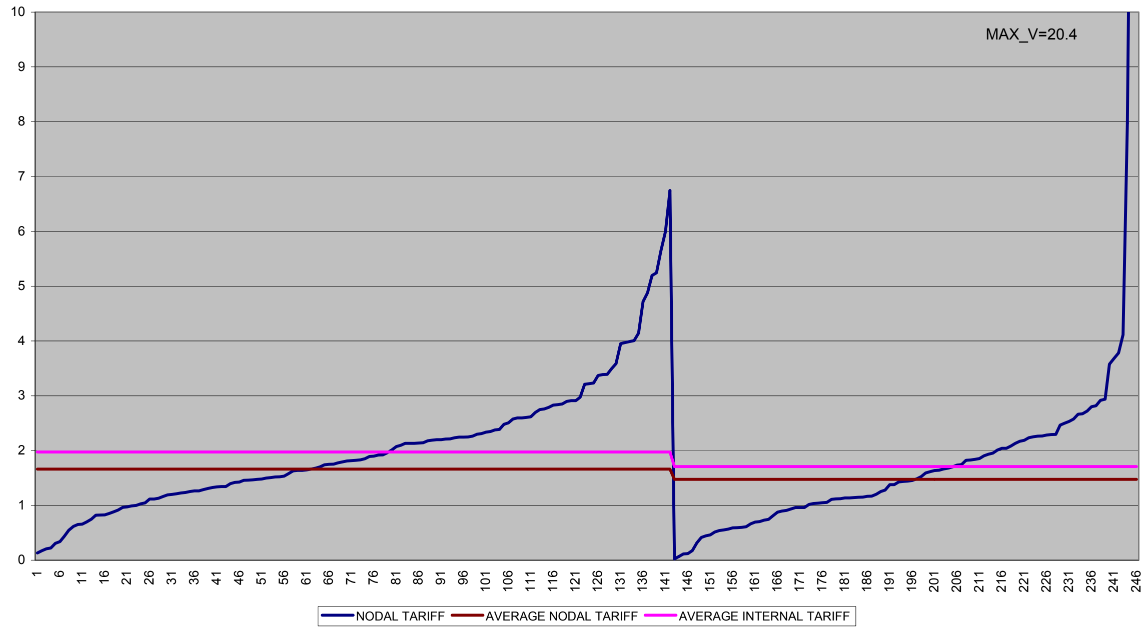

Figure 26: Nodal tariffs for Switzerland

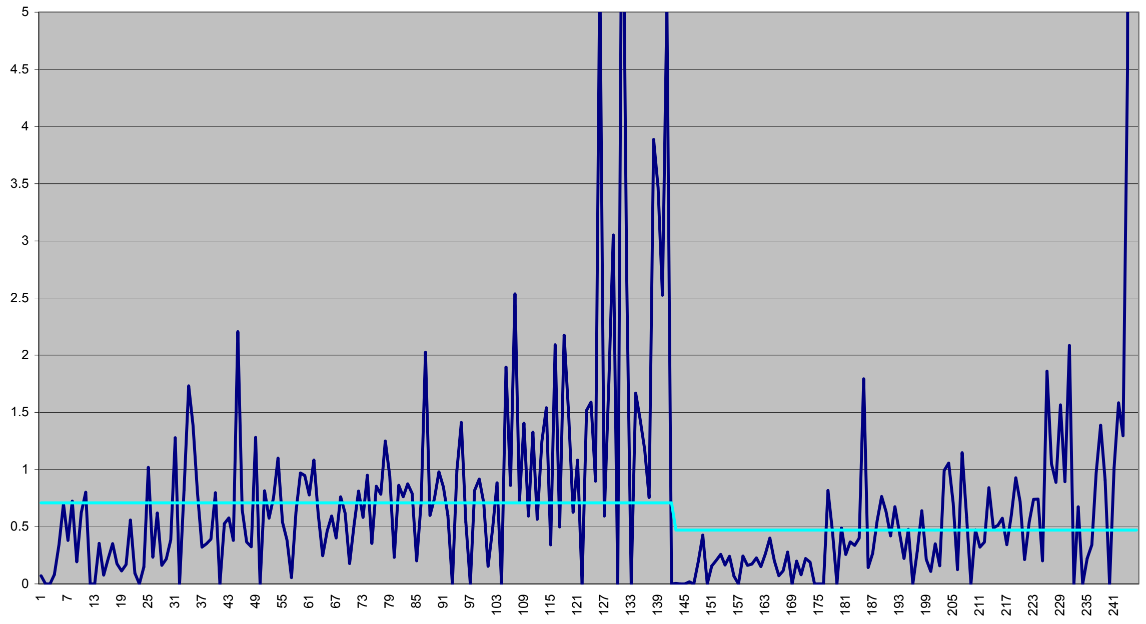

Figure 27: Standard deviation of the nodal tariffs for Switzerland (3 loads with standard deviation between 5.1 and 6.9euros/MWh and 2 generators with standard deviation between 27.8 and 49.6 euros/MWh)

