Study on the further issues relating to the inter-TSO compensation mechanism

Study commissioned by the

European Commission

Directorate-General Energy and Transport

Final Report

13 February 2006

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Contents

Abbreviations

AP	Average Participations
APT	Average Participations applied to Transits
EC	European Commission
ERGEG	The European Regulators Group for Electricity and Gas
IEM	Internal Electricity Market
ITC	inter-TSO compensation
MP	Marginal Participations
SGU	Superposition of Grid Uses
TSO	Transmission system operator
WWT	With-and-Without Transits

1 Introduction

The tarification of cross-border network access (formerly called CBT – cross-border tarification, now called ITC – inter-TSO compensation) has been on the list of major topics in the European discussion since the beginning of electricity market liberalisation.

In the regulation framework of the EU Internal Electricity Market (IEM), the ITC mechanism plays a vital role: the related EU Directives aim at creating a "single market" where trade across borders is as far as possible free of barriers when compared to trade within borders. However, cross-border flows (as a result from cross-border trade) do influence foreign networks, and TSOs do face cost due to this. The ITC mechanism aims at compensating these cost. It therefore serves the goal of the "single market": By considering the cost TSOs incur due to cross-border power exchange, and by compensating them among TSOs, the ITC mechanism allows trade to function as if there were no such cost.[1]

In recent years, the development of the ITC mechanism was mostly focused on enlarging the area of countries among which ITC payments are determined according to a joint mechanism, and on the structure of these payments, e.g. the abolishment of the export fee. In contrast, the method used to determine the amount of payments has undergone relatively little change, albeit being called a preliminary solution since its introduction in 2002.

Based on the requirement to specify Guidelines on ITC according to Regulation 1228/2003 [1], the European Commission (EC) and ERGEG are now planning to introduce an advancement of this method.

The goal of this study is to provide an informed assessment of alternative ITC methods as an input to EC/ERGEG considerations and decisions in relation to the above mentioned developments.

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1 Additional cross-border related payments between network users and TSOs exist in cases where congestion management mechanisms (such as auctions) create revenues for TSOs. Therefore, a discussion about ITC methods needs to take into account the interface to congestion management.

The analysis shows that there is not one single approach superior to all others in every respect, but that trade-offs between different criteria will be required. It is explicitly not the task of this study to formally recommend one single solution. Rather, the final weighting of the individual pros and cons is up to the EC and ERGEG (and subject to the formal consultation process that all Guidelines have to pass).

This study picks up and continues analyses presented in earlier EC studies ([3, 4]). While those studies provided a general and fundamental assessment of conceivable methods, the present study is based on the aim that the new ITC method should be suited for practical implementation and operation in the short term, if possible for incorporation into guidelines in 2006. Aspects of practicality therefore receive significant attention.

While our analyses comprised numerous detailed aspects required for the preparation of Draft Guidelines, this report focuses on the main arguments, thereby following the aforementioned goal of providing a basis for key decisions as to which method to propose for the enduring ITC scheme.

This report is structured as follows:

- In chapter 2 we set out our methodical approach, leading to a separation of further analysis in the two steps of costing method and cost allocation method.
- Chapter 3 provides an analysis of alternatives in relation to cost definition for the ITC mechanism.
- In chapter 4 we analyse the different aspects of ITC cost allocation mehods.
- Chapter 5 presents our conclusions.

Our analyses in preparation of this report have been accompanied by several meetings with ERGEG, the EC and the ITC Task Force of ETSO. In addition to providing their view on the different aspects of the ITC methods, ETSO have supported our analyses by providing load flow data that allowed us to perform quantitative comparison of the methods. We would like to thank ETSO for this valuable support.

2 Methodical approach

Regulation 1228/2003 [1] sets out a number of requirements for the ITC mechanism

- Transmission system operators[2] shall receive compensation for costs incurred as a result of hosting cross-border flows of electricity on their networks;
- The compensation … shall be paid by the operators of national transmission systems from which cross-border flows originate and the systems where those flows end;
- 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 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; and
- 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.

Essentially, as with the majority of tarification schemes (e.g. tariffs for access to national networks), it is possible to consider the derivation of any ITC mechanism in two parts:

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[2] In principle, participants to the ITC mechanism could be either individual TSOs or groups of TSOs who participate as one entity and deal with their internal compensations on a subsidiarity basis. To reflect this we sometimes use the term "entity" as a generalised form to denote a participant to the ITC mechanism.

- A **costing** methodology, to establish the costs which TSOs bear as a result of hosting cross border flows – this may be a total cost or a unit cost; and
- A **cost allocation** methodology, to establish how these costs which have to be recovered should be collected from other relevant TSOs.

In combination, these two elements should ensure that the hosting TSO receives an "appropriate" level of compensation (and hence that the domestic users of that TSO do not bear costs more appropriately associated to foreign use) and that the TSOs that are the source or sink of foreign flows contribute an "appropriate amount" (and hence to ensure that domestic users on those networks pay some proportion of the cost of their aggregate use of external networks).

This can best be seen by use of a simple stylised example, set out in the table below.

Costing methodology	**Cost allocation methodology**
Cost of 380kV line assets in TSO A's area = €30/km Cost of 220kV line assets in TSO A's area = €20/km	TSO A has 100km of 380kV line assets and 50km of 220kV line assets. The flow over the 380kV assets is 1000MW in a given period. Of this, 500MW of this flow (i.e.50%) can be said to result from cross-border flows The flow over the 220kV assets is 500MW in the same period. Of this, 100MW (i.e. 20%) can be said to result from cross-border flows.
International compensation due to TSO A	
Compensation = network length * percentage facilitating cross-border flows * unit cost = 100km * 50% * €30/km + 50km * 20% * €20/km	

Table 2.1: Separation of ITC mechanism into costing and cost allocation

In our analysis, we have followed this "two stage" approach. We have first considered the definition of the "appropriate" level of costs (we discuss this in chapter 3 below), and subsequently considered how they should be allocated (we discuss this in chapter 4). In both areas, we consider:

- The relevant objectives of the ITC methodology;
- The extent to which different approaches meet these objectives; and
- The factors to be taken into account by ERGEG and the European Commission in coming to final conclusions on the definition of the ITC scheme.

3 Cost definition

As noted above, Regulation 1228/2003 provides guidance as to how the cost of cross-border flows should be defined. Specifically:

- Costs are required to be based on 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; and
- recognised standard-costing methodologies shall be used.

However, this does not uniquely define the costing approach. For example, the use of the phrase "and appropriate proportion" requires consideration to be given as to what is "appropriate". Simply put, it could be "appropriate" for the cost basis to be:

- entirely based on forward looking long run average incremental costs;
- entirely based on the cost of existing infrastructure; or
- based on some combination of the two (for example, the unit cost of a given line type could be a weighted average of the long run average incremental costs of that line type and the cost of existing lines of that type).

A choice between these alternatives cannot be made without a view of the overall objectives of the tarification mechanism, as these should form the yardstick against which "appropriateness" should be measured.

In this chapter, we therefore consider:

- the economic objectives of the ITC mechanism, and the implications of these objectives for the choice of cost base; and
- the detailed specification of the cost basis for the mechanism in relation to infrastructure; and
- the detailed specification of the cost basis for the mechanism in relation to transmission losses.

Finally, we present the cost data on which the results presented in this report are based.

3.1 Economic objectives of the ITC mechanism

In line with mechanisms implemented elsewhere, there are two frequent objectives cited for network tariffs:

- **facilitation of economic efficiency**: by facing network users with charges which reflect the economic costs which use imposes on the network, users' individual decisions (taken in the knowledge of those tariffs) should be consistent with the optimal outcome for the network as a whole; and
- **recovery of costs**: by ensuring that, in aggregate, the payments by users total the costs incurred by the network operators, the ongoing operation of the network is financed.

The objectives of the ITC mechanism, and the relative weighting in them of these two typical tarification objectives, cannot be considered in isolation. The enduring ITC mechanism is to be implemented as part of a wide-ranging suite of arrangements to create a single European market in electricity. For example, the same Regulation that establishes the ITC mechanism also requires that:

> *Network congestion problems shall be addressed with non-discriminatory market based solutions which give efficient economic signals to the market participants and transmission system operators involved*.

By this, the Regulation could be taken to imply that arrangements for congestion management should:

- Signal the extent of congestion (through the market value placed on scarce capacity) to participants using network;
- Provide one set of signals to TSOs and regulators regarding the need for and value which might be placed on transmission expansion; and
- Provide one potential source of revenue for such transmission expansion.

If such arrangements are put in place for the management of congestion at borders (and looking around Europe, a number of market based approaches to managing interconnector congestion have now been put in place or are under active discussion) then it is not clear that sending signals in relation to economic efficiency should be the prime objective of the ITC mechanism. It would appear more appropriate that economic efficiency be achieved by market based mechanisms, rather than arrangements based on administered charges or allocation mechanisms. This would imply that the ITC mechanism's principal objective should be ensuring that sufficient revenue is recovered to fund the parts of the host TSO's network which facilitate cross border flows.

There may be further issues to consider in relation to the interaction between ITC charges and payments and revenues from congestion management arrangements. For example, if revenue from a market-based congestion management mechanism is funding a particular circuit or part of the network (as is permitted by Regulation 1228/2003), it may be that it would be appropriate for this to be taken account as part of the payments or receipts of that TSO under the enduring ITC mechanism.

It is the ultimate goal of the EU network access framework to achieve a harmonised way in which ITC and congestion management (and national transmission network tariffs) interact. Yet it is not within the scope of this study to achieve this high level harmonisation. Rather, the study focuses on identifying an ITC mechanism that is consistent in itself. In addition, however, it should be compatible to already existing cases where congestion revenues do interact with transmission tariffs. In some countries, some particular transmission assets are financed through past or future congestion revenues[3]. When defining the (national) cost basis for ITC, Regulators should have the possibility to correct the cost basis for such cases in order to avoid excessive compensations for the respective assets. It would be sensible for some consideration to be given to the issue (and in particular to ensuring that specific national funding approaches can be accommodated) by ERGEG and the European Commission in the formulation of ITC guidelines.

If the objective of the ITC mechanism is principally related to cost recovery, then it follows that in determining an "appropriate proportion" of the cost of existing infrastructure relative to forward looking long run average incremental cost for cost basis of the mechanism, the em-

3 For example: DC link between Germany and Denmark (Kontek), DC link between France and the UK (IFA)

phasis should be placed heavily on the cost of existing infrastructure. This approach is consistent with the text of Regulation 1228/2003.

A simple hypothetical example can demonstrate that use of costs based heavily on forward looking long run average incremental costs may not be appropriate if the objective of the mechanism is cost recovery. Suppose a hosting TSO has built a part of its network entirely to facilitate cross border flows, and that this part has a present value cost €100m (the entire of which it should receive in future ITC payments). Suppose further that, following construction of the network, the cost required to construct a similar network reduced by 10% (for example, as a result of a technological advance). Using a forward looking average incremental cost basis for the ITC mechanism would mean that the hosting TSO risked a significant under-recovery relative to the costs actually incurred.

This approach could be implemented by using a unit cost basis for the mechanism calculated as a weighted average of forward looking average incremental costs and the cost of existing infrastructure, with the weighting heavily skewed towards the latter. It is for ERGEG and the European Commission to take a final view on the precise weightings to be employed.

3.2 Detailed specification of cost basis in relation to infrastructure

As was demonstrated in the stylised example in the previous chapter, the cost estimates for particular line types are combined with the results of the allocation mechanism to derive ITC payments and receipts. Our modelling of the ITC mechanism considers the cost of four classes of asset (consistent with the network modelled for the cost allocation mechanisms):

- Very high voltage line (e.g. 300kV or above);
- Other high voltage line (e.g. 220kV to 300kV);
- DC lines of any voltage; and
- Transformers which transform between very high voltage levels, between other high voltage levels, or between other high and very high voltage levels.

Below we consider the detailed specification of the determination of regulated values and forward looking incremental costs in relation to these infrastructure types.

3.2.1 Regulated values

The cost of existing infrastructure can sensibly be determined by using regulated values (i.e. the allowed revenues[4]) for each TSO. These regulated values will reflect the decisions taken by the relevant national regulatory authority in relation to such factors as:

- The value of network assets on the ground;
- Depreciation profile and asset lives; and
- Efficiently incurred operating and capital costs.

Furthermore, these will be the basis on which domestic users contribute to the costs of the high voltage network.

In some cases, in arriving at an appropriate value for allowed revenue, it will be important to ensure that purely network related revenue is considered. For example, deductions might be required in relation to the revenue allowed for the procurement of network losses and other non-network asset related activities (including, but not limited to, the costs of control room and despatch operations, the net costs of balancing the system and the costs of procuring ancillary services). Transmission losses are dealt with in another part of the mechanism, and the other activities would be required in the absence of cross-border flows, and there is likely to be little incremental cost in these areas if cross-border flows increase.

The total network allowed revenue will need to be converted into unit costs for individual line types. This can be achieved with reference to the volume of each asset type (km of line, MVA of transformer) used in each network, and estimates of the cost relativities between asset types. These cost relativities may be best estimated on the basis of something close to "factory gate" prices, as these are less prone to differences in interpretation across countries. Since we are using the cost estimates to allocate a given cost between assets rather than determining an absolute value, the cost relativities can be more approximate than would other-

4 Or, pending the introduction of formal regulated values, a transparently assessed estimate of actual revenue.

wise be the case. Errors will only be a problem to the extent that the cost allocation mechanism differentially allocates flow between asset types – this is less likely.

Regarding the computation of unit cost from allowed revenues, a numerical example can be found in annex B.

3.2.2 Forward looking long run average incremental costs

One of the key theoretical issues in the calculation of long run average incremental costs is the treatment of joint and common costs (costs which cannot be directly associated with the provision of an individual service).

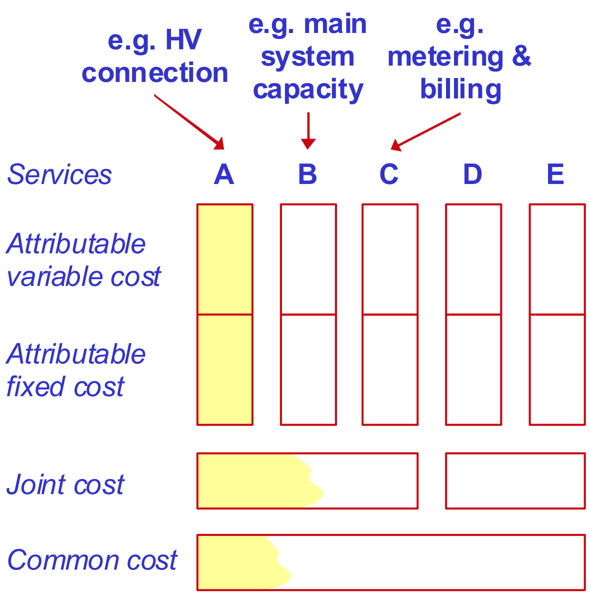

Fig. 3.1: Derivation of long run average incremental costs

This is an issue which has been considered extensively in relation to telecom companies – a range of potential allocation approaches can be employed, varying from a "thin" definition of incremental costs (which includes only variable costs which can directly be attributed to the provision of the service) to a "thicker" definition broadly equivalent to the cost of providing the service on a stand alone basis (in which all joint and common costs are associated with the provision of a service).

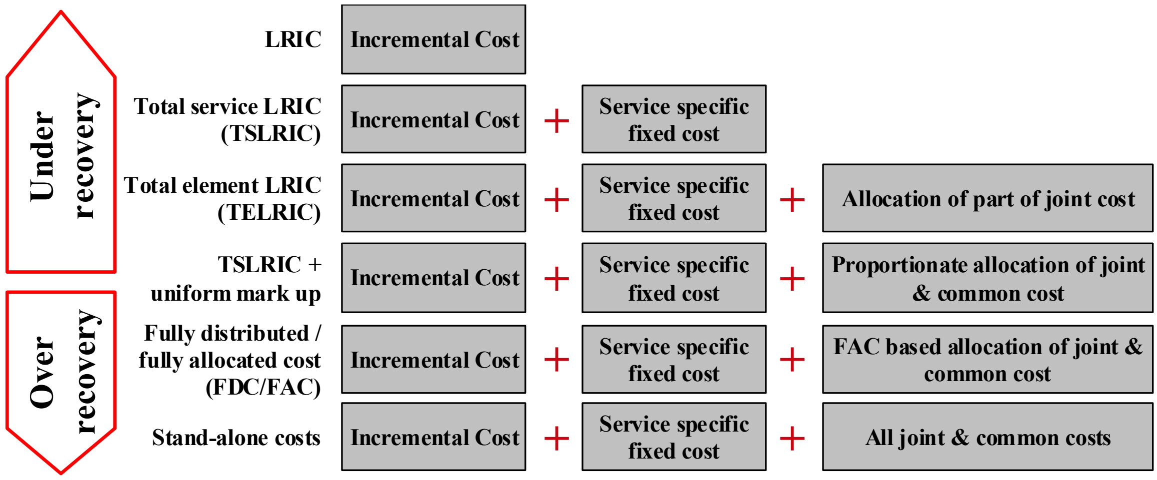

Fig. 3.2: Allocation of joint and common costs

In choosing between these approaches, since a large proportion of the cost basis for the mechanism will be based on regulated values, cost recovery need not be an overriding consideration. It may therefore be more appropriate to adopt a cost definition which minimises subjectivity, and can be interpreted consistently across countries.