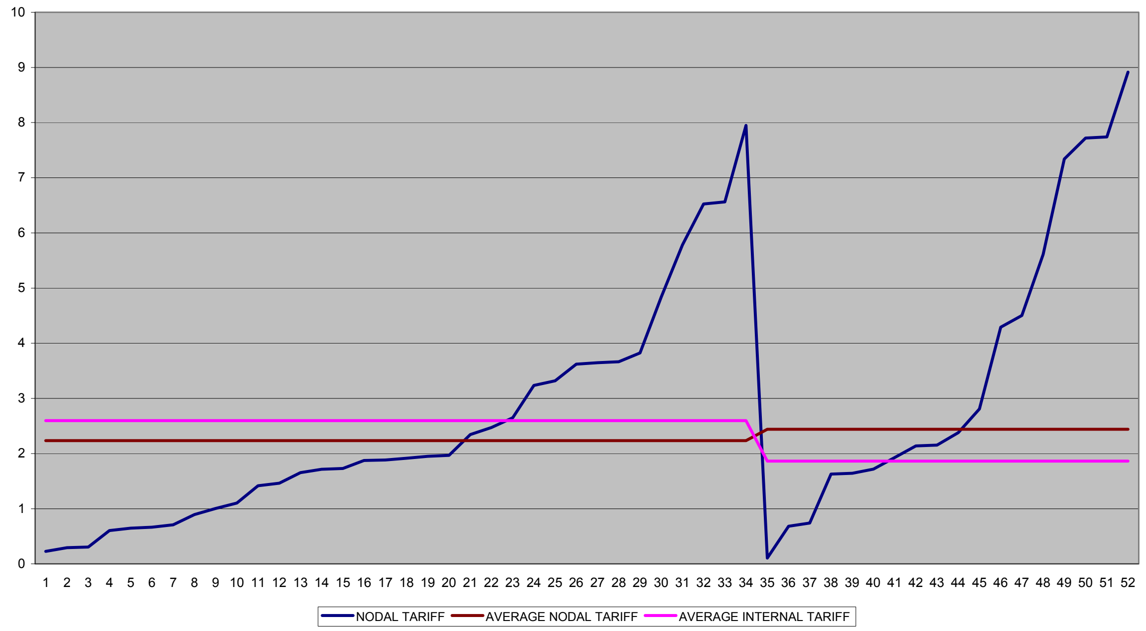

Figure 28: Nodal tariffs for the Czech Republic

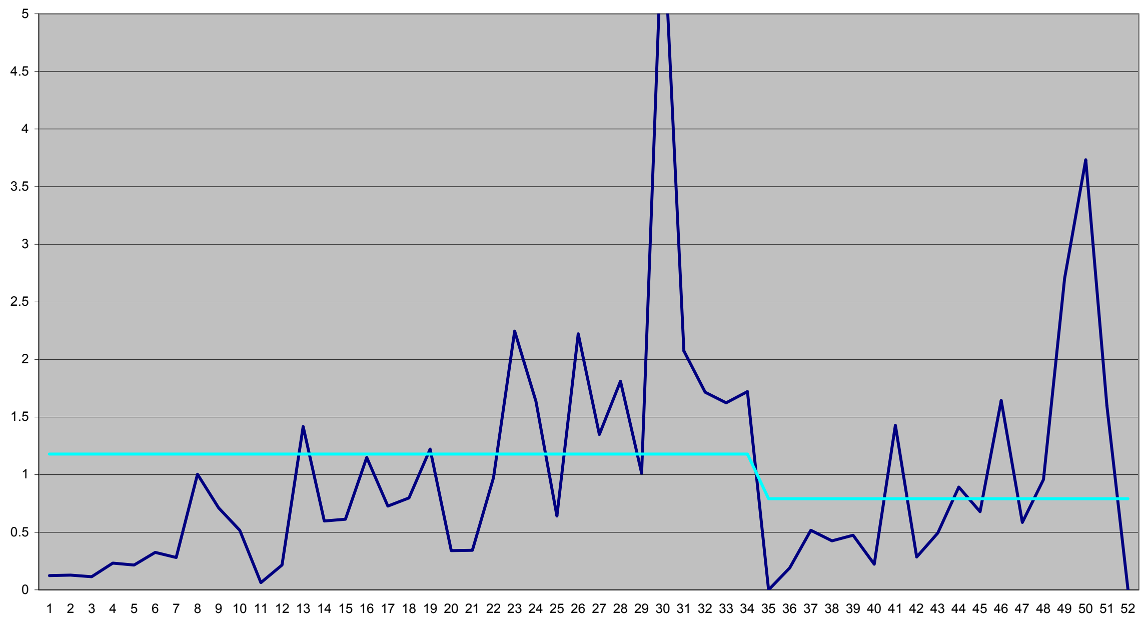

Figure 29: Standard deviation of the nodal tariffs for the Czech Republic (1 load with standard deviation of 5.9 euros/MWh)