This would tend to imply a "thin" definition with standardised parameters for some cost categories – for example:

- only direct costs of transmission network should be taken into account when incremental costs are estimated and there should be no allocation of joint and common costs to the incremental costs (e.g. project management overhead across a number of investment projects, corporate centre costs etc.);
- installation, testing and commissioning expenditure should be taken into account when costs are estimated; and
- in addition to the capital cost, the incremental operating cost of the lifetime of the asset shall be calculated as a fixed percentage of the Gross Asset Value of the asset.

Based on this approach to deriving forward looking average incremental costs, an annual forward looking average incremental cost for each asset type considered (as set out above in relation to regulated values) can then be calculated by annuitising the total unit cost estimate (i.e. cost per km or cost per MVA) over a fixed period (e.g. 40 years) and using a standard nominal rate of interest agreed by regulators. While it would equally be possible to use the asset lives and cost of capital assumed by national regulatory authorities for the purposes of fixing allowed revenues, the use of standard parameters in this way could be considered to minimise subjectivity and satisfy the requirement in Regulation 1228/2003 for a "standardized costing approach".

3.3 Detailed specification of cost basis in relation to losses

Arriving at an appropriate cost basis for the ITC mechanism in relation to transmission losses is simpler than is the case for infrastructure. Where an *ex ante* estimate of the unit cost of losses is required, if a market based approach to tendering for the procurement of losses is taken, a relevant benchmark price may be directly available. Alternatively, to the extent there are forward markets for electricity (albeit not representing the volume profile likely to be required to cover losses), it may be acceptable to use a benchmark forward price.

For *ex post* reconciliation, national regulatory authorities should have access to the unit cost for the purchase of losses actually incurred by the TSO. Where the TSO does not purchase losses, to the extent they are available, short term electricity prices (weighted by an appropriate profile) could be used[5].

3.4 Cost data used for the purposes of this report

In order to analyse the impact of different cost allocation mechanisms, we have relied on indicative cost data. It is important to note that we have not undertaken any work to validate the accuracy of this data – since the objective of this study is to allow comparison of the broad differences between different allocation approaches. In establishing values for the enduring ITC mechanism, national regulatory authorities and the European Commission will clearly have to engage in work to derive robust cost estimates.

5 If short term prices are not available from either an energy exchange or a recognized price reporting service, then an appropriate alternative may be short term prices in a neighbouring jurisdiction adjusted appropriately for transportation and, if relevant, congestion management costs.

For the purposes of regulated values, we have used allowed revenue data provided by national regulatory authorities and our own estimates of the cost relativities between different asset types. For systems where no data was available (CH, IT, NI, and PL), or where the data provided represented an extreme outlier relative to other systems (one of the German TSOs), we use the average of the regulated values for other systems or TSOs (as for Germany), respectively.

As an estimate of forward looking long run average incremental costs, we have relied on a study by ICF Consulting[6] for the Commission. We have used data based on the average cost of 380kV single overhead line and 380kV double overhead line expressed in a 380kV equivalent per circuit basis. Based on this data the forward looking element of the unit cost would be lower than the lowest cost figure for regulated cost. Moreover, the data source does not allow to reasonably estimate a variation of forward looking values across countries. Rather, quantification of both the overall level and the country-wise variations of forward looking cost are subject to future considerations (see above) and outside the scope of this study.

In order to avoid distortions by too rough (and too uniform) data, our quantitative analyses of cost allocation methods is based on regulated cost values and not on LRAIC data. (In addition, we present results based on uniform standard cost, however without referring to any absolute cost level.) Fig. 3.3 and fig. 3.4 show the proportions of the determined unit costs of 380 kV and 220 kV lines based on costs provided by the Regulators for 2003 and 2004.

6 Unit Costs of constructing new transmission assets at 380kV within the European Union, Norway and Switzerland, October 2002.

Unit costs based on regulated costs for 2003 (normalised with average 380kV line costs)

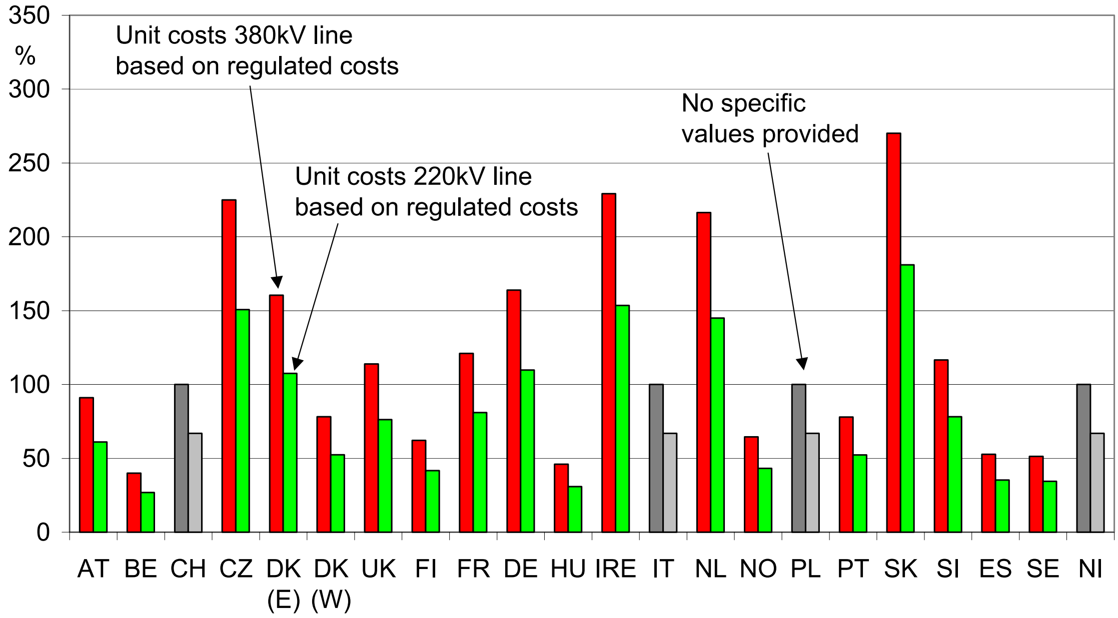

Fig. 3.3: Unit costs of lines available for the purposes of assessing cost allocation mechanisms based on regulated costs for 2003 (normalised with average 380 kV line costs)

Unit costs based on regulated costs for 2004 (normalised with average 380kV line costs 2003)

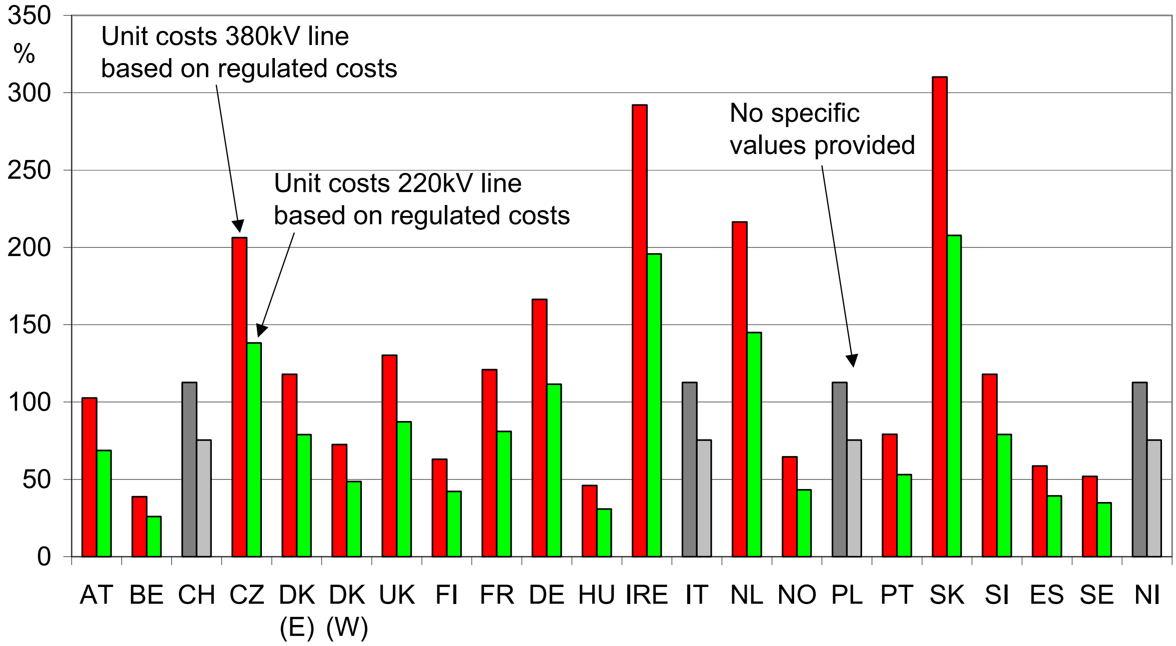

Fig. 3.4: Unit costs of lines available for the purposes of assessing cost allocation mechanisms based on regulated costs for 2004 (normalised with average 380 kV line costs for 2003)

4 Cost allocation mechanism

4.1 Approach to evaluation

Our evaluation approach for the cost allocation mechanism has three key stages:

- Definition of objectives for the mechanism: based on the requirements of the mechanism as a whole, laid down in the main in Regulation 1228/2003, we set out key objectives required of the cost allocation mechanism (section 4.2);
- Qualitative evaluation: against the set of objectives defined for the mechanism, we qualitatively assess each of the methods, in order to understand whether some can be seen to be unambiguously inferior to others even before a quantitative assessment using real network data is undertaken (section 4.5); and
- Quantitative evaluation: for the remaining set of mechanisms, we use network data from 2003 to simulate how the mechanism would operate, and then assess the results to select the most appropriate mechanism (section 4.6).

Prior to the qualitative and quantitative analysis, we list and describe the cost allocation methods that have been analysed in this study (section 4.3).

4.2 Objectives for the allocation mechanism

4.2.1 Objectives applied for our analysis

The objectives for the allocation mechanism need to be seen in the context of the objectives of the ITC scheme as a whole.

Regulation 1228/2003 sets out a number of requirements for the ITC mechanism:

- Transmission system operators shall receive compensation for costs incurred as a result of hosting cross-border flows of electricity on their networks. The compensation shall be paid by the operators of national transmission systems from which cross-border flows originate and the systems where those flows end;

- 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; and
- 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 (LRAIC), 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.

Other than stating that the costs shall be established on the basis of an appropriate proportion of LRAIC and the cost of existing infrastructure, the Regulation does not set out the objectives of the compensation payments themselves or the way in which this “appropriate proportion” should be determined.

In general, tarification systems have two main objectives:

- Economic efficiency: sending price signals to market participants and/or TSOs to incentivise them to act in a way which is efficient from the viewpoint of the system as a whole (e.g. making areas of the network with significant export constraints more expensive for generators wishing to connect); and
- Revenue recovery: ensuring that TSOs recover an appropriate amount of revenue (in this case in relation to the hosting of cross border flows).

Frequently, tarification systems attempt to satisfy both objectives.

In considering the ITC scheme in the context of all of the other elements of the enduring internal market regime, we conclude that the objective of compensation amounts under the ITC scheme should principally be revenue recovery – whereas congestion management regimes should ensure that key price signals are sent in relation to economic efficiency (both for participants, indicating where there is most significant congestion and therefore where incremental use of the network will have the most significant impact, and for TSOs in relation to where additional network investment would be most valuable).

In the light of this, the objectives against which we evaluate each of the cost allocation mechanisms are as follows:

- Accuracy: the mechanism should accurately model the extent to which injections and offtakes on one TSO's network create flows on other networks in recognition of the laws according to which electricity flows, and reflect this in the payments made between TSOs;
- Practicality and ease of implementation: the mechanism should be practicable to operate – in particular, increased complexity and effort required in collecting and validating the data for the mechanism or in using the mechanism should be justifiable in terms of the other objectives; and
- Stability and transparency: the mechanism should result in compensation amounts which are relatively predictable and transparent given the input data;

4.2.2 Relation to ERGEG objectives

ERGEG has developed a set of eight criteria for the assessment of ITC methods [2]. Table 4.1 shows that most of these criteria can be mapped on to those that we have set out in the previous section, with the following remarks:

- We combine a number of the ERGEG criteria under our criterion accuracy. This aggregation does not imply any weighting in relation to the other ERGEG criteria, especially no intended consideration of criteria subsidiary to others. From our point of view the ERGEG criteria can be interpreted such that some, e.g. "technical soundness", are meant as general criteria, whereas others (like #2) are quite specific. We try to capture a wide variety of aspects under accuracy, including all related ERGEG criteria, to the same degree.
- For our analyses the three objectives introduced in section 4.2.1 are each divided up into a number of subcategories that are assessed separately. Hence, the nominal concentration of the analysis to three criteria serves to provide a clearer structure for the evaluation rather than narrowing the variety of aspects to be considered therein.

ERGEG objective # Description	Corresponding objective in our evaluation	Remarks
1 Legislative	–	Prerequisite, to be fulfilled by any method. Not suited for discrimination between methods.
2 Take into account as far as possible all cross-border flows (Reg. 1228/2003, Art. 3)	Accuracy	Other clauses of Art. 3 should receive equal attention
3 Consistent with “single system paradigm”	Accuracy	
4 Consistent with overall framework of transmission regulation	Accuracy, transparency	Main goal of ITC should be revenue recovery; no provision of incentives
5 Economic	Accuracy, transparency	
6 Technical soundness	Accuracy	Some components of ERGEG objective as drafted also refer to stability and transparency.
7 Implementation	Practicality and ease of implementation	
8 Ability to be easily understood and verified	Stability, transparency, practicality	

Table 4.1: Relation between ERGEG objectives and objectives applied in our study

- ERGEG objective #1 (i.e. compliance with Regulation and Directive) is a prerequisite to any method that is taken into serious consideration (we note that the current ETSO method may not be seen to fulfil this requirement). Insofar we are implicitly applying this objective as well. However, since its fulfilment cannot be described as a gradual property, the objective can not be used to discriminate between methods (other than in relation to ETSO2005).
- ERGEG objective #2 refers to Article 3 of Regulation 1228/2003 and demands for taking into account all cross-border flows. In this context, we believe it is worthwhile to note

  - that Article 3 does not explicitly state "all flows"[7]. Therefore, objective #2 can, in contrast to objective #1, be considered a gradual objective, we include the degree to which it is met under our assessment of accuracy; and
  - that Article 3 demands for additional properties of the ITC method whose fulfilment should – in terms of accuracy of the method – receive equal attention. An important example is that "Benefits that a network incurs as a result of hosting cross-border flows shall be taken into account to reduce the compensation received" (Art. 3(6)).

  Under our „accuracy" criterion, we consider both the extent to which all flows are taken into account and the extent to which benefits from flows are considered in each of the methods.

- ERGEG objective #4 is related to our objectives of accuracy and transparency insofar that the ITC method should avoid any side-effects on other elements of cross-border transmission regulation. We would, however, like to restate that the ITC method itself should not follow the goal to provide economic incentives e.g. for network expansion, but should be *consistent* with arrangements which are targeted towards this.

4.2.3 Conclusions for our further analysis

In considering the extent to which each of the mechanisms support the objectives set out in section 4.2.1 above, there will be clear trade-offs – no single mechanism is likely to score well against all of the objectives. For example, a mechanism which is highly accurate and reflects the way in which electricity flows around the network is likely to require more effort – in relation both to the collection and validation of consistent data and in relation to its operation.

The selection of the final mechanism will therefore require

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7 Article 8(2)c of the Regulation states that the related guidelines shall specify "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, […]"

- quantitative analyses in order to find out to which extent qualitative differences between the methods actually affect the resulting payments; and
- a view on the relative importance of each of the objectives, as this will determine which trade-offs are considered acceptable.

Preparatory to these steps, the qualitative evaluation serves to analyse whether some methods can be seen to be unambiguously inferior to others even before a quantitative assessment, and to identify those conceptual differences between the methods for which quantitative comparisons – in addition to a comparison of the total inter-TSO compensations resulting from the methods – are recommendable in order to assess the factual importance of such conceptual differences.

4.3 General properties of cost allocation methods

4.3.1 Determination of compensations and charges

In a generic description the different cost allocation methods to be analysed (cf. section 4.4 below) need to answer two questions:

- Which share of the ITC network cost basis of a participating entity (e.g. a TSO) should be allocated to users that are external to this entity? This share is the *compensation* that the respective entity should receive from the other entities.
- Who pays which share of the total amount of compensations? This step determines the *charges* to be paid by each entity.

Some allocation methods determine compensations and charges in separate steps, while others directly calculate who should be compensated by whom.

The sum of all compensations is often referred to as the ITC fund and used as a measure for comparing ITC methods. However, the financial position of each entity in relation to the ITC mechanism ultimately depends only on the difference between its compensations and charges.

4.3.2 Distinction between infrastructure cost and cost of losses

In principle, the cost of network infrastructure could be allocated in a different way than the cost of losses. This would be justified if there was reason to believe that the responsibility of external network users for losses is different from their responsibility for infrastructure cost. However, losses arise from power flows. And all cost allocation methods are based on deriving the responsibility for infrastructure cost from the responsibility for power flows. Hence the allocation method that is considered most appropriate for the infrastructure cost should also be most appropriate for allocating the cost of losses[8].

After determining the flow on a given line/transformer due to external network users, one could in theory calculate the additional losses arising from these external flows when they are imposed on the network that originally is only used by domestic users.

However, due to the quadratic increase of losses with the power flow on a line/transformer, this would discriminate against those users who are considered the "second ones". In order to avoid such discrimination, we recommend to allocate the cost of losses not only by the same method as the infrastructure cost, but by the very same allocation key.

4.4 Cost allocation methods considered

We were explicitly requested to consider only methods that were already under discussion or that were newly proposed by the TSOs, and not to attempt to derive and consider any new methods. This led to the following list of six methods:

- The currently applied method (ETSO2005);
- With-and-Without Transits (WWT);

[8] There has been some discussion whether potential benefits from cross-border flows relate to losses in a different way than to infrastructure cost. When discussing this issue in more detail in section 4.5.1.2 we conclude that this is not the case.

- Average Participations applied to Transits (APT);
- Average Participations (AP);
- Marginal Participations (MP) and
- Superposition of Grid Uses (SGU).

These six mechanisms represent the five already considered in the Comillas study [3] and a sixth (SGU) newly proposed by ETSO.

The following sub-sections briefly introduce the six allocation mechanisms and provide references to more detailed descriptions.

4.4.1 ETSO2005

The currently applied CBT mechanism takes into account all transit flows of each participating entity. Transits are defined as the minimum of aggregated import flows and aggregated export flows. Compensations for hosting cross border flows are calculated by means of the so-called transit key considering the ratio between the amount of transits and the load plus transits of an entity on a hourly basis. This ratio determines for how much of the costs – including costs for infrastructure as well as for network losses – of the horizontal network (describing the relevant network elements) an entity is compensated[9]. The sum of compensations of all participating entities (=fund) is financed from

- the so-called perimeter countries (these countries have at least one border to the ITC area but are not participating in the ITC mechanism) by being charged an explicit injection fee, and
- the entities participating in the ITC mechanism according to the "net flow", i.e. the net import or export of each entity on an hourly basis.

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9 If a standard cost per km was applied under this model it would effectively amount to a standard value for cost per MWh of transit. This assumes that the extent of km affected is proportional to the amount of transit.

Refer to [5] for a detailed description.

4.4.2 WWT

In order to determine the amount of compensations for each entity two network situations are compared (for each regarded point of time). One is the reference situation (containing actual flows) and the other is a modelled situation after removing transits (using the same definition as for the current mechanism).

With a first load flow calculation for the reference situation (situation with transits) all actual flows are identified. After removing transit flows on the interconnectors a second load flow calculation for the situation without transits is done. The calculated flows for this modelled situation are an estimate of the flows caused by domestic network utilisation. The flows caused by transits are defined as the difference of the actual flows (with transits) and domestic flows (without transits).

Summing up the impacts on each considered network element due to transits leads to the compensation for an entity[10].

The resulting fund is financed following the same rules as for the current ITC mechanism (cf. section 4.4.1), including the treatment of perimeter countries.

Refer to [3] for a detailed description[11]. (Note that [3] sets out the treatment of losses under WWT such that TSOs should be compensated for any incremental losses arising from transits.

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10 This gives a standard value for the cost per MWh · km resulting from transits where the extent of km affected is explicitly modelled.

11 Note: In [3] options are given regarding the way how to quantify the impact of transits on the network utilisation of a considered ITC entity. Actually, we applied the second alternative (comparing the flows in each line for the reference network situation and for the fictitious situation after removing all transits) but under consideration of all flow changes, i.e. regardless of whether flows increase or decrease due to transits. This allows for the consideration of benefits due to cross-border flows, which we discuss in detail in section 4.5.1.2.

As we have stated in section 4.3.2 we consider this an inappropriate discrimination against external users. However, this is not a fundamental disadvantage of the WWT method. Rather, our recommended approach of treating losses identically to network infrastructure can also be followed with WWT.)

4.4.3 AP

AP takes into account each individual load and generator. It is assumed that electricity flows can be traced by supposing that at any network node the inflows are distributed proportionally to the nearest outflows. (This can be interpreted as a "water flow" view, because like with a water stream the flow on lines with a net outflow are deemed to be exclusively created by flows on lines with a net inflow to a considered node.) Under these assumptions the method identifies, for each generator injecting power into the network, paths starting at the generator until they reach load nodes where they end. In analogy, paths from loads to generators can also be determined. This allows to allocate the responsibility for flows on each considered network element to single generators and loads. The cost of each line or transformer is then distributed to the different users according to how much the flows starting at a certain load/generator have circulated along the corresponding network element.

Since the flow on each network element is fully explained twice by the method (one by tracing downstream from generators, and one by tracing upstream from loads), an ex ante weighting factor is required, defining which share of the costs shall be borne by loads and how much by generators.

A complete description of the AP method can be found in [3].

4.4.4 APT

The APT method is based on the same algorithm as AP, but applied only to transits defined in the same way as for the methods WWT and ETSO2005. Once the transit flow for a considered entity has been determined, the method consists of tracing these transit flows both upstream (towards generators) and downstream (towards loads) with the "water flow" algorithm (cf. section 4.4.3). Thus, one can determine how much the transit flows are using the considered entity's network (defining compensations) and which is the origin of the transit flow in order to allocate responsibilities (defining charges). More details are given in [3].

4.4.5 MP

Identical to AP the Marginal Participation algorithm considers the impact of each load and generator on flows on lines and transformers. It also allows to allocate the responsibility for flows on each considered network element to single generators and loads.

This is achieved by calculating sensitivities that represent how much the flow in a line/transformer increases in relation to an injection increase in a given node. The total participation of each node in a particular line flow is calculated by multiplying the amount of its injection by the above sensitivity. The cost of each network element is allocated to the different loads and generators according to their relative participation to the physical flow in this element.

We note here that the names of the allocation methods have been adopted from [3]. However, the main difference between AP and MP is not that one of the is based on an "average" and the other on a "marginal" approach. Formally the calculation of the sensitivities in MP follow a marginal algorithm (more precisely: an incremental algorithm, where 1 MW of additional injection is simulated on top of a base case load flow situation). But since the load flow algorithm can be linearised with reasonable accuracy, the sensitivities de facto constitute average participation factors[12]. Hence the main difference between AP and MP is not what their names suggest, but rather the fundamental algorithm by which the concrete participations of nodes in the flow on lines/transformers is determined, i.e. load flow vs. water flow.

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12 For example, if an incremental injection of 1 MW at node A resulted in 0.4 MW of incremental flow along line 1, then it can be stated with reasonable accuracy that if there were 100 MW of injection to start with at node A, the contribution of that injection to flow on line 1 would be 40 MW. And if the total actual flow on line 1 was 800 MW and the total actual injection at node A was 100 MW, node A can be assigned the responsibility for 5 % (40 out of 800 MW) of the actual flow on line 1.

In the detailed description of MP given in the Comillas study [3] the issue has been raised that the choice of the slack bus can significantly influence the results. When calculating the participation sensitivities the injection in a node is increased by 1 MW, which needs to be balanced in the slack bus, such that actually a transaction between the considered node and the slack bus is considered. Consequently, changing the slack bus influences the participation sensitivity of the single node.

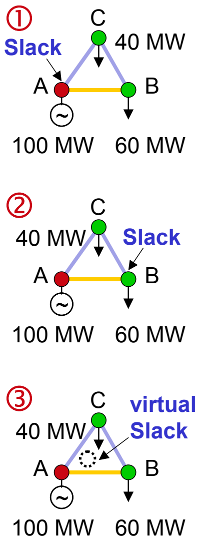
However, as [3] confirms, by changing the slack bus all sensitivity factors are modified by a fixed additional term, which is constant for all nodes. As a consequence, the percentages of flows (and thus cost) that are allocated to generators and load, respectively, change.

At a first glance, this seems to be an inadmissible ambiguity of the method. However, if one prescribes in advance the share of cost to be borne by generators and loads, respectively, one can determine a corresponding slack bus (see example on page 28). The necessity to prescribe the cost share between generators and loads is identical to the AP method (see above).

In relation to the MP method it is sometimes argued that it considers additional incremental flows that, in case of network constraints, would not reach the common slack bus. However, it must be remembered that the MP model is designed to allocate costs for actual flows, which are already constrained by the congestion that currently exist in the network.

MP method: Determination of a “virtual slack bus”

For demonstration purposes we consider a network consisting of 3 nodes A, B and C, where A is a generating node (100 MW) while B and C are loads (60 MW and 40 MW respectively) and concentrate on the line A→B.



① PTDF values

	A	B	C
Line A→B	0	-0.6	-0.35

Responsibilities for line flow A→B

0·100MW — Gen: 0 MW
+ (-0.6)·(-60MW)
+ (-0.35)·(-40MW) — Load: 50 MW
=50MW

② PTDF values

	A	B	C
Line A→B	0.6	0	0.25

Responsibilities for line flow A→B

0.6·100MW — Gen: 60 MW
+ 0·(-60MW)
+ 0.25·(-40MW) — Load: -10 MW
=50MW

③ PTDF values

	A	B	C
Line A→B	0.25	-0.35	-0.1

Responsibilities for line flow A→B

0.25·100MW — Gen: 25 MW
+ (-0.35)·(-60MW)
+ (-0.1)·(-40MW) — Load: 25 MW
=50MW

Fig. 4.1: Slack dependency of MP

Assuming that A is the slack bus (first case in the figure), this leads to the given sensitivity values (PTDF = power transfer distribution factor). Note, that the value for A is zero, because by being the slack bus any increase of injection in A is balanced also in A and therefore does not effect the flow on line A→B. The set of PTDF values is valid to describe the load flow correctly. In our example the flow on line A→B is 50 MW being the sum of the individual impacts of the 3 considered nodes resulting from multiplying the load/injection with the corresponding PTDF value (right hand side of fig. 4.1).

In the second case, we assume B to be the slack bus. To achieve this we have to assure that the PTDF value for B is zero, which can be done by adding 0.6 to the PTDF value for B. In order to maintain the load flow on line A→B, this value has to be added to the PTDF values of all other nodes as well. The sum of all individual impacts regarding the flow on the considered line is again 50 MW but the single contributions to the flow are nominally changed (A: from 0 MW to 60 MW; B: from 36 MW to 0 MW; C: from 14 MW to -10 MW).

With a given share – in the example the ratio is 50:50 – defining how much of the resulting flow shall be allocated to loads and how much to generators, a value can be found which has to be added to all PTDF values to achieve the desired allocation to loads and generators. This is shown in the third case of fig. 4.1, where both generators and loads are nominally responsible for 25 MW of the flow on line A→B. In addition, one can notice that none of the PTDF values is zero anymore. This means that neither A nor B nor C is the slack bus, but that only a “virtual” slack bus is suitable to fulfil the requirements. However, this is just a mathematical phenomenon and has no physical relevance.

In analogy to this simple example, the procedure can be applied to all network elements of a real network.

4.4.6 SGU

This method describes the use of the international grid as the superposition of various uses, each one defined by its entity of origin and entity of destination. This leads to two types of grid uses:

- National use: Origin and destination in the same entity
- Exchange use: Origin in an exporting entity and destination in an importing entity

National use by an entity induces

- national flows in its own grid
- loop flows in other grids

The flows induced by exchange use are defined as

- Export flows: in the network elements of the entity where the exchange use has its sources
- Import flows: in the network elements of the entity where the exchange use has its sinks
- Transversal flows: in the network element of all other entities.

In order to determine the participation of each generator and load to each type of grid use, the principle of proportional allocation is used. One has to distinguish between the allocation level:

- Allocation at one entity's level:
  - In an exporting entity each generator has the same participation to national use and to export use. The participation factor for national use (respectively for export) is the ratio of national load (respectively export) to the sum of national load and export.
  - In an importing entity each load has the same participation to national use and to import use. The participation factor for national use (respectively for import) is the ratio of national generation (respectively import) to the sum of national generation and import.
- Allocation at the international level:

- All exports (from various exporting entities) have the same participation in the import of one importing entity. The participation factor is the ratio of the import of this importing entity to the sum of all importing entities.
- All imports (into various importing entities) have the same participation in the export of one exporting entity. The participation factor is the ratio of the export of this exporting entity to the sum of all exporting entities.

The amount flows due to national as well as exchange use of the grid is then determined by a load flow calculation where the sum of the aforementioned types of flow is equal to the real flow following the principle of superposition.

Assuming that all other types of flow can be covered by national tariffs or are not related to cross border trades, each importing or exporting entity participating in the ITC mechanism has to compensate others for transversal flows induced by its exchange uses.

Since each network element is assumed to be used by several uses, the full cost (infrastructure and losses) of one network element is proportionally shared among these uses according to the flow component induced by each particular use (counted positively if this flow component has the same direction as the real flow, and negatively otherwise). The overall compensation due to an entity for hosting transversal flows is obtained by summing up the determined compensation of each considered network element.

As the method also identifies the entities of origin and destination of transversal flows this indicates who has to pay the corresponding compensation. Under the assumption that a sharing factor between exporting and importing entities is defined, the costs for inducing transversal flows are shared in proportion to that factor.

The detailed original description of the SGU method can be found in [6].

4.5 Qualitative evaluation

The objectives to the ITC method as defined in section 4.2.1 are – similarly to ITC objectives defined elsewhere – quite general and therefore difficult to apply when concretely comparing methods. In this chapter (sections 4.5.1 to 4.5.3) we break down the objectives into specific elementary aspects that allow for a discrimination between the methods. Section 4.5.4 gives a conclusion of the qualitative evaluation.

4.5.1 Accuracy

4.5.1.1 Consistency with rules of physics

The question to which extent a method complies with the rules of physics is directly linked to its accuracy in terms of cost reflectivity.

The current mechanism (ETSO2005) is a very rough approximation of how injections and offtakes influence power flows on line and transformers in external grids. For both the determination of compensations and the allocation of responsibilities for external grid use it underlies many assumptions that highly aggregate single aspects and do often not properly reflecting the laws of physics.

Since WWT, SGU and MP are based on a load flow algorithm, these method are in general following the laws of physics and therefore can be denoted as accurate. This is because the purpose of the load flow algorithm is to determine the power flows as they result from the generation and load pattern and the physical properties of the network. Therefore, it ideally mirrors the requirement to determine the physical origin and destination of cross-border flows[13].

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[13] In this context it is often discussed whether to apply a so-called AC load flow algorithm or a simplified so-called DC algorithm. Experience tells that the accuracy gain of an AC algorithm compared to a DC algorithm is in the order of magnitude of a few percent. The DC simplification is, therefore, by far less severe than other aspects of "roughness" that are inherent to all considered allocation methods. Moreover, the DC algorithm is more robust because it is not iterative and therefore not subject to convergence problems. Consequently, the DC algorithm is appropriate in view of the requirements of a cost allocation method within the ITC mechanism.