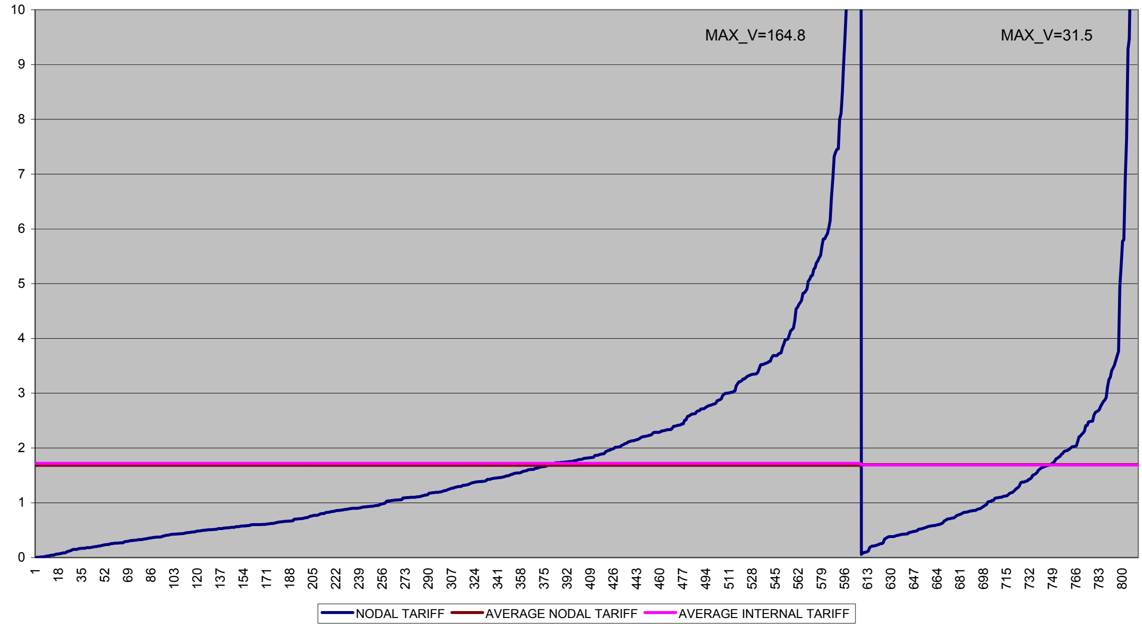

Figure 30: Nodal tariffs for Germany

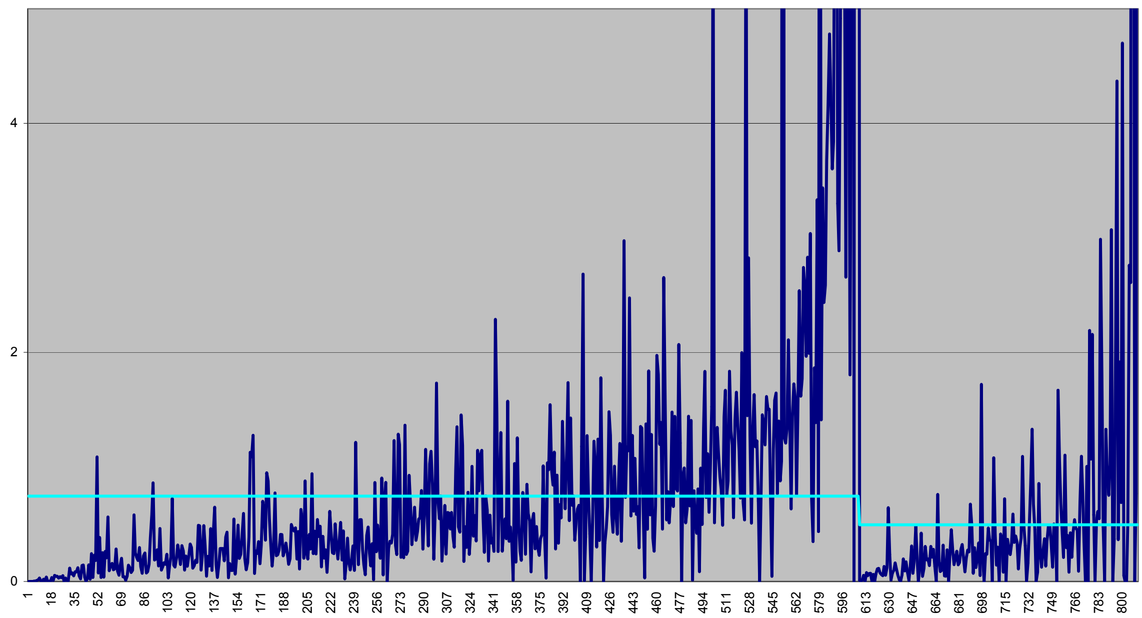

Figure 31: Standard deviation of the nodal tariffs for Germany (15 loads with a standard deviation between 5.4 and 252.4 euros/MWh and 3 generators with standard deviations between 10.7 and 81.7 euros/MWh)

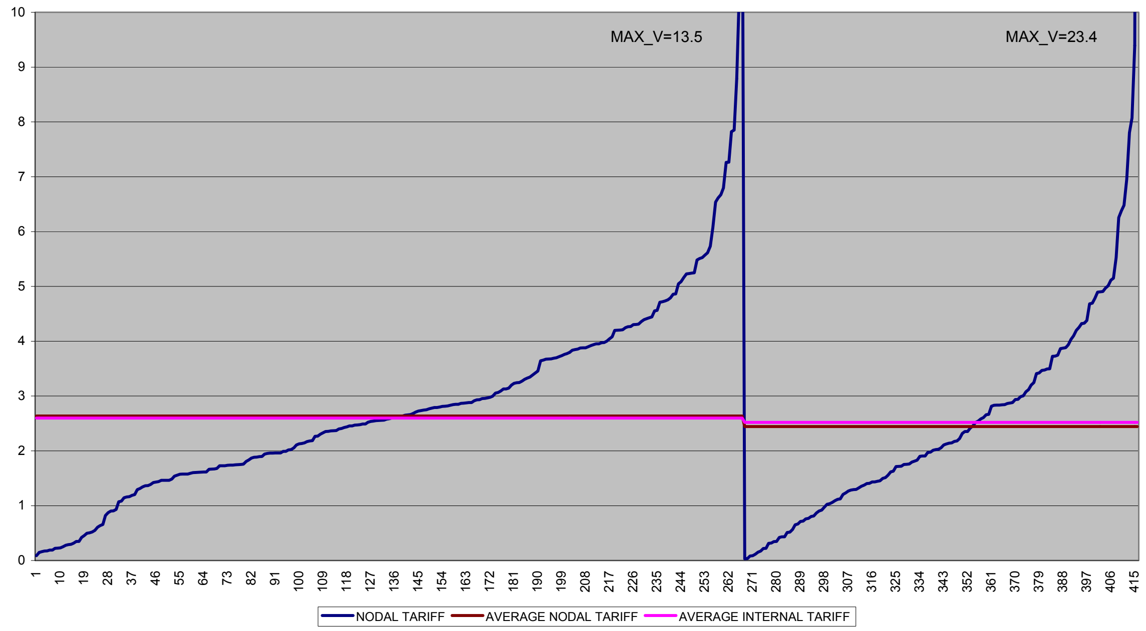

Figure 32: Nodal tariffs for Spain

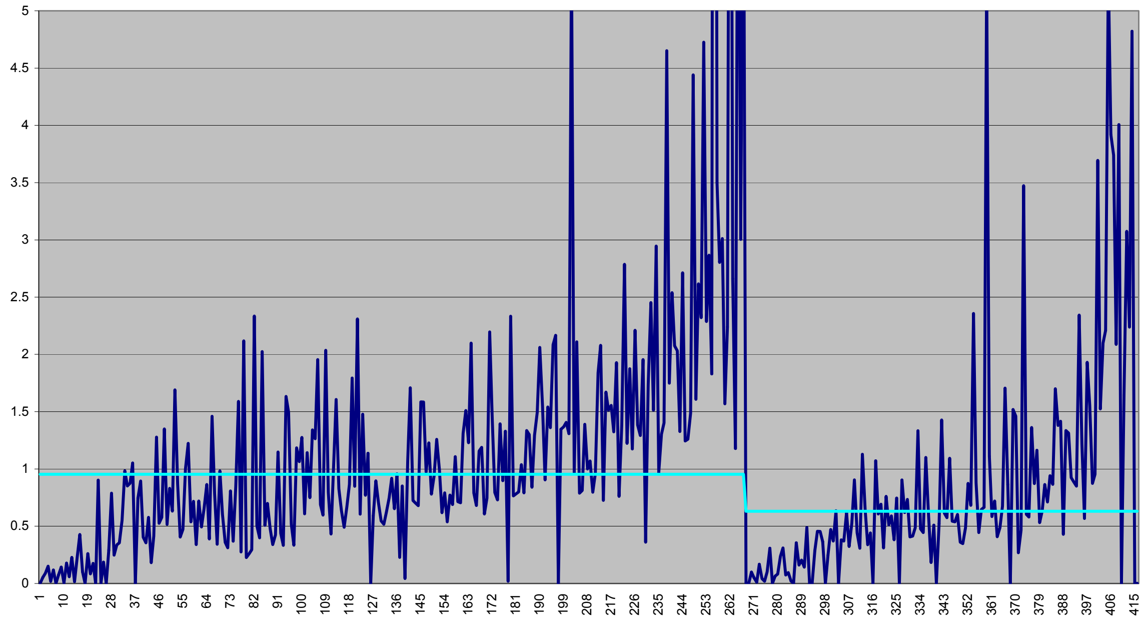

Figure 33: Standard deviation of the nodal tariffs for Spain (5 loads with standard deviations between 5.5 and 18.4 euros/MWh and 2 generators both with a standard deviation of 5.3 euros/MWh)

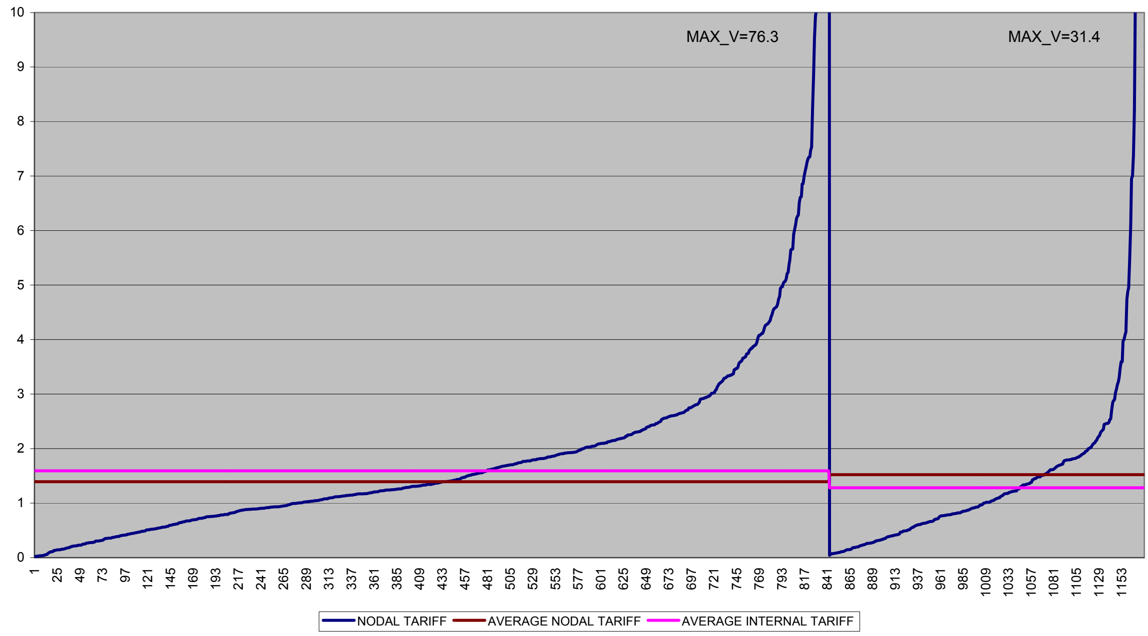

Figure 34: Nodal tariffs for France

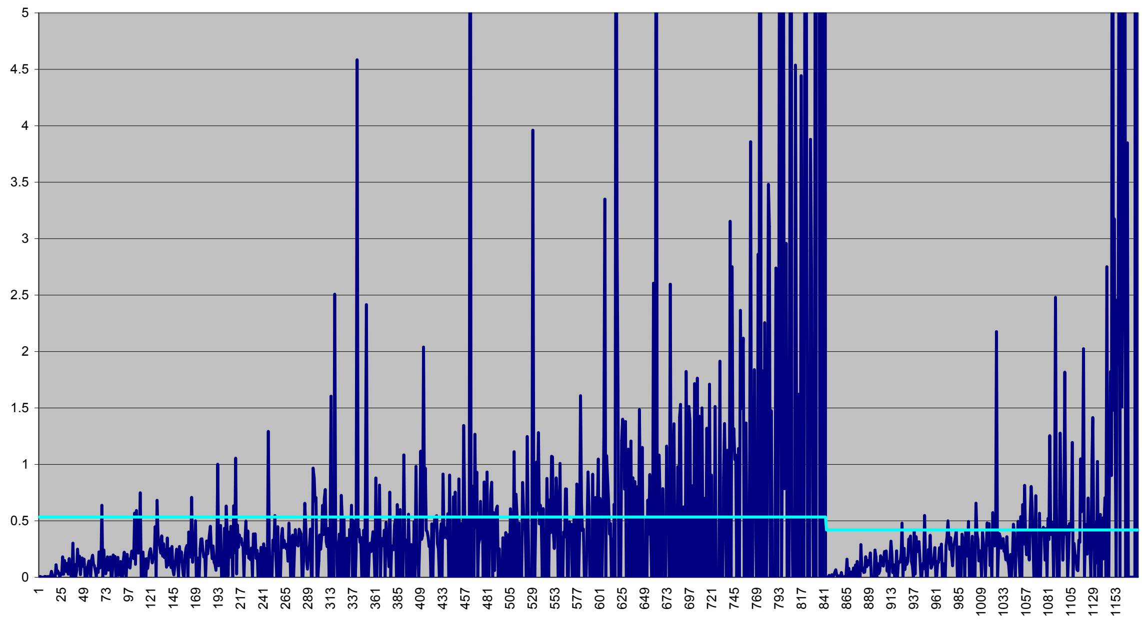

Figure 35: Standard deviation of the nodal tariffs for France (17 loads with standard deviations between 5.4 and 65.7 euros/MWh and 6 generators with standard deviations between 6.1 and 21.1 euros/MWh)