However, WWT, SGU and MP methods are not equivalent in terms of accuracy because one has also to take into account to which extent each of the methods are also based on assumptions, that are more or less an appropriate approximation of physical reality. For example, WWT is – as ETSO2005 – based on the heuristic estimation of transits from export and import flows (cf. separate discussion in section 4.5.1.4).

AP and APT are based on a rough heuristic approximation of physical reality using an flow tracking algorithm that is more suitable to describe a water flow than power flows in an electricity network. In particular, AP and APT do not respect the superposition principle: The identified impact of some entity on the network should not be affected by the way in which other entities use the network[14]. Under AP/APT, however, some additional network use may alter the flow direction on a line, thereby affecting the flow tracking result for all other entities in the region. Under load flow based methods, in contrast, the impact of an entity on some line is determined independently from the final flow on that line.

In order to demonstrate this effect we consider a real load flow situation regarding one single injection in France close to the Spanish border (fig. 4.2).

[14] Note: This relates only to the *impact* (how much flow on a line is allocated to an entity), whereas the individual *payments* should of course depend on all entities' utilisation of the grid, because they should reflect their relative responsibility for the utilisation.

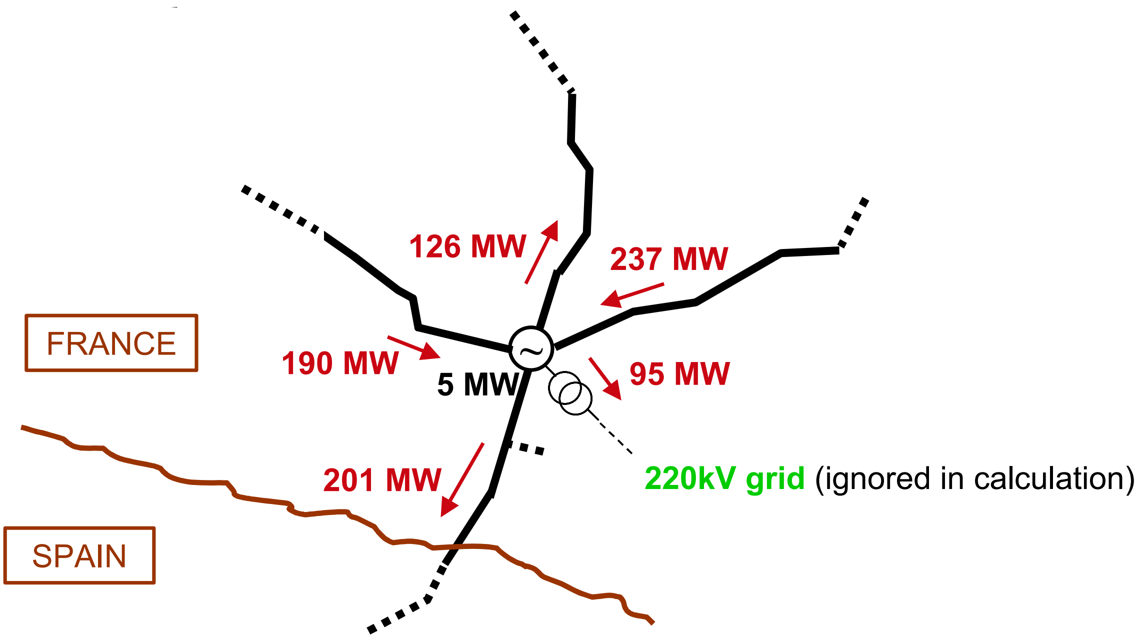

Fig. 4.2: Exemplary load flow situation of French generator node

Applied to AP and MP, fig. 4.3 and 4.4 illustrate the fundamental difference between the approaches (water stream vs. load flow).

The example shows that the impact detected by AP does not reach as far as with MP, and that the impact is limited to those directions in which the actual flows have the "appropriate" sign (in the example, directions North and South). This latter effect leads to the consequence that the cross-border impact of injections close to borders of highly importing entities is practically ignored because the flow starting from such an injection is not tracked towards the neighbouring entity (because it faces only opposing flows). Physically, however, a power injection "pours" into all directions, thereby modifying the flows on all lines connected to the generator node. Since MP is based on the load flow algorithm, it correctly captures this effect.

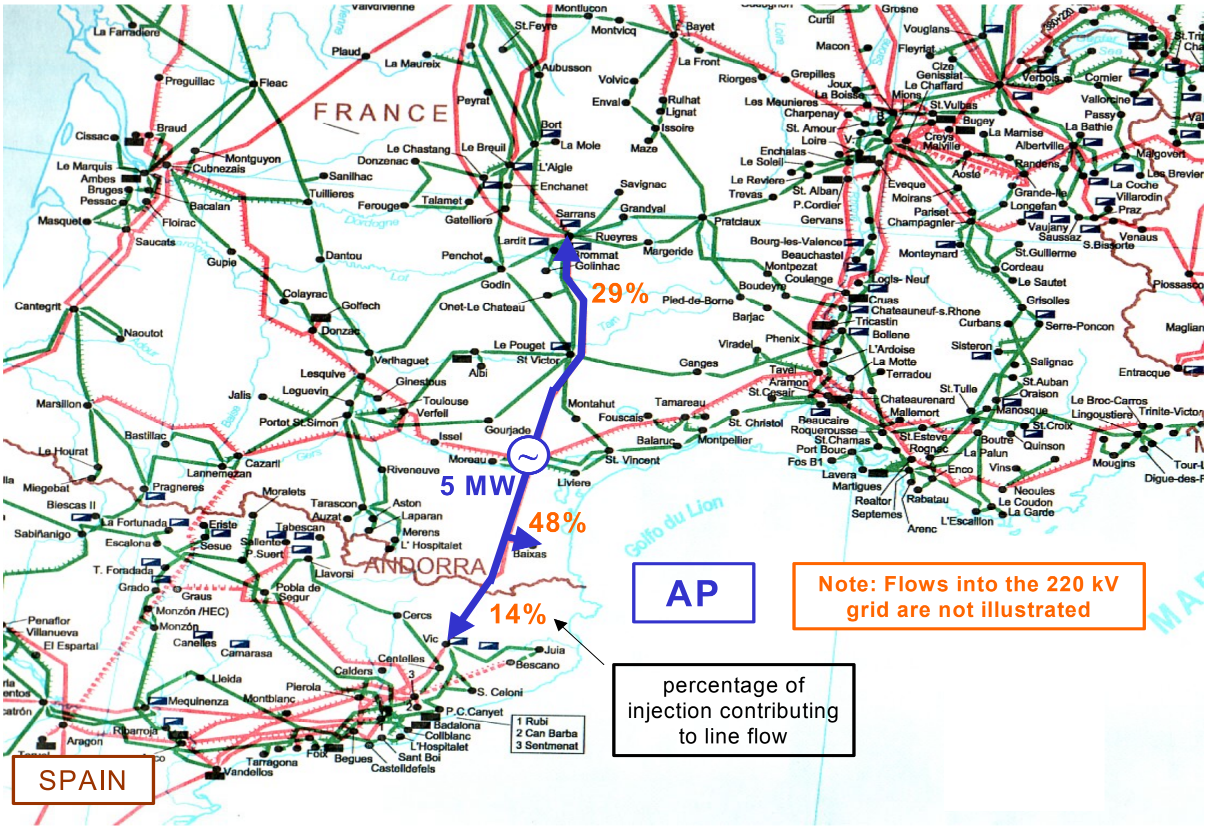

Fig. 4.3: Geographical impact of a single injection on line flows (AP)

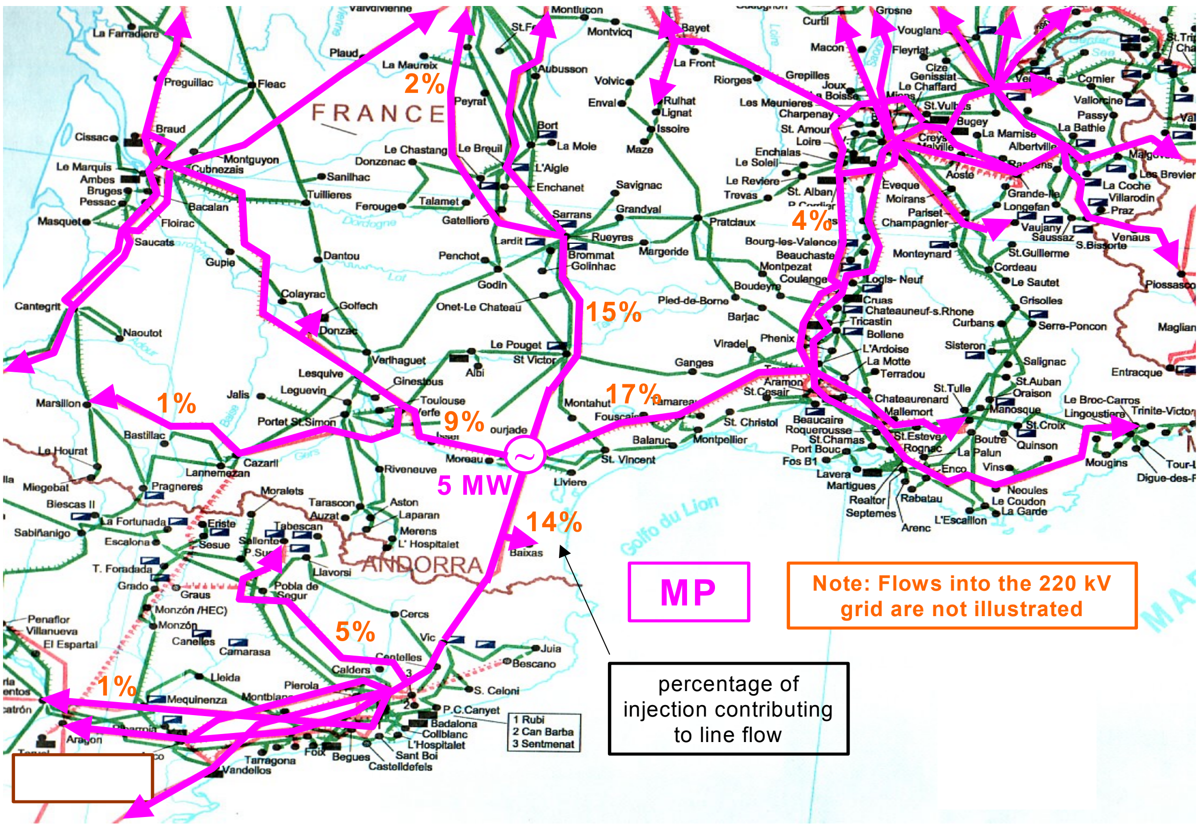

Fig. 4.4: Geographical impact of a single injection on line flows (MP)

4.5.1.2 Identification of benefits due to cross-border flows

Regulation 1228/2003 demands that benefits that a network incurs as a result of hosting cross-border flows shall be taken into account to reduce compensations under the ITC mechanism.

There has been some discussion in the past to which extent such benefits occur. While it is usually agreed that cross-border flows may reduce losses, a reduction of network infrastructure cost is sometimes questioned. However, the widely accepted understanding that *positive* cost due to cross-border flows do occur is usually based on the observation that cross-border flows increase the flow through the transmission network, such that a part of the network cost are required to serve the international part of network use. This is reflected in the cost allocation methods by determining the internationally induced share of the power flow, either as an aggregate figure (ETSO2005) or per line/transformer (all other methods). When regarding the single line or transformer, it is obviously a simplification to assume that this element's particular cost are exactly induced by international and national users according to their share in the power flow. (For example, if the contribution of cross-border flows to a line flow is 20 %, the line would not have been built for 80 % of its cost if there were no cross-border flows. This has many reasons: line cost are not proportional to the transmission capacity, line utilisation is volatile, etc.) Nevertheless, on the TSO level the flow share is widely accepted as a reasonable estimate of the cost share, and the discussion about the different methods focuses mainly on the question by which algorithm the flow share is determined.

We summarise that positive cost incurred by cross-border flows are deemed to be related to the positive increase of flows due to cross-border flows. Symmetrically, it is consequent to deem that for some network elements, cost are reduced by cross-border flows because they relieve these elements. (In other words: If one denied that cross-border flows can reduce network infrastructure cost by reduced flows, it would be hard to justify that network cost are increased by cross-border flows according to their positive contribution to the line/transformer flows.[15])

We conclude that in the cost allocation method – under simplified assumptions that are generally accepted in the context of the ITC mechanism – the benefit due to cross-border flows can be expressed by the relief of line/transformer flows due to cross-border flows.

By principle, only load flow based methods (WWT, MP, SGU) can detect if cross-border flows (partially) relieve lines or transformers (while the other considered methods [ETSO2005, APT, AP] are not able to consider relieving effects), which is the prerequisite for taking such relief into account as benefits contributing to a reduction of compensation payments[16].

15 Indeed a number of national tariff regimes in use currently – for example, that in the UK – recognise that certain power flows can reduce the need for network investment.

16 As regards AP, the general argument that this method "implicitly" considers such benefits – as stated on p. 108 of the 2nd Comillas report on CBT [4] – is not comparable to the explicit detection of benefits as achieved by WWT, MP and SGU. In fact, the argument could in its general form be claimed by any method.

Details on the consideration of benefits from cross-border flows

There exists a variety of possibilities how to exactly account for the relieving effect of cross-border flows when computing compensations. In the course of this study, two of these approaches have been in the focus of the discussions (fig. 4.5):

- "Proportional": In this approach the compensations are determined according to the ratio of external flow contribution to the resulting flow.
- "Incremental": In this approach the compensations are determined according to the difference between domestic flow contribution and the absolute value of the resulting flow.

Our analysis has led to the conclusion that the incremental approach is discriminating because the allocation of responsibilities is depending on the assumed order of network uses. In the example in fig. 4.6 we analyse a single physical flow situation where the resulting flow F_R is composed of two contributions F_1 and F_2. By swapping the assignment of these contributions to external and domestic users (i.e. by changing from case A to case B) the flow responsibilities and thus compensation payments are swapped as well when applying the proportional approach. In contrast to this, under the incremental approach, the assigned responsibilities are completely changed. This effect is systematically advantageous for external network users in all cases where the share of external network use exceeds the resulting flow.

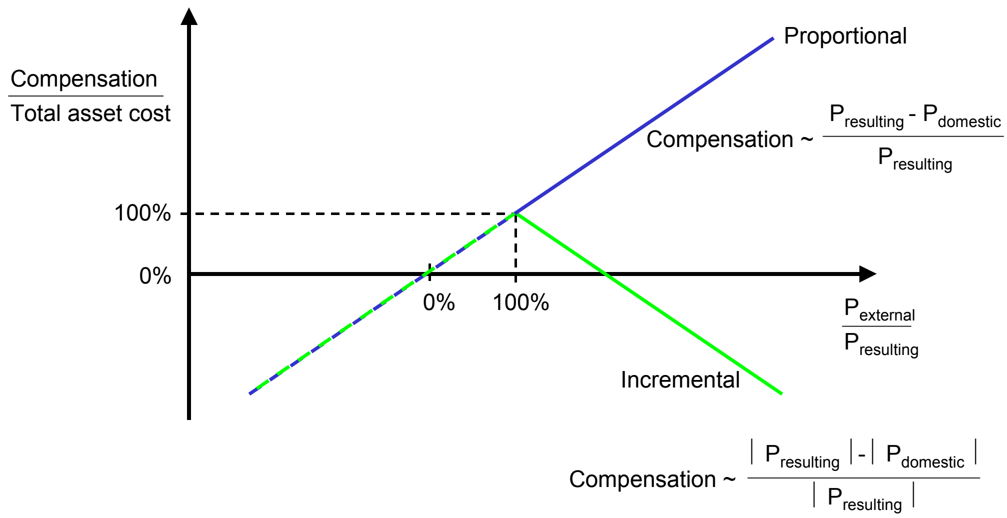

Fig. 4.5: Comparison of proportional and incremental approach

Our conclusion is that from an economic point of view a proportional approach seems to be appropriate in terms of following the principle of cost reflectivity.

For both approaches, proportional and incremental, implausible results may occur in case the actual flows are small, but result from large contributions in opposite directions. In extreme cases single entities could be allocated a multitude of the line or transformer cost (fig. 4.7).