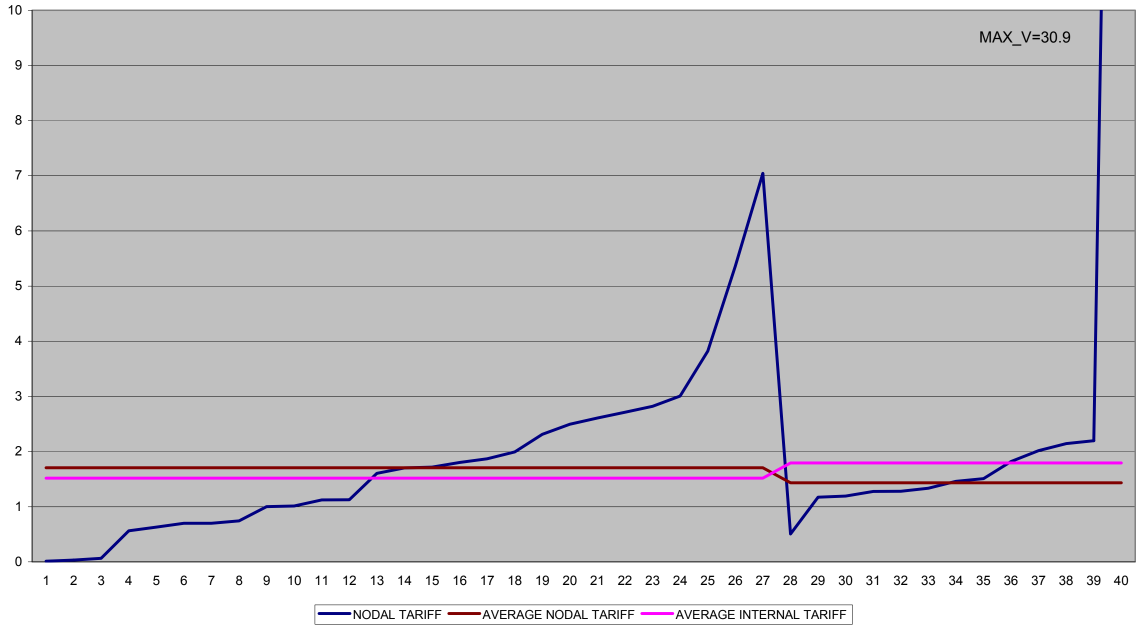

Figure 36: Nodal tariffs for Hungary

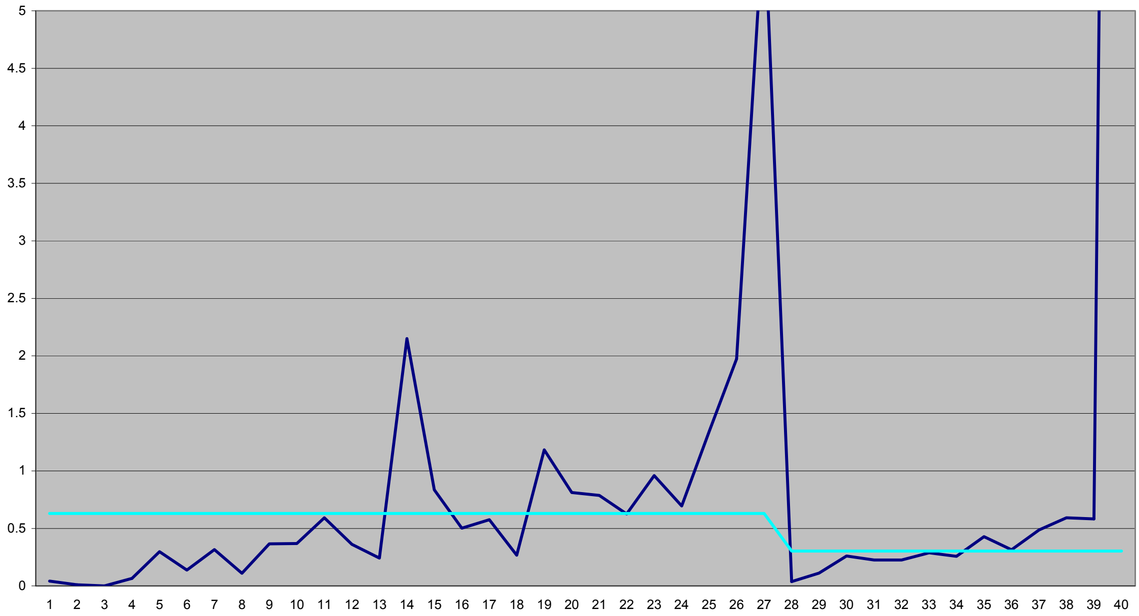

Figure 37: Standard deviation of the nodal tariffs for Hungary (1 load with a standard deviation of 5.9 euros/MWh and 1 generator with a standard deviation of 29.8 euros/MWh)

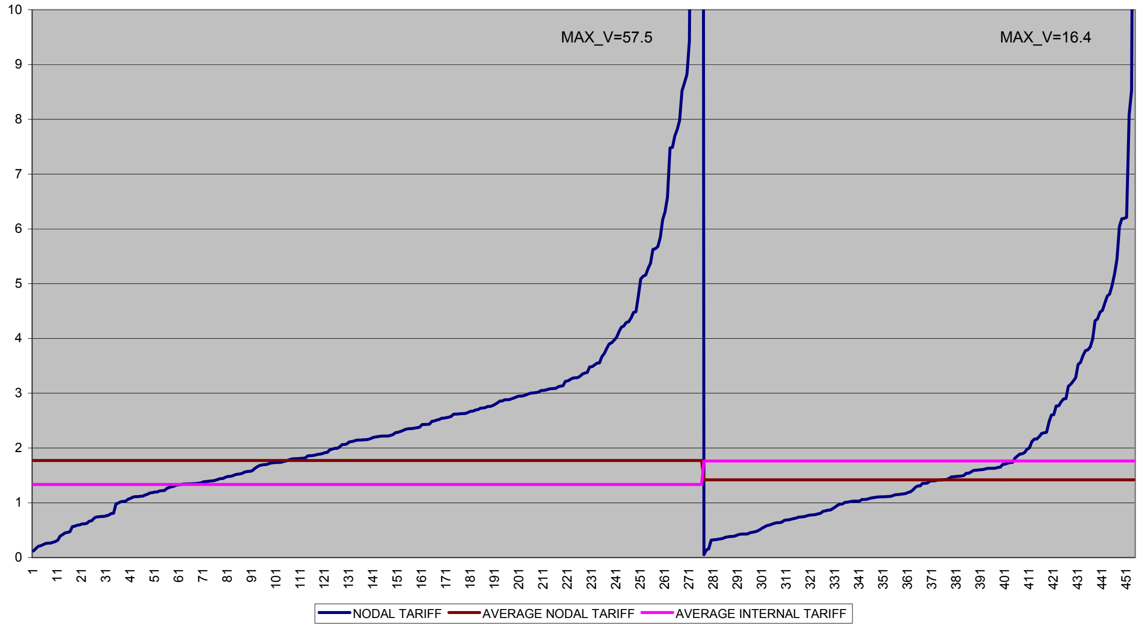

Figure 38: Nodal tariffs for Italy

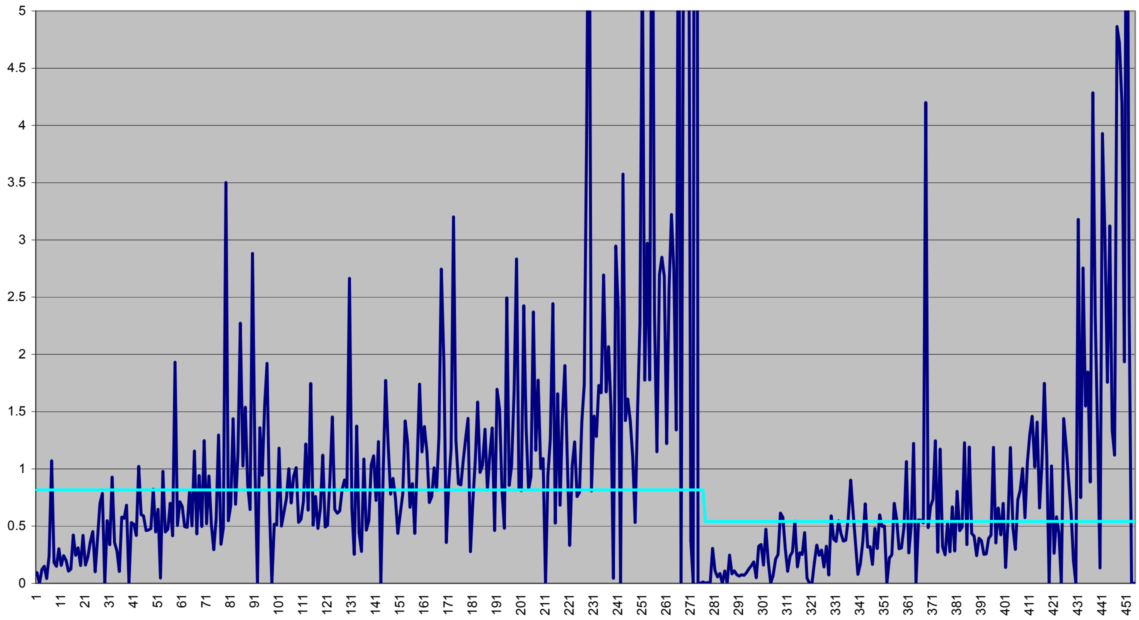

Figure 39: Standard deviation of the nodal tariffs for Italy (8 loads with standard deviations between 5.6 and 19.6 euros/MWh and 1 generator with a standard deviation of 7.8 euros/MWh)

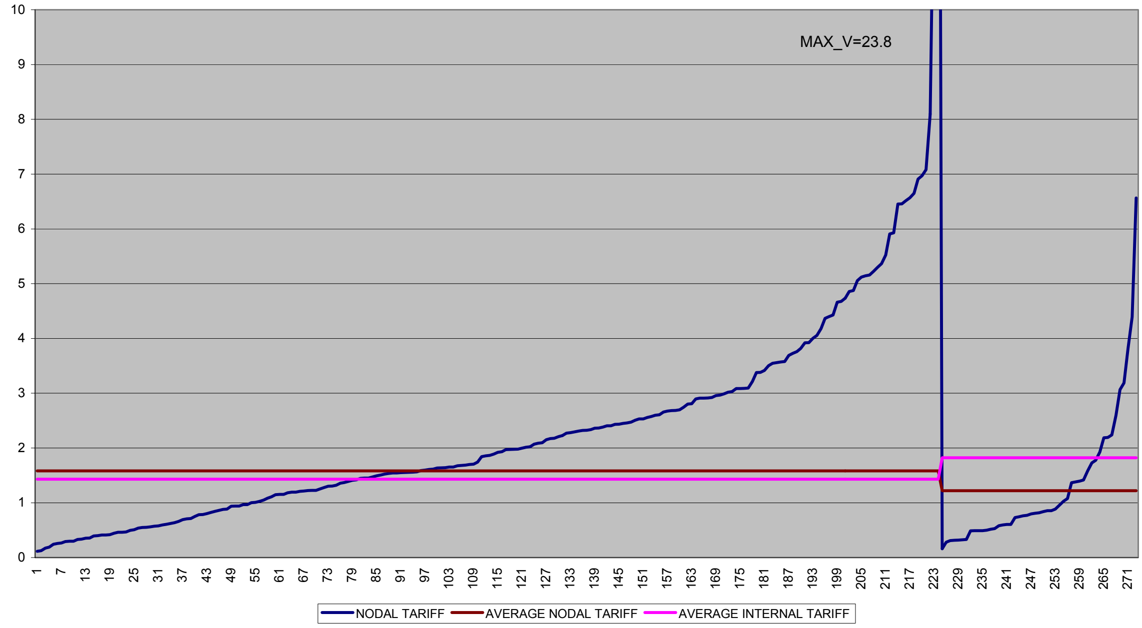

Figure 40: Nodal tariffs for The Netherlands

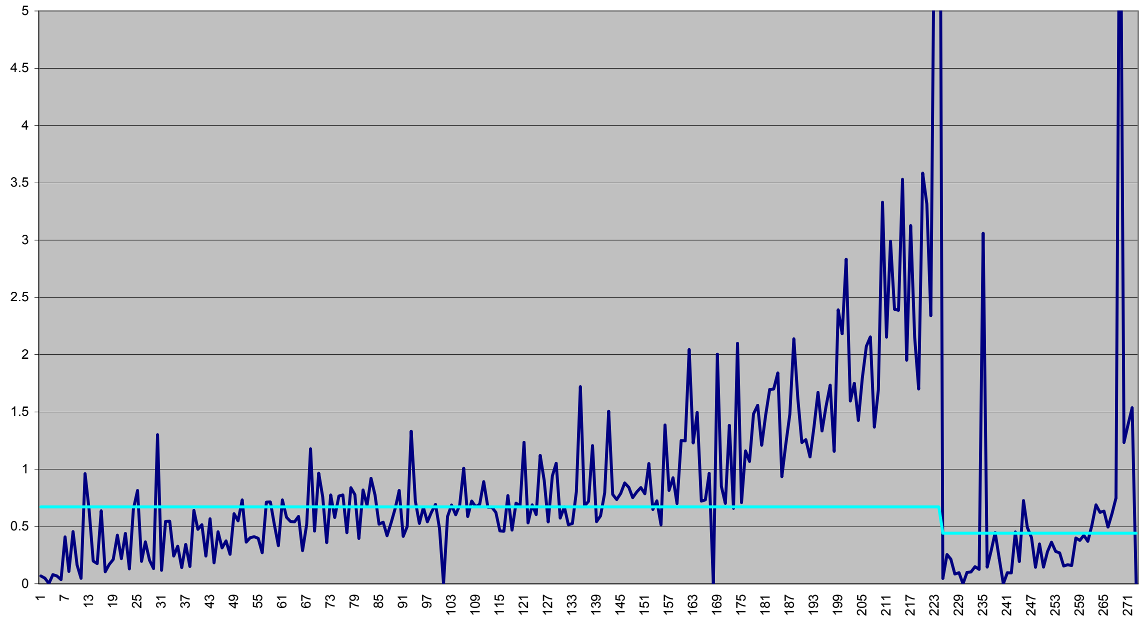

Figure 41: Standard deviation of the nodal tariffs for The Netherlands (2 loads with standard deviations of 6.4 and 9.4 euros/MWh respectively and 1 generator with a standard deviation of 6.8 euros/MWh)