Clearly this would not be considered a fair and economically reasonable allocation of cost. In order to avoid such singularities, the limitation of payments due to opposing power flows ("capping") seems to be an appropriate amendment of the "pure" proportional approach. In the quantitative evaluation (cf. section 4.6.5.1) the effect of different cap levels is assessed.

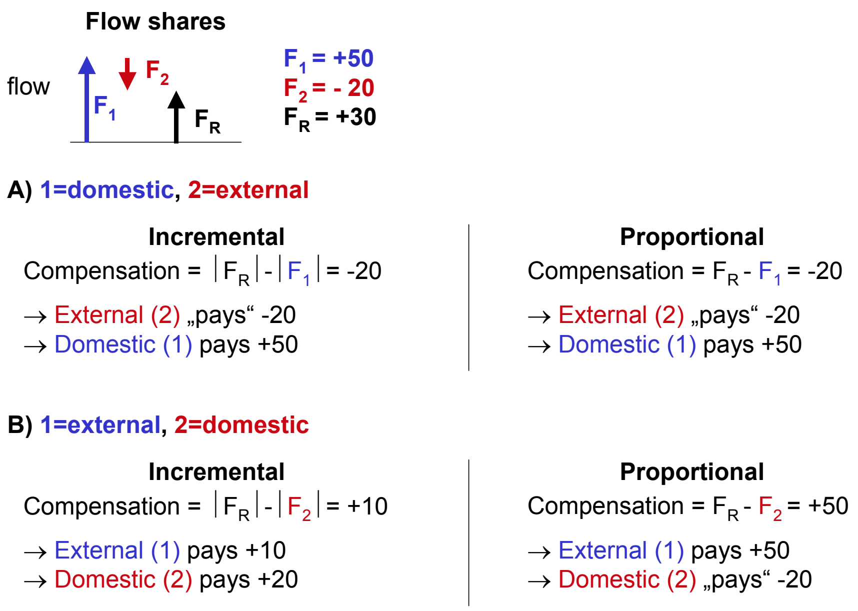

Fig. 4.6: Allocation of responsibilities to domestic and external grid users – Example

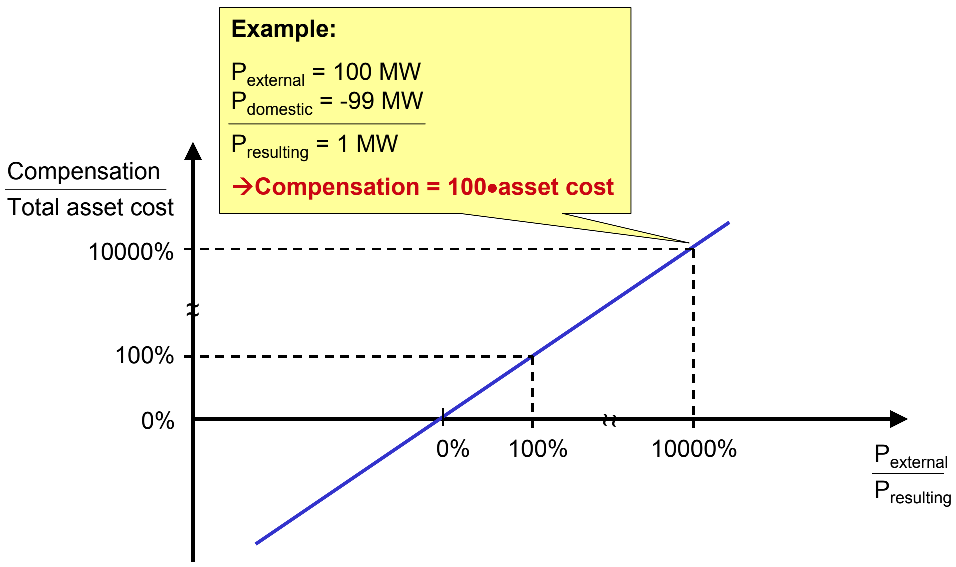

Fig. 4.7: Origin of implausibly high compensations (example: proportional approach)

4.5.1.3 Identification of network elements used by cross-border flows ("Horizontal network")

ETSO2005 requires an external algorithm for the determination of the horizontal network, which identifies the network elements on which the amount of compensation for each participating entity is based on. The horizontal network is currently determined once a year and valid for all considered points of time being another disadvantage in terms of accuracy. For a detailed description of the calculation algorithm, refer to [5].

Considering MP and WWT the detection of relevant network elements is done within the method. Another advantage compared with ETSO2005 is that these elements are determined individually for each scenario.

As already described, AP and APT use a flow tracking algorithm. For instance, starting from a generation node of the transmission grid it follows the flow down over transformers to lower voltage levels if these are contained in the network model. Therefore, lower voltage level would at first be included in the cost allocation. However, this could in practice be avoided by setting the cost of these voltage levels to zero, such that also AP and APT automatically consider only the horizontal – i.e. transmission – network.

(Besides the above considerations on the detection of the horizontal network, the question whether or not lower voltage levels are modelled does have an impact on the results of AP and MP. This is due to the ambiguity caused by differences of the modelling of load and generation on node level, see sections 4.5.3.2 [qualitative analysis] and 4.6.5.3 [quantitative example]).

4.5.1.4 Consideration of all cross-border flows (as opposed to only transits)

Regulation 1228/2003 demands that the ITC mechanism determines the cost incurred as a result of hosting cross-border flows. Although it does not explicitly demand for the consideration of *all* cross-border flows, such behaviour would clearly be rated advantageous in terms of cost-reflectivity and thus accuracy.

Some of the methods under consideration determine the compensations according to transits: ETSO2005, APT and WWT. This means that they are based on the simplified assumption that the mutual impact of neighbouring countries is identical[17]. In addition, APT and WWT require an arbitrary rule to distribute the transits to the individual interconnectors by allocating the total amount of transit according to the contribution of the interconnector flows to import or export respectively (cf. [3]). For WWT this leads to the fact that for the situation without transits some flows on the interconnectors are set to zero with the conclusion that these interconnectors seem to be exclusively used by transits.

Moreover, countries who are exporting over all interconnectors (or importing over all interconnectors) at a given point of time are assigned zero transit (and, consequently, zero compensation), although they may be not only creating cross-border flows, but also hosting some.

Clearly, the above issues constitute a lack of accuracy compared to MP and AP (and SGU if its original specification is modified such that in addition to transversal flows also loop flows are considered). These methods are able to detect the responsibilities of flows on network elements on node level, so that also flows between neighbouring countries (i.e. not only transits) can explicitly be taken into account.

4.5.1.5 Impact of size of participating entity

There is another aspect of accuracy which is often referred to in relation to the transit definition: the dependency of the results on the size of the participating entity. The stronger such dependency is, the more relevant are

- the different sizes of ITC entities due to national borders (i.e. due to the difference in country sizes); and

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[17] Consequently, one could argue that these methods do consider all cross-border flow, but partly (transits) explicitly and party (mutual impact of neighbouring countries) by an implicit assumption.

- the financial consequences of the decision of TSOs to form a group that participates in the ITC mechanism as a single entity.

MP and AP are by definition not affected by this issue. For those methods that are based on transits (ETSO2005, WWT, APT) the size and number of areas affects the total nominal volume of transits in the network. For example, by splitting a transited network in two halves, the volume of transits can be nominally doubled (fig. 4.8).

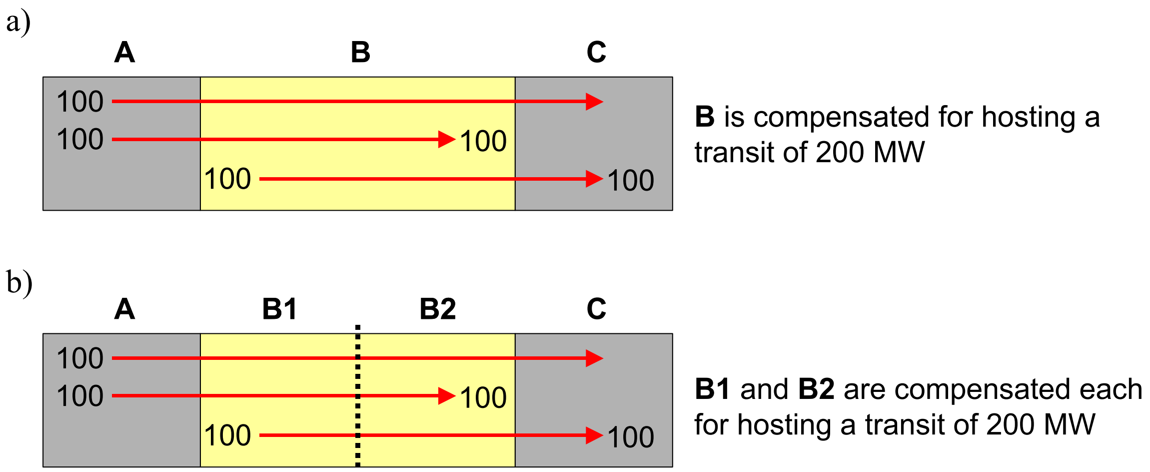

Fig. 4.8: Influence of the area size on the results of transit based methods

However, this has only an effect for the ETSO2005 and the APT methods:

- For ETSO 2005, the load of B1 and B2 is half as much as that of B, while the transits are the same for B, B1 and B2. Hence, the aggregated transit keys of B1 and B2 exceed the transit key of B, i.e. in B1 and B2 a larger percentage of the network cost are allocated to transit use and therefore subject to compensation. Consequently, the two smaller networks B1 and B2 receive together more compensation than the larger network B.
- Under APT (as under AP) the impact of injections or loads on the network is geographically limited. Hence, in smaller networks the transits have a higher likelihood of penetrating a larger share of the grid. Consequently, a set of two small networks will lead to the assignment of more lines to be used by transits than a single large area, where the central part is likely to be assigned to domestic use only.

Under WWT the transits through B1 and B2 each affect only half of the network elements than the transits through B. In total, the calculated impact of the transits is identical in both cases.

However, WWT does not solve every conceptual problem of the currently applied mechanism with regard to the size of the participating entity. This is because of the transit concept (cf. also section 4.5.1.4). For instance, in a system of only two entities there will be no compensations for any entity because there are no transits but only exports and imports. In case one of the entities decides to split up and participate as two single entities suddenly transits and therefore compensations appear showing that the WWT results at least to some extent still depend on the size of a participating entity.

(For SGU a similar reasoning than for WWT applies: SGU does not suffer from the area size problem, although it is based on area definitions similarly to ETSO2005, APT and WWT.)

4.5.1.6 Assignment of responsibility for network utilisation

MP and AP are able to consider the geographical constellation of individual networks. Since they detect to which extent network elements are influenced by the injection/load of single nodes, the responsibilities for the use of these elements can directly be allocated. Both methods also reflect that the impact of injection or load of nodes on a network element is smaller the more distance there is between the node and the considered element.

In this context, all other methods are less accurate and thus inferior to AP and MP because they assume a proportional responsibility of all participants to all flows that require compensation.

4.5.1.7 Coverage of varying load flow situations throughout the year

The current mechanism (ETSO2005) is based on hourly data of the metered flows on the interconnectors, and therefore capturing all different network situations occurring throughout the year. All other methods are based on load flow files that have to be created by the TSOs. Since the data provision is much more complex (cf. practicality discussion in section 4.5.2.1), the considered load flow files have to be limited to a significantly lower number of (e.g. 72) representative scenarios.

In addition to their larger number, the metered flows on the interconnectors are more accurate than the corresponding results based on the load flow files[18].

But these advantages are achieved at the expense of ignoring all information on the internal load flow situation (such as topology, origin of load and injection, etc), which is clearly worse in terms of accuracy. Hence the reliance on hourly metered flows cannot be considered a clear advantage of the ETSO2005 method.

Nevertheless, two conclusions can be drawn from these considerations:

- For all methods that are based on load flow files (i.e. all but ETSO2005) a data consistency check (e.g. by comparing tie line flows between data provided by neighbouring entities) should be performed when applying them in practice.
- One can and should make use of the accurate hourly cross-border flow data when calculating the net flows for WWT (which could alternatively be computed on the basis of the load flow files).

4.5.2 Practicality and ease of implementation

4.5.2.1 Data requirements

One key element of the assessment as to the practicality of the mechanism relates to the data requirements – collection and validation of appropriate and consistent network related data is

[18] This has various reasons, e.g.: the metered values are based on hourly integrated flows whereas the load flow files are based on momentary snapshots; the snapshots might reflect slightly different points of time and therefore bear the risk of inconsistencies across TSOs; etc.

probably the most resource intensive aspect of the operation of the allocation mechanism. In relation to data requirements, the methods broadly fall into four groups:

- **ETSO 2005**: the current ETSO ITC scheme involves the lowest data requirements of all the mechanisms being considered for the enduring scheme. The mechanism relies only on metered data for interconnections and load (for all 8760 hours during the year), and a specification of the cost of the Horizontal Network. Any load flow data is not required;
- **WWT**: while it does not require a specification of the Horizontal Network, the WWT method requires[19] all of the metered data required by the ETSO method. In addition to that the WWT method requires TSO specific load flow data for a defined number of snapshots during the year. The collection and validation of this TSO specific load flow data is more onerous than the collection of metered interconnection and load data;
- **AP/APT**: the AP and APT methods the collection and validation of load flow data in relation to which flows on tie-lines are consistent. While the WWT method requires TSO specific load flow data, the method does not require these datasets to be fully consistent – the method will work even if load flow files for two interconnected networks indicate different flows (e.g. because the snapshots were taken at slightly different times)[20]. This is not the case with the AP method, which requires tie-line flows to be consistent. Hence, for these methods, the process of preparing, validating and correcting data is even more onerous than for WWT;
- **MP/SGU**: the MP and SGU methods – as WWT and AP/APT – do not require the specification of the capacity of the Horizontal Network. However, they require completely merged load flow files for the whole ITC area. The requirement to derive a merged load

[19] This is not a formal requirement, but accuracy can be improved by using metered data for the determination of the net flows (cf. section 4.5.1.7).

[20] Of course interconnector flow consistency helps improving the accuracy of the results also under WWT. But it is not a prerequisite for the stability of the method.

flow dataset makes the MP and SGU methods the most onerous in terms of data collection and manipulation.

Table 4.2 summarises the data requirements of each of the methods, in order from the least to the most data intensive mechanism.

Required data	**ETSO 2005**	**WWT**	**AP/APT**	**MP/SGU**
"External" definition of Horizontal Network?	Yes	No – derived by method	Yes	No – derived by method
Metered inter-connector and load data?	Yes – for derivation of distribution of payments	Yes – for derivation of distribution of payments	No – fund and distribution of payments derived by same process	No – fund and distribution of payments derived by same process
Load flow data?	No	Yes – TSO specific	Yes – with consistent tie line flows	Yes – fully merged

Table4.2: Data requirements of allocation mechanisms

4.5.2.2 Other aspects of implementation effort

Another issue in terms of practicality is the effort for implementing tools or algorithms necessary to compute the results.

Regarding this aspect, again ETSO2005 has the lowest requirements because the calculation method – with the exception of the determination of the horizontal network – can be implemented as an EXCEL sheet.

For WWT, MP and SGU load flow calculations have to be carried out, while for AP and APT the "water flow" algorithm has to be implemented. Both requirements are quite similar in terms of complexity. Since WWT works on TSO specific load flow files, compensations can be computed for each TSO (or, more general, participating entity) independent from other TSOs' data. SGU and MP evoke additional effort because merged load flow files are required for the calculation, and therefore, an algorithm has to be implemented that merges TSO specific load flow data of all entities to a complete model of the ITC area. Incomplete data sets, (i.e. in case at least the data of one TSO is missing for a considered point of time) cannot be used, so that in such cases no results for a complete scenario can be obtained.

Another negative aspect for MP and SGU is that a special treatment of DC links is required because these elements are not passively reacting to changes of load and generation in a load flow algorithm[21].

4.5.3 Stability and transparency

4.5.3.1 Relative amounts of compensations and charges

The net payments determine which participating entity is receiving money from the ITC mechanism and how has to pay for external network use. Since the net payments are calculated as the difference between compensation and charges, they are obviously depending on the single values of compensation and charges. A potential stability problem may occur in cases when both single values are high because some minor changes in either compensation or charge could result in switching the sign of net payment for an entity. As we will see later, this issue is most relevant for MP where charges and compensations are significantly higher than for all other considered methods (cf. 4.6.2).