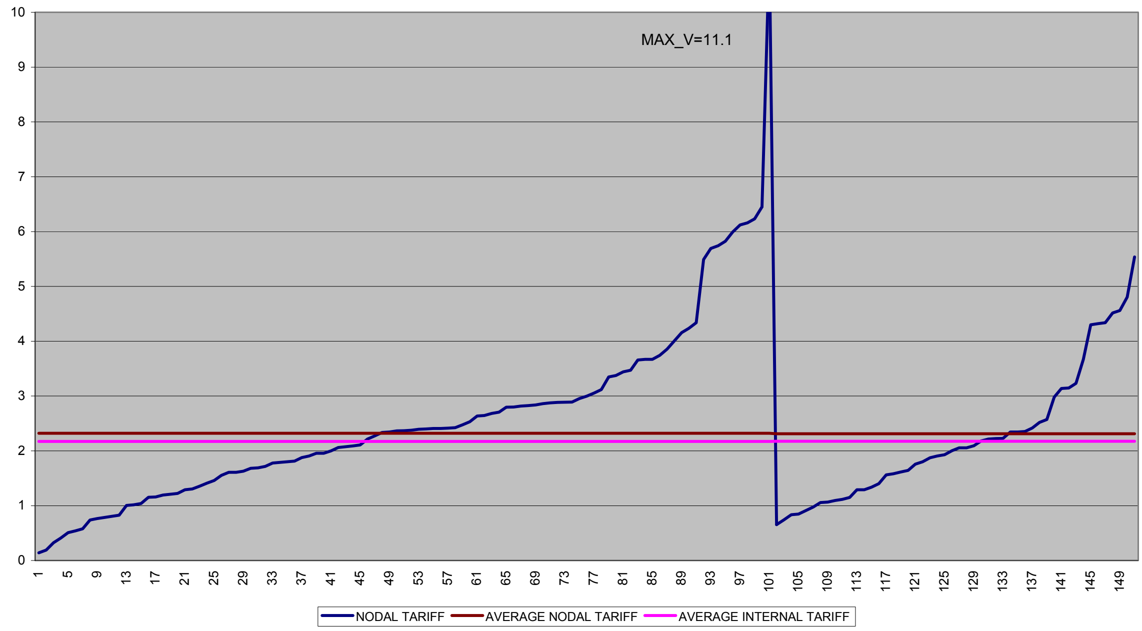

Figure 42: Nodal tariffs for Portugal

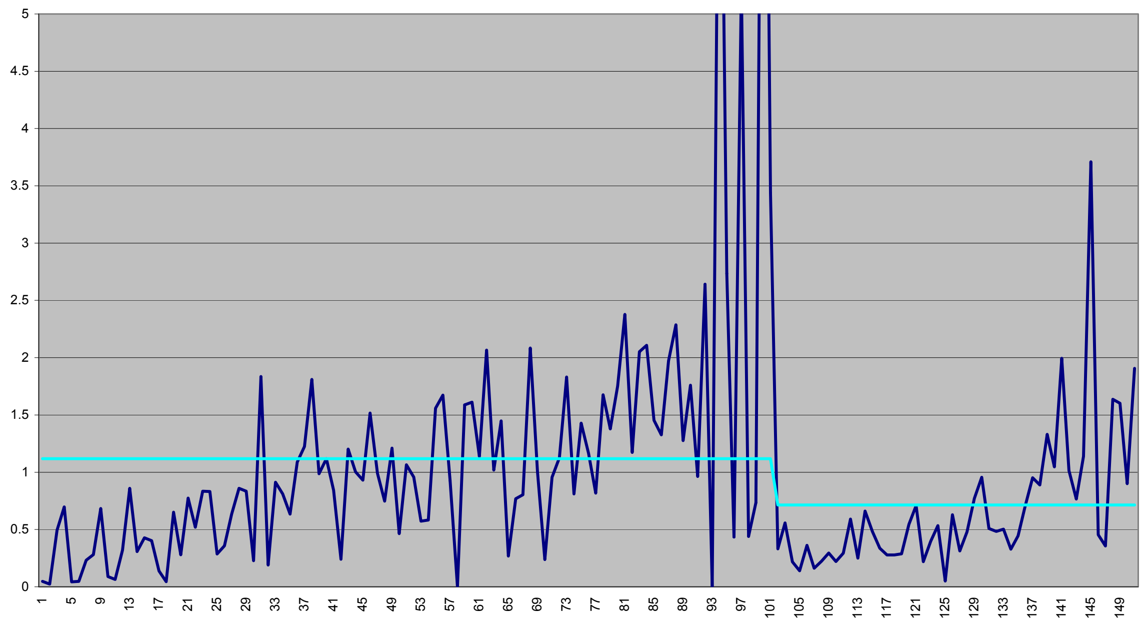

Figure 43: Standard deviation of the nodal tariffs for Portugal (3 loads with standard deviations between 5.3 and 10.5 euros/MWh)