4.5.3.2 Dependency on split of nodal balance into generation and load

Without altering the load flow in the grid, the power balance of a node can nominally be split differently into load and generation. For example, a total balance of 1000 MW could be modelled either as a single generation of 1000 MW or as a generation of 1500 MW along with a load of 500 MW. Since only very few "real" loads are connected to the transmission network, and also a significant share of generators is connected to lower voltage levels, TSOs have

[21] This does not constitute a problem for the WWT mechanism as long as – like it is currently the case – all (relevant) DC links in the ITC area are tie lines.

some freedom in how to represent these distributed loads and generators when modelling the transmission network. While some TSOs might focus on the physical load flow and represent the aggregated power balance of each node by a single figure (i.e. either as load or as generation), others might want to reflect the different amounts of distributed load and generation by providing two figures per node.

For both the AP and the MP method, the calculation results are affected by the way in which the nodal power balances are split up into generation and load.

For the AP method, this effect can be demonstrated by the following simple example (fig. 4.9).

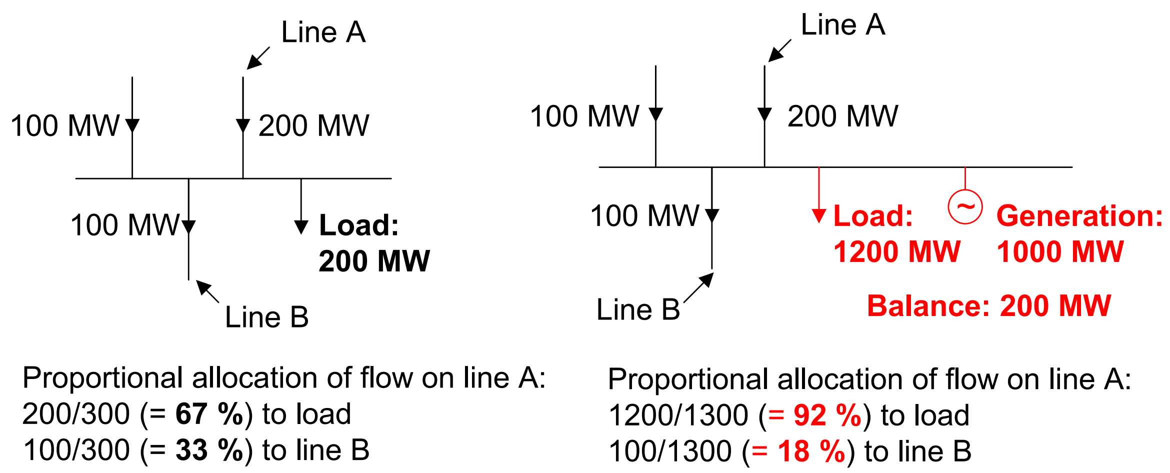

Fig. 4.9: Influence of different modelling of nodal balance for AP method

The example shows that splitting up the nodal balance into generation and load significantly changes the calculated responsibilities for line flows because the allocation of flow shares at each node obviously depends on the modelling decision.

With the MP method, increasing generation and decreasing load at a node by the same amount does not affect the physical impact of that node on the system. However, it affects the total impacts assigned to all loads and all generators, respectively. Since the split of the total cost between loads and generators must be fixed (cf. 4.4.5, discussion on slack dependency) the impact assigned to *individual* nodes is altered in order to keep the overall split constant[22].

To demonstrate that this is a relevant issue, we indicate below for each entity how many nodes are modelled as load or generation only and how many nodes have both generation and load (fig. 4.10).

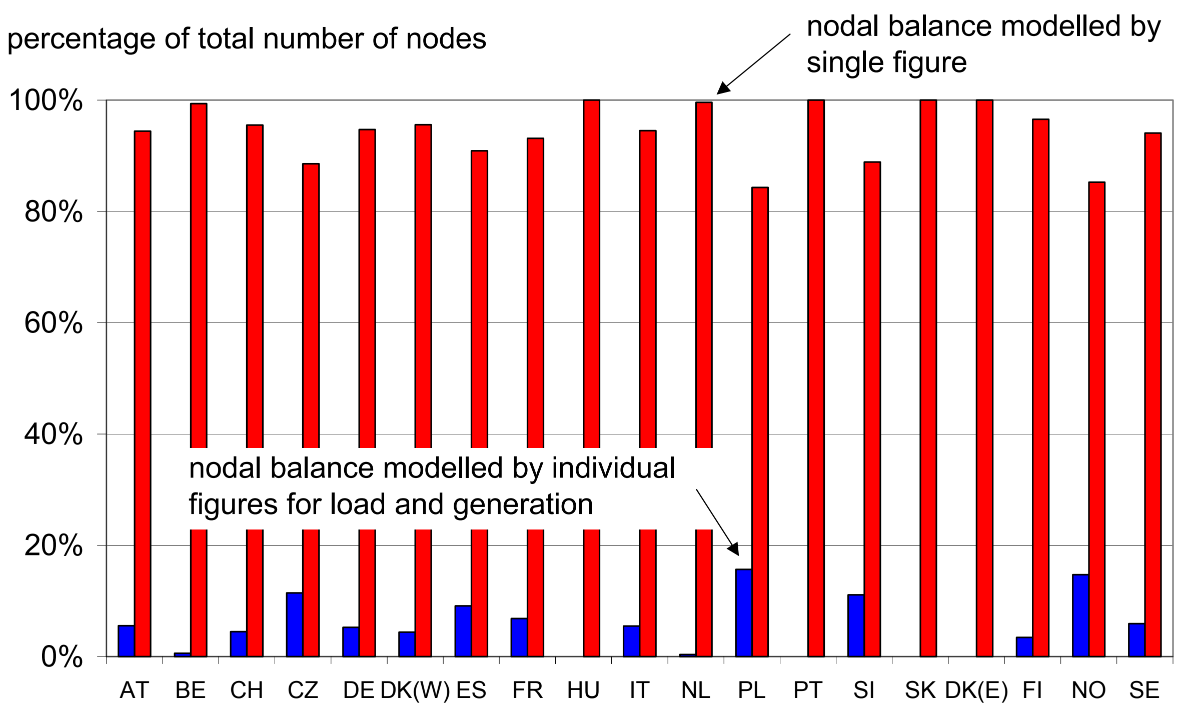

Fig. 4.10: Different modelling of nodal balance (based on one exemplary scenario)

Obviously the participating TSOs make use of their freedom in modelling the nodal balances. Consequently, the aforementioned effects can be expected to be non-negligible in reality.

22 Technically, the simultaneous change of load and generation at a node would lead to a different „virtual slack node“ in order to achieve the desired share of total cost between all loads and all generators.

A pragmatic approach to avoid distortions by different rules adopted by the TSOs, we suggest to always aggregate load and generation at each node and use the resulting nodal balance as input to the allocation method (be it AP or MP)[23].

However even with this harmonisation in place, one element of instability remains: When some TSOs only include voltage levels of 220 kV and above in their data while others also include lower voltage levels, the nodal balances are different. If e.g. the 110 kV grid is included, any flow from e.g. 380 kV to the 110 kV grid will not be part of the load and generation balance of the respective 380 kV node. If the 110 kV grid is omitted, flows from 380 kV to 110 kV will contribute to the 380 kV load and hence to the nodal balances.

In the sample load flow files we received for this study from ETSO (cf. section 4.6.1 below), 11 out of 19 considered countries contained lower voltage levels than 220 kV (excluding voltage levels for generator nodes).

If AP or MP were considered as future allocation mechanisms, in order to completely avoid instabilities due to the model of nodal generation and load, one would have to define a common rule how to deal with voltage levels lower than 220 kV. In this case, stability would be increased at the expense of decreased practicality and ease of implementation. (For our exemplary quantitative calculations, we have used the load flow files as is, i.e. we have aggregated load and generation at each node of 220 kV and higher prior to determining its impact on the network, ignoring any flows on transformers to lower voltage levels.)

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[23] An alternative to this approach would be to agree on common rules how to model distributed generation and load in the load flow data sets. However, it seems reasonable to assume that distortions of the compensation payments would mostly result from *heterogeneous* treatment of this aspect, whereas the effect of different but *harmonised* models is probably much less significant. Therefore, the effort of agreeing on, applying and verifying a complex common method for splitting the nodal balances into generation and load does not seem to be justified.

4.5.3.3 Transparency

The question if the results of an allocation method are trusted depends on how transparent and how easy to comprehend it is. In this context the ETSO2005 method is clearly the one that can be understood easiest. Although WWT bears more complexity (and therefore less transparency), it is still quite intuitive because there are a number of aspects where WWT and ETSO2005 are identical, e.g. the determination of charges. Moreover, the concept of comparing two network situations is easy to understand, and the determination of compensations is performed independently for each entity.

AP and APT can be described as transparent and intuitive as well, but only related to the "water flow" algorithm (ignoring the lack of compliance with physical reality of that approach), which is used trace the path of impacts from a single power source to its assigned destinations and vice versa. The overall results, i.e. the aggregated values for compensation and charges, are – as with MP/SGU – coming out of a "black box".

4.5.4 Conclusions of qualitative evaluation

The qualitative evaluation shows that none of the considered methods can (or must) be excluded for categorical reasons, i.e. because it fails to meet indispensable prerequisites. Rather, all aspects discussed in the previous sections allow for a gradual differentiation of the methods with respect to our assessment criteria.

On the basis of this differentiation, it is possible to narrow down the range of options to those which involve a reasonable trade-off between accuracy and practicality.

ETSO2005 is clearly the simplest method, but also the one with the least accuracy. Its only advantage with respect to accuracy is the utilisation of hourly metered data; however, we believe that it is outweighed by the other aspects of accuracy in which ETSO2005 is weaker than all other methods considered.

In terms of accuracy, WWT yields significant improvements over ETSO2005 (e.g. load flow based, consideration of relieving flows, greater independence of area size).

Comparing WWT and AP, the relative accuracy is somewhat unclear. AP is superior since it considers all cross-border flows and determines the responsibility for network utilisation within the process on the basis of the geographical constellation of countries. AP is, however, also inferior to WWT because it cannot consider relieving flows for determining partial benefits from cross-border flows. Moreover, the basis of AP is just a heuristic approximation of the laws of physics ("water flow") instead of the actual load flow algorithm used by WWT.

MP and SGU are clearly more accurate than AP, because they bear WWT's advantages due to the application of the load flow algorithm (including the ability to consider relieving flows) while avoiding its disadvantages due to the restriction to transits.

As fig. 4.11 indicates, for the level of complexity involved with both APT and SGU, it is possible to achieve a greater level of accuracy (i.e. to make fewer assumptions about the pattern of flows): APT is based on transits, but practically as complex as AP; SGU ignores the geographical constellation of countries when assigning flow responsibilities, but is practically as complex as MP. The figure indicates that AP is marginally more accurate than WWT – as we note above, while we believe this ordering is probably correct, it is not clearly so from the qualitative analysis.

Hence, on the basis of the qualitative assessment, we therefore rule out both APT and SGU.

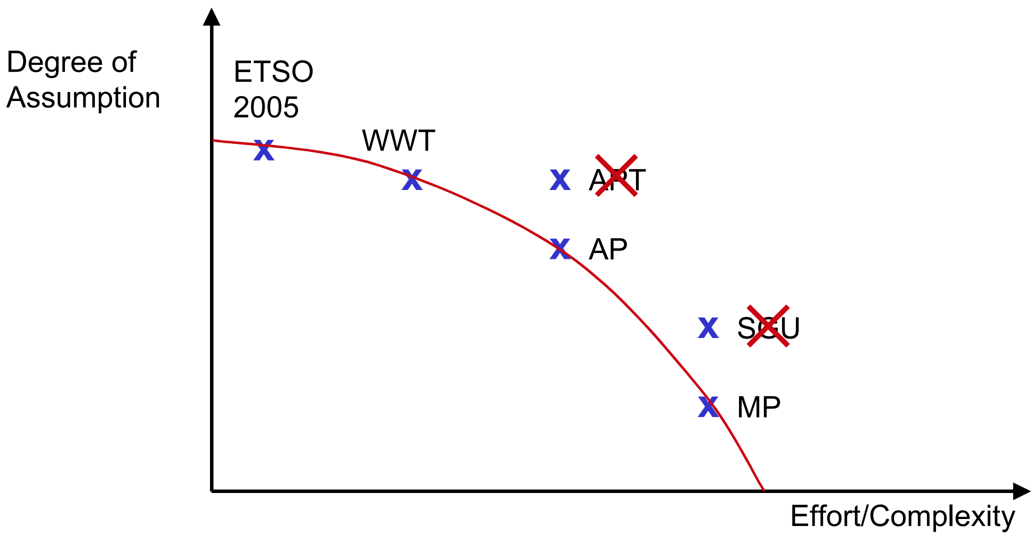

Fig. 4.11: Summary of qualitative evaluation

4.6 Quantitative evaluation

In this section we will describe and explain the outputs of the four remaining allocation methods (ETSO2005, WWT, AP and MP) following the qualitative analysis when applied to real network data. In addition to that, we will discuss sensitivity analyses against various aspects.

4.6.1 Data basis and assumptions for calculations

Load flow scenarios

For our quantitative evaluation of the remaining cost allocation methods ETSO provided us load flow data sets for 2003 and 2004. The 2003 data set contains 72 scenarios, where for each second Wednesday of a month and the following Sunday three time stamps (03:30h, 10:30h and 19:30h) have been modelled. For 2004, the same time stamps have been used; however, 8 out of the 72 scenarios are missing, i.e. a total of 64 scenarios have been provided. For our calculations, we have replaced each missing scenario by the most suitable available scenario, e.g. for a missing weekday scenario (11:30 h) the respective scenario of a month before (also weekday 11:30 h) has been used.

Each scenario has been weighted according to the temporal representation of weekdays and weekends, i.e. that each weekday scenario represents 174 hours[24] of the year while each weekend day scenario represents 70 hours of the year.

The data of each scenario consist of a merged load flow model of the UCTE area and a merged load flow model for the NORDEL area. The 2004 data also contain the UK, Ireland and Northern Ireland. In order to achieve a consistent basis for the comparison, the merged load flow models have been used for all considered cost allocation methods including those that not necessarily need merged load flow data sets, e.g. WWT.

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[24] 8760 hours per year, 8760 * 5/7 = 6257 weekday hours per year, 6257 / 12 = 521 weekday hours per month, 521 / 3 = 174 weekday hours per weekday scenario

Considered voltage levels

In our calculations we only considered network elements with a voltage level of 220 kV and above, i.e. lower voltage levels have been excluded from the analyses.

Cost data

For calculating unit costs per country we used regulated costs for 2003 and 2004 as well as data on the network equipment (line lengths distinguished between different voltage levels, rated power of transformers) provided by the regulators of these countries. For countries for which no data was available (Switzerland, Italy and Poland) we assumed the average regulated costs. For Germany the data for one (out of four) TSO was implausible, and for another one was missing, so that we used the average values of the remaining two German TSOs.

The above cost data has been provided by the regulators to allow us to estimate the broad order of magnitude of the financial impact of the different methods. The cost data should in no way be taken to be definitive, even in relation to regulated values, as the regulators will need to go through a process of validating the inputs and interpretations made.

(As mentioned in section 3.4 the results do not consider any forward looking cost [LRAIC] component, because we are not in possession of an appropriate LRAIC cost base but only a rough approximation. Any analysis of the impact of different proportions of LRAIC on the results is strongly depending on the LRAIC definition, and therefore, not reliable until a reliable definition of LRAIC data has been provided.)

Limitation of payments due to opposing flow directions

In section 4.5.1.2 we discussed the reasons for introducing a limitation of the compensation to assigned individual network elements in individual scenarios (“capping”). The quantitative dependency of WWT and MP results on such limits (“capping factors”) is investigated in section 4.6.5.1 by means of a sensitivity analysis. In all other sections, results for WWT and MP consider an upper capping factor of 200 % and a lower capping factor of -100 %. Since ETSO2005 and AP are not able to take into account relieving effects of external network use, capping factors have not been introduced for these methods.

Split of nodal balance into generation and load

For both the AP and the MP method, the calculation results are affected by the way in which the nodal power balances are split up into generation and load (cf. section 4.5.3.2 for a discussion of this issue). In order to avoid distortions by different rules adopted by the TSOs, we always aggregate load and generation at each node and use the resulting nodal balance as input to the allocation method (be it AP or MP).

Losses

For each of the considered methods the costs of network losses have been distributed to the entities according to the very same allocation key as the costs for network infrastructure (cf. section 4.3.2). For all countries and all scenarios a common cost assumption of 30 € per MWh has been used. For results that are based on standard cost assumptions, i.e. km-related unit costs, losses are not considered.

Perimeter countries

The actual utilisation of networks of ITC entities by perimeter countries due to the latter ones exporting into the ITC area can only be determined with AP and MP but not with WWT or the currently applied mechanism. Both ETSO2005 and WWT impose a contribution of perimeter countries to the fund by charging each MWh flowing from a perimeter country into the ITC area with a fixed injection fee (e.g. 1 € in the presently applied method).

In order to achieve an objective comparison of the considered methods the impact of perimeter countries has been excluded from the calculations. Instead, a separated analysis of the treatment of perimeter countries can be found in section 4.6.6.

4.6.2 Results based on cost data provided by Regulators

Note that the quantitative results in this chapter serve to inform the relative assessment of the allocation methods. They must not be interpreted as an anticipation of future ITC payments, be it absolute or relative.[25]

Fig. 4.12 to fig. 4.15 present the average net payments (i.e. the difference of charges and compensations) per entity regarding the considered cost allocation methods based on 2003 and 2004 data. The average net payment allows to compare actual money flows because both compensations and charges are considered.

An overview of compensations, charges and resulting net payments for all considered entities is given in table 4.3.

[25] In fact, we find that the results significantly depend on the underlying cost data, both in absolute and in relative terms. This is analysed in the next section 4.6.3, where we conclude that calculations based on standard cost data (i.e. identical unit cost for all countries) are recommendable for an objective and transparent comparison of the allocation methods.

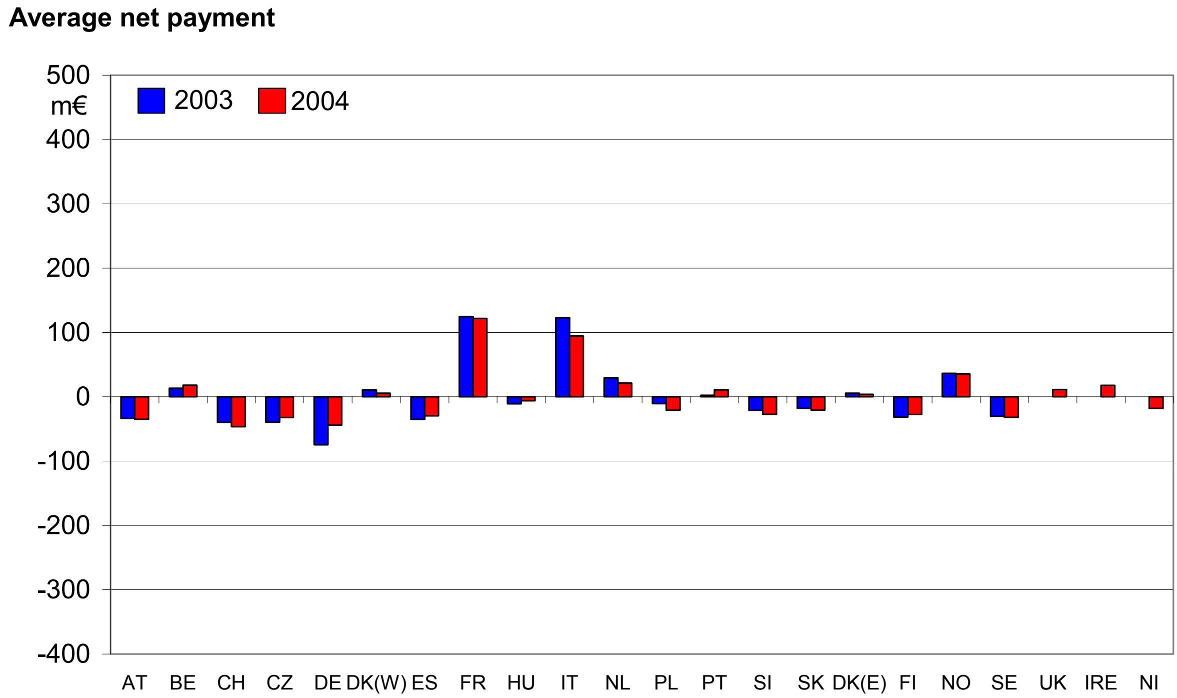

*Fig. 4.12: Average net payment per entity for allocation method **ETSO2005** (simulated figures based on 72 (64 for 2004) snapshots– not to be mixed up with actual payments of the currently operational ITC mechanism)*

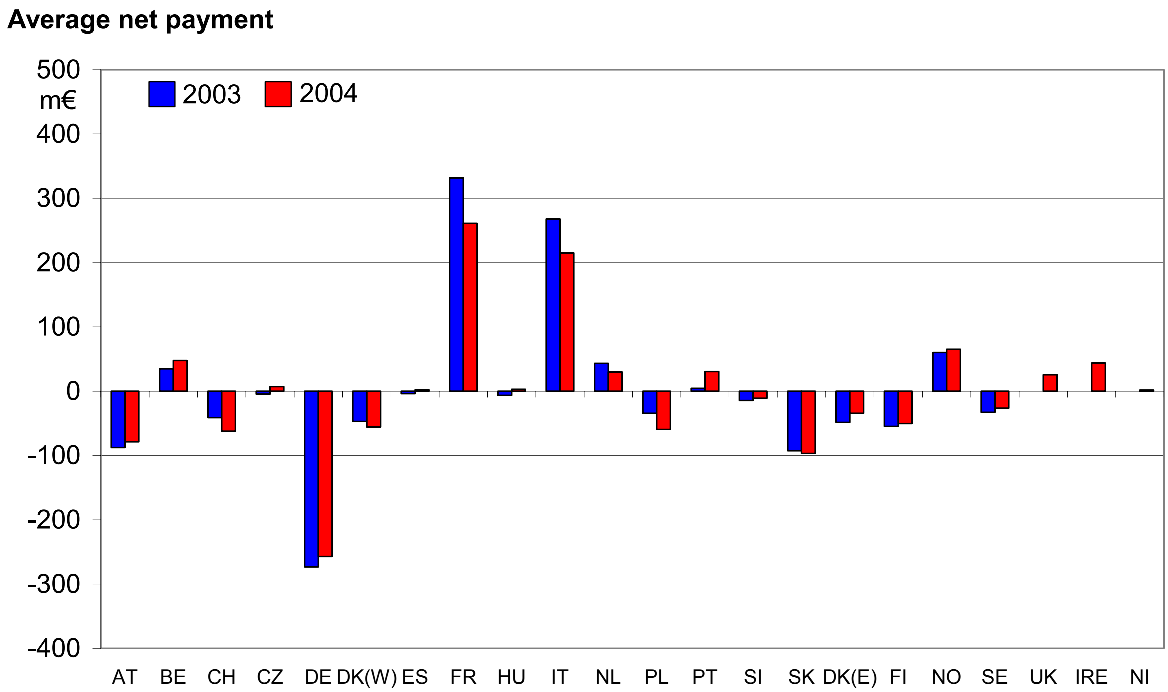

*Fig. 4.13: Average net payment per entity for allocation method **WWT***

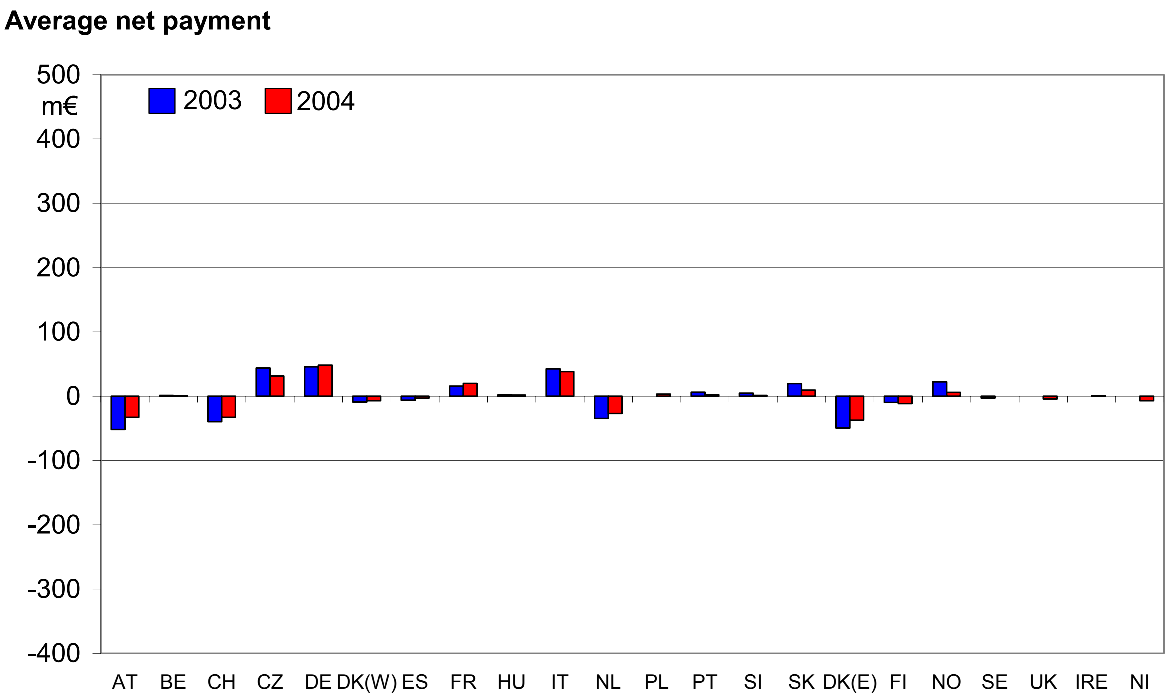

*Fig. 4.14: Average net payment per entity for allocation method **AP***

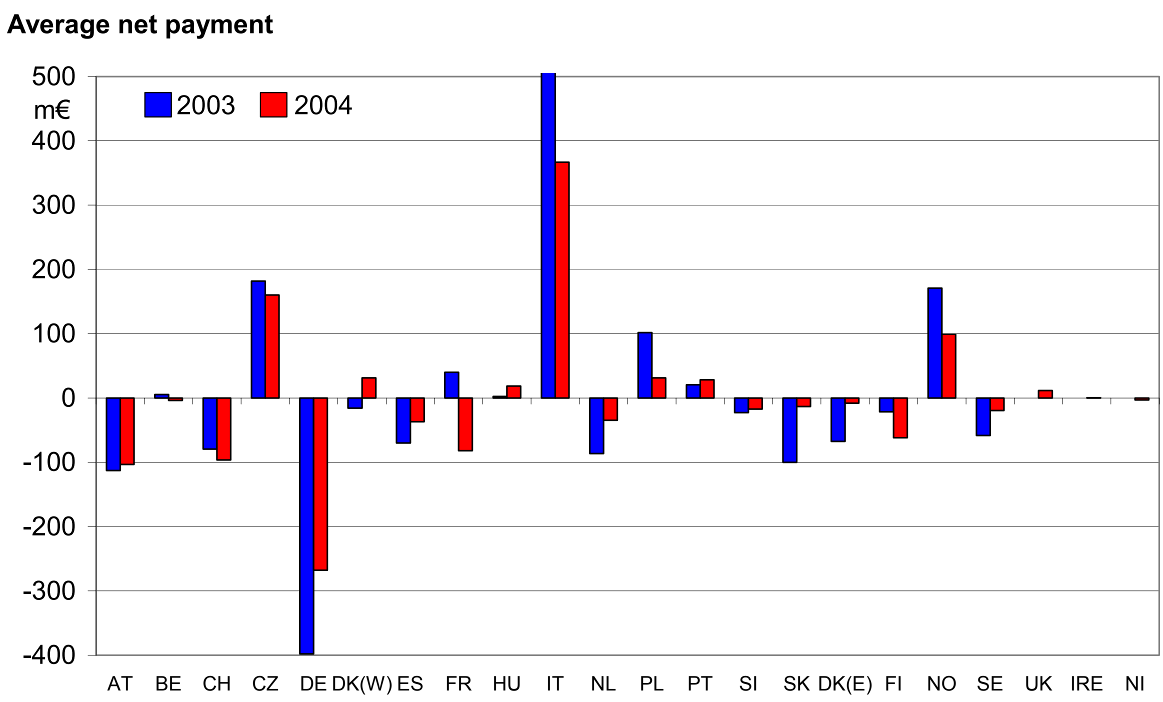

*Fig. 4.15: Average net payment per entity for allocation method **MP***

			AT	BE	CH	CZ	DE	DK(W)	ES	FR	HU	IT	NL	PL	PT	SI	SK	DK(E)	FI	NO	SE	UK	IRE	NI
2003	ETSO2005	Compensation	46,6	3,2	72,9	81,5	124,3	5,8	43,8	11,7	15,0	0,2	8,2	32,8	6,1	22,7	25,5	2,1	35,5	1,4	56,4			
		Charge	12,8	16,5	33,3	42,0	49,8	16,4	8,3	136,4	4,1	123,1	37,7	22,3	8,4	1,5	7,4	7,8	3,9	37,9	26,0			
		Net payment	-33,7	13,3	-39,6	-39,5	-74,5	10,5	-35,5	124,7	-10,8	122,9	29,5	-10,5	2,3	-21,3	-18,1	5,7	-31,6	36,5	-30,4			
	WWT	Compensation	121,3	6,9	122,8	108,3	397,9	87,1	28,5	4,0	23,7	33,7	50,0	88,2	17,2	18,3	111,1	68,1	64,8	33,8	98,6			
		Charge	33,6	41,6	81,7	103,6	124,7	40,0	24,8	335,8	17,2	301,7	93,4	53,9	21,4	3,7	18,4	19,2	9,8	93,9	65,8			
		Net payment	-87,7	34,7	-41,1	-4,7	-273,2	-47,1	-3,7	331,9	-6,5	268,0	43,3	-34,3	4,3	-14,5	-92,8	-48,8	-55,0	60,2	-32,8			
	AP	Compensation	88,9	8,4	106,2	111,5	195,3	20,0	29,5	116,0	7,7	62,6	72,2	47,5	18,3	15,5	84,2	61,7	36,3	20,8	59,1			
		Charge	37,2	9,6	66,5	155,3	240,9	11,1	23,2	131,7	9,4	105,1	37,4	47,6	24,7	20,2	103,9	12,0	26,5	43,0	56,3			
		Net payment	-51,7	1,2	-39,7	43,7	45,6	-8,9	-6,3	15,7	1,7	42,5	-34,8	0,1	6,3	4,7	19,7	-49,6	-9,7	22,2	-2,7			
	MP	Compensation	159,6	18,0	166,2	186,7	737,8	89,7	103,3	266,4	36,5	54,5	197,2	70,1	25,1	25,9	183,8	61,2	66,2	13,9	116,5			
		Charge	46,5	23,2	86,7	368,6	339,7	73,9	33,3	306,5	39,1	564,3	110,6	172,0	45,5	3,2	83,5	-6,4	44,9	184,9	58,4			
		Net payment	-113,1	5,2	-79,4	182,0	-398,1	-15,9	-70,0	40,1	2,6	509,8	-86,6	101,9	20,4	-22,7	-100,3	-67,6	-21,2	171,0	-58,2			
2004	ETSO2005	Compensation	45,5	2,0	70,8	67,7	84,7	7,0	42,2	9,0	13,9	0,5	9,1	34,6	3,3	28,5	27,0	1,5	31,7	1,5	54,1	3,6	0,0	22,7
		Charge	10,4	20,1	24,2	35,3	40,6	12,7	12,7	130,8	7,8	94,8	30,2	13,7	14,3	1,3	6,4	5,1	4,0	37,0	22,1	14,8	17,8	4,8
		Net payment	-35,1	18,1	-46,6	-32,4	-44,1	5,7	-29,5	121,8	-6,1	94,3	21,1	-20,9	11,0	-27,2	-20,6	3,6	-27,7	35,5	-32,0	11,2	17,8	-17,9
	WWT	Compensation	106,7	6,0	126,3	87,9	365,4	89,0	33,1	88,0	18,4	39,1	52,2	97,0	8,3	14,6	113,7	48,3	61,3	33,0	87,9	13,9	3,8	11,0
		Charge	27,8	53,8	63,8	95,1	108,3	33,2	35,1	349,1	21,2	254,3	82,1	37,4	38,7	3,5	17,0	14,0	11,0	98,1	61,4	39,5	47,7	12,7
		Net payment	-78,9	47,8	-62,5	7,2	-257,1	-55,8	2,1	261,1	2,8	215,2	29,9	-59,6	30,3	-11,1	-96,8	-34,3	-50,2	65,1	-26,4	25,6	43,9	1,7
	AP	Compensation	70,2	6,3	92,3	84,3	163,1	16,2	25,9	90,6	6,1	54,0	55,4	44,9	19,5	11,7	83,0	44,9	28,2	26,1	47,7	21,0	43,1	20,2
		Charge	37,5	7,4	59,4	115,6	211,4	9,0	22,8	110,7	7,8	92,2	28,5	48,2	21,6	12,9	92,3	7,5	16,7	32,2	47,6	16,7	44,2	13,0
		Net payment	-32,8	1,1	-32,9	31,3	48,3	-7,2	-3,1	20,0	1,6	38,2	-26,9	3,2	2,1	1,1	9,3	-37,4	-11,5	6,1	-0,1	-4,3	1,1	-7,2
	MP	Compensation	145,8	14,5	161,7	133,8	581,4	13,3	72,9	370,4	8,1	101,2	84,0	97,6	22,6	21,6	116,7	43,8	48,3	13,5	57,3	25,3	16,7	15,4
		Charge	42,5	10,9	65,1	294,1	313,6	44,8	35,9	288,3	26,7	468,1	49,1	128,9	50,9	4,3	103,2	35,9	-13,6	112,7	37,9	36,9	16,9	12,4
		Net payment	-103,3	-3,6	-96,6	160,3	-267,7	31,5	-37,0	-82,0	18,6	367,0	-34,9	31,3	28,3	-17,2	-13,4	-7,9	-61,9	99,3	-19,4	11,6	0,2	-3,0

Table 4.3: Compensation, charge and resulting net payment per entity for 2003 and 2004 data (all values given in m€). (Simulated figures based on 72 (64 for 2004) snapshots and on cost data provided by ERGEG for this study – not to be mixed up with actual payments of the currently operational ITC mechanism)

4.6.3 Impact of cost data on net payments

The cost data provided by the Regulators leads to notable differences of unit cost between countries (cf. section 3.4). Unit cost differ by a factor of more than 700 % in some cases (fig. 3.3 and 3.4).