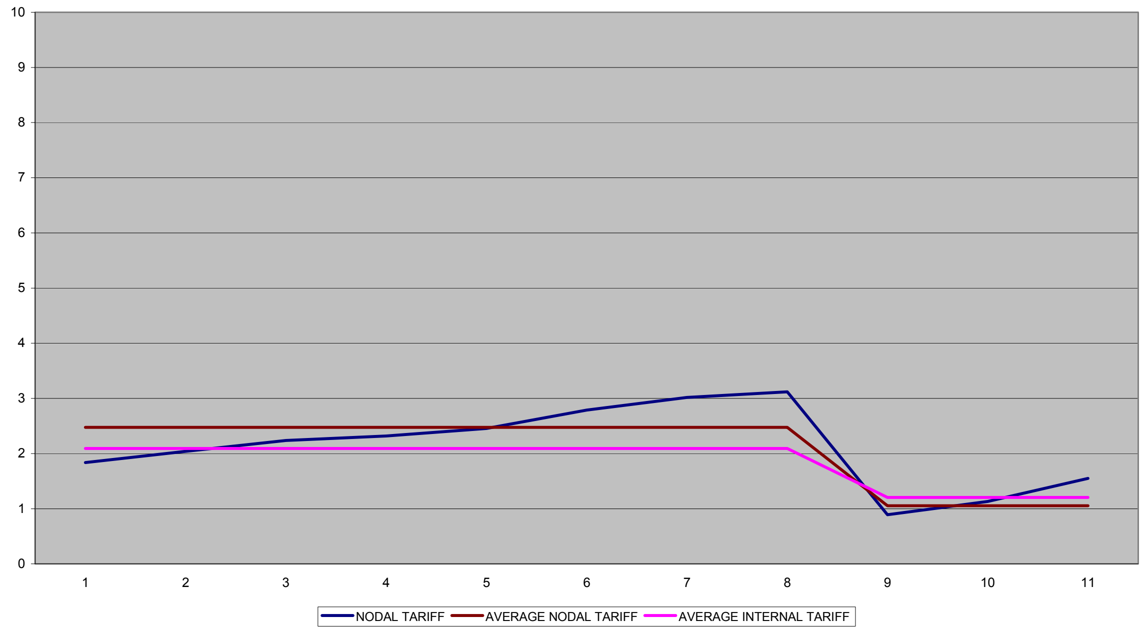

Figure 44: Nodal tariffs for Slovenia

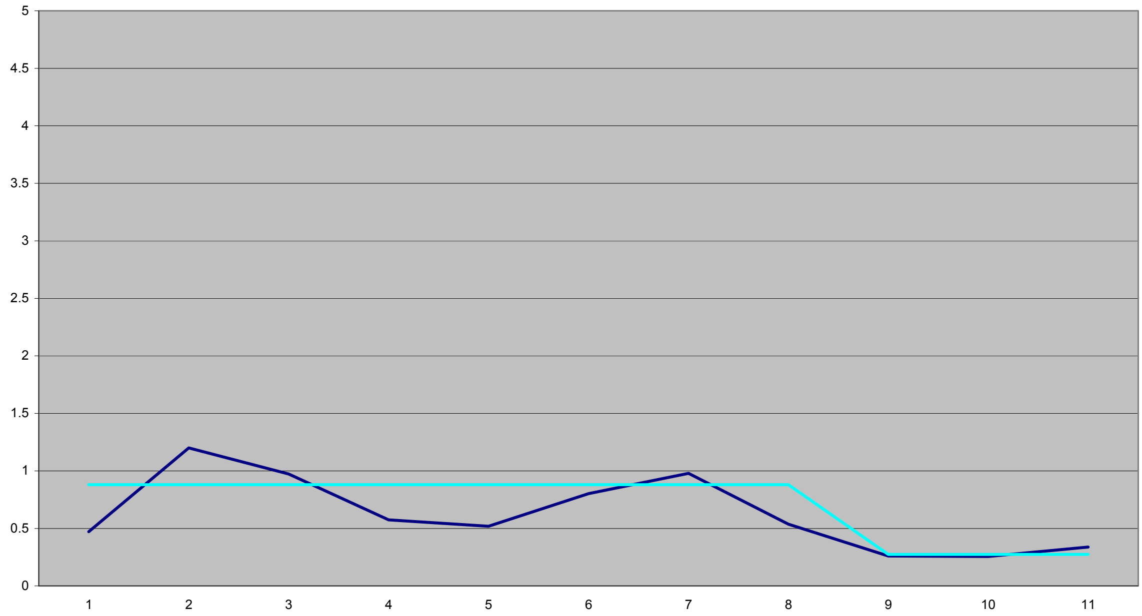

Figure 45: Standard deviation of the nodal tariffs for Slovenia

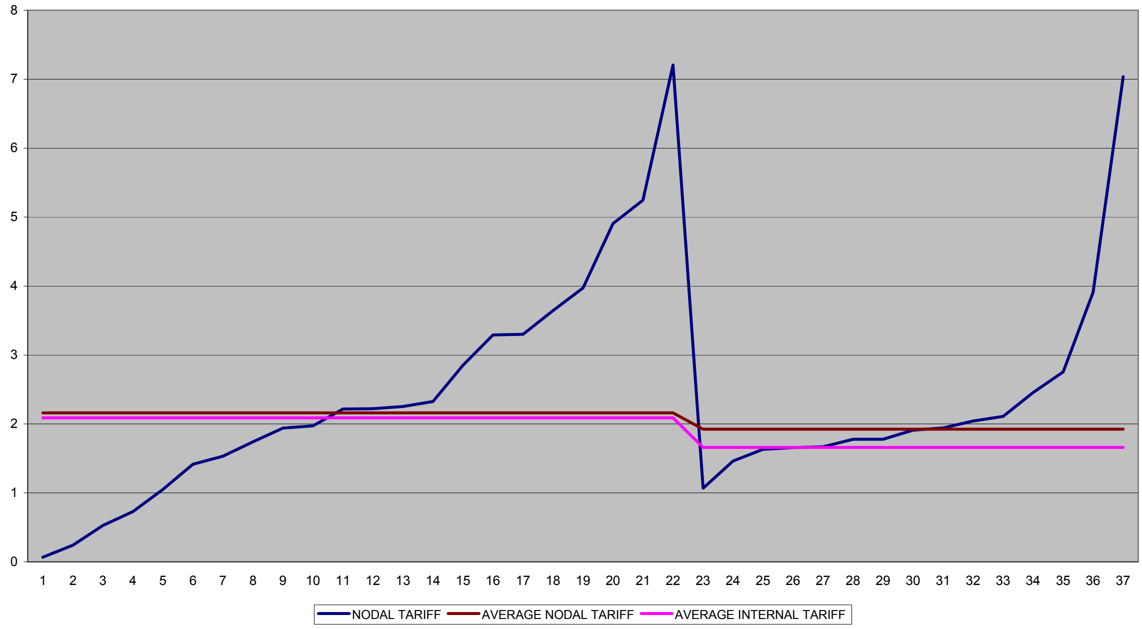

Figure 46: Nodal tariffs for Slovakia

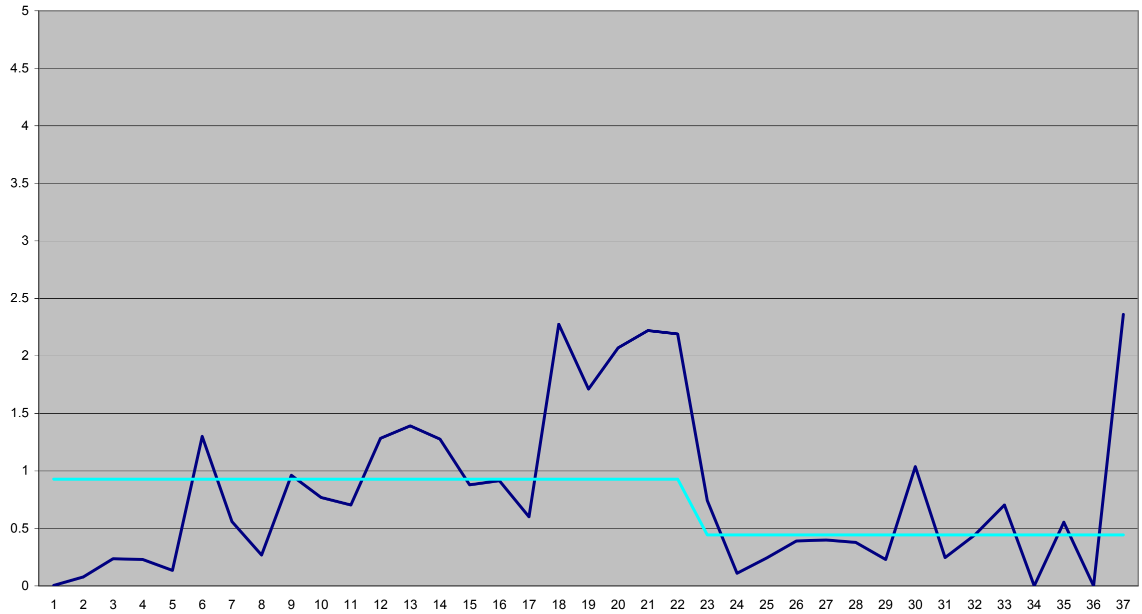

Figure 47: Standard deviation of the nodal tariffs for Slovakia