In order to evaluate the impact of individual cost data per entity on the results we compare the average net payments computed with cost data provided by the Regulators (basis for the results illustrated in section 4.6.2) with the net payments based on common cost data for all entities. These standard costs can be expressed in km-related values (for transformers it is assumed that the cost for 30 MVA rated power is equal to 1 km of line). For the purpose of appropriately comparing both cost bases, all values are normalised with the respective average absolute net payment.

Fig. 4.16 exemplarily shows the results for the year 2003 under the cost allocation method WWT. Similar results can be found with other allocation methods.

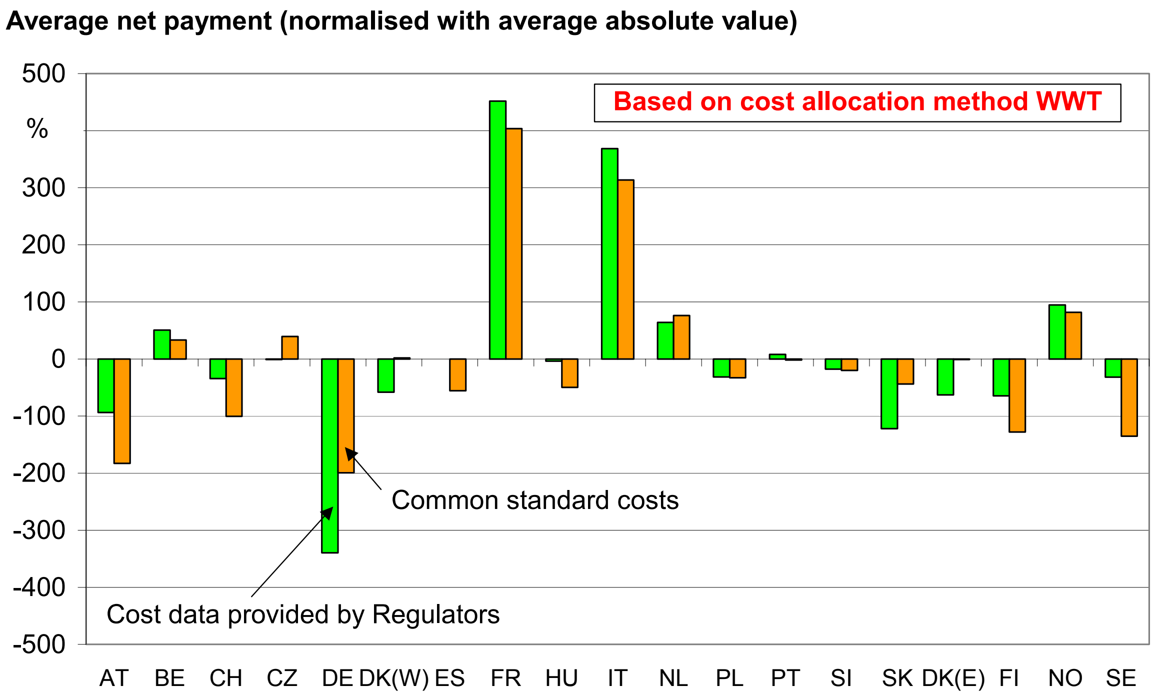

Fig. 4.16: Average net payment per entity for different cost data (exemplary results for WWT taking into account 72 scenarios of 2003)

The figure demonstrates the significant influence of the chosen cost basis on the resulting net payments. For some of the entities payments are more than doubled (e.g. Switzerland, Slovakia), or even the sign of payment is different (e.g. West-Denmark). Since the focus of our evaluation is to objectively compare the characteristics of the considered cost allocation methods, all following results are based on standard cost assumptions, i.e. unit costs that are km-related and hence identical for all countries.

4.6.4 Results based on standard cost assumptions

This section firstly illustrates a comparison of the considered methods related to aggregated values followed by an analysis regarding the similarity of the methods by comparing two methods at a time. It is important to note that all absolute figures in the following diagrams, although expressed in the unit km, are not exclusively related to km of lines. Rather, as mentioned in section 4.6.3 above, transformers are included by means of a "km equivalent". Consequently, the km figures must not be compared to the aggregated length of transmission lines per entity. A comparison of the ITC compensations to each entity's horizontal network cost is provided separately in section 4.6.4.2.

4.6.4.1 Comparison of aggregated results

Fig. 4.17 gives an overview of the average net payment per entity for the considered allocation methods. The average net payment allows to compare actual money flows because both compensations and charges are considered.

Compared to the currently applied mechanism WWT and MP lead to significantly higher payments while under AP the payments are on average only half as much as for ETSO2005.

Regarding the size of the fund, i.e. only considering the sum of compensations, all methods lead to higher values than ETSO2005 (cf. fig 4.18).

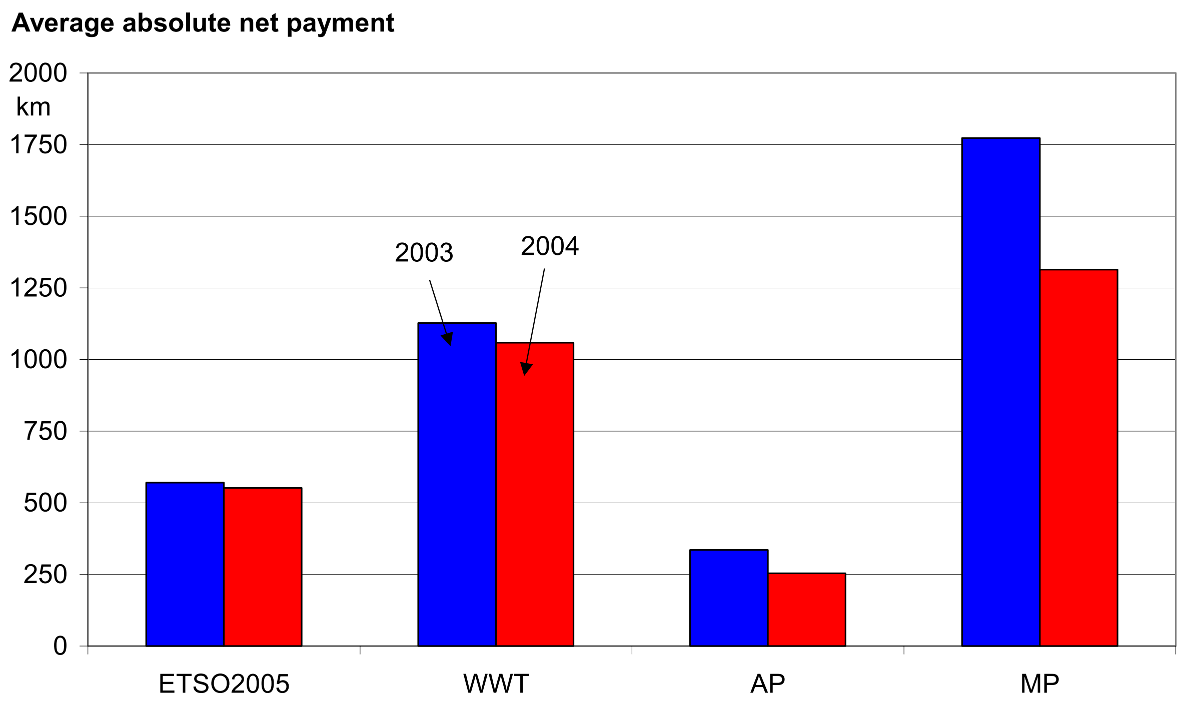

Fig. 4.17: Average absolute net payment per entity for the considered allocation methods (simulated figures based on 72 (64 for 2004) snapshots and on standard cost assumptions)

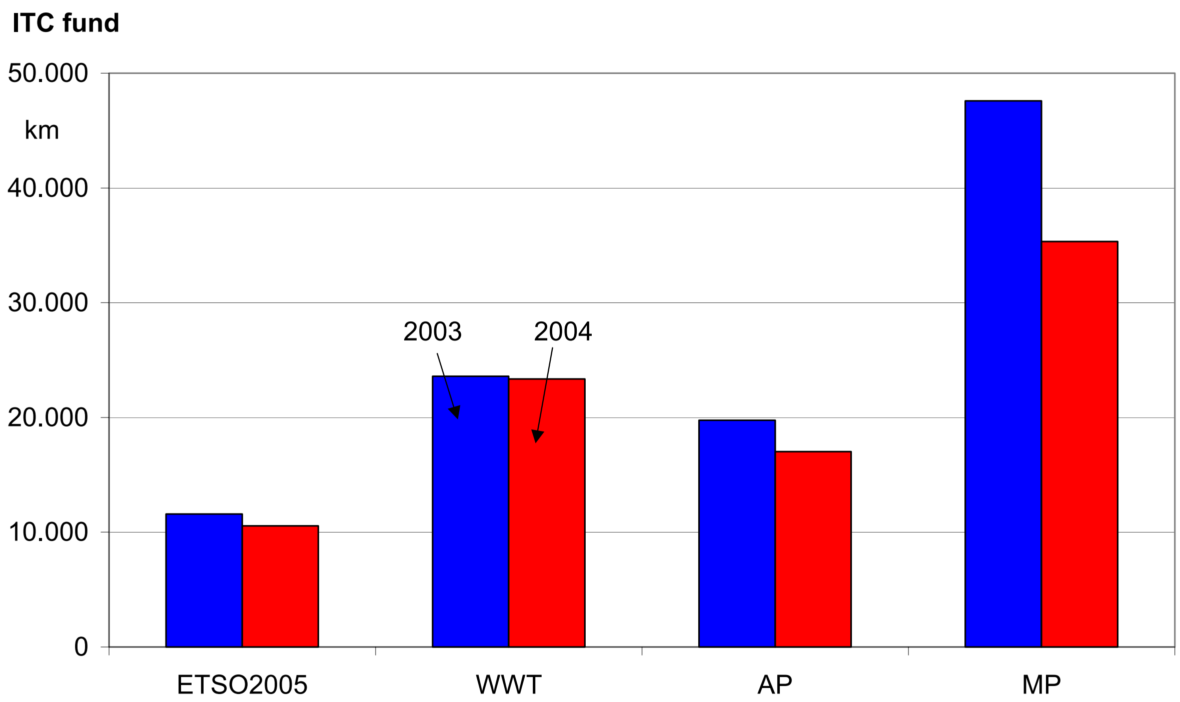

Fig. 4.18: Size of the ITC fund for the considered allocation methods (simulated figures based on 72 (64 for 2004) snapshots and on standard cost assumptions)

Fig. 4.18 in connection with the resulting average net payments also shows that with AP and MP both high compensations as well as high charges occur. For AP, for example, the fund (only considering compensations) is about twice as large as for ETSO2005 while the average net payment (also considering the charges) is only 50 % of the payments for the current mechanism.

A comparison of 2003 and 2004 yields, for all methods, a lower fund and lower average net payments for 2004. However, changes from 2003 to 2004 are not such significant that they alter the relative order of the methods in terms of those measures, nor that they significantly affect the conclusions as to the consequences from applying one method or another.

An overview of compensations, charges and resulting net payments based on standard costs for all considered entities is given in table 4.4.

Year	Model		AT	BE	CH	CZ	DE	DK(W)	ES	FR	HU	IT	NL	PL	PT	SI	SK	DK(E)	FI	NO	SE
2003	ETSO2005	Compensation	1144,4	125,5	1678,6	798,3	2050,1	150,0	931,2	547,7	484,5	4,8	114,8	645,3	250,2	267,3	626,8	71,1	367,9	31,2	1286,2
		Charge	249,4	320,8	646,2	816,4	968,0	318,1	161,3	2650,6	80,6	2392,8	732,9	432,7	163,8	28,8	144,1	152,2	75,3	736,5	505,8
		Net payment	-895,0	195,3	-1032,5	18,1	-1082,1	168,1	-769,9	2102,9	-404,0	2388,0	618,1	-212,6	-86,5	-238,5	-482,7	81,0	-292,5	705,2	-780,4
	WWT	Compensation	2921,0	225,7	2607,9	1131,7	4584,4	613,5	1121,1	70,4	920,4	702,1	488,5	1284,9	361,2	320,2	862,4	317,9	1827,3	425,4	2813,1
		Charge	534,2	661,2	1299,2	1647,5	1982,8	636,0	393,8	5339,4	273,6	4796,7	1484,2	857,5	340,5	59,3	292,1	306,0	155,5	1493,0	1046,5
		Net payment	-2386,7	435,5	-1308,7	515,8	-2601,6	22,5	-727,3	5269,0	-646,8	4094,6	995,7	-427,4	-20,7	-260,8	-570,3	-11,9	-1671,8	1067,6	-1766,6
	AP	Compensation	2106,1	270,3	2231,6	1132,8	2526,8	294,3	1111,1	1797,2	304,9	1386,5	634,7	736,1	469,4	276,1	655,7	262,7	1097,1	388,3	2072,8
		Charge	930,0	393,9	1392,2	1558,9	2814,5	250,7	798,2	2334,1	367,1	2117,5	338,3	1010,2	621,7	385,5	827,7	142,9	761,1	1202,0	1507,8
		Net payment	-1176,0	123,6	-839,4	426,1	287,8	-43,5	-312,9	536,9	62,1	731,0	-296,3	274,1	152,3	109,4	172,1	-119,9	-336,0	813,7	-565,0
	MP	Compensation	3838,1	585,9	3556,9	1889,0	9490,3	1911,4	4176,6	5383,3	1540,3	1369,0	2032,5	1302,7	741,9	522,9	1598,6	176,9	2014,4	251,9	4073,9
		Charge	1006,5	756,5	1778,4	3878,1	4648,7	1646,8	1040,3	5484,6	1252,0	11389,9	1162,9	3430,4	1032,6	64,5	887,3	-58,0	1087,2	4592,8	1375,1
		Net payment	-2831,6	170,6	-1778,5	1989,1	-4841,6	-264,6	-3136,3	101,3	-288,3	10021,0	-869,6	2127,7	290,7	-458,4	-711,2	-235,0	-927,3	4340,9	-2698,8
2004	ETSO2005	Compensation	994,2	75,8	1453,5	717,9	1813,5	193,6	783,5	324,7	443,5	9,2	123,7	645,2	136,3	264,6	593,0	50,3	327,5	34,0	1097,3
		Charge	196,0	378,6	456,7	665,8	765,5	238,6	239,3	2463,6	146,6	1785,8	568,5	258,2	270,1	23,7	121,3	96,6	75,4	696,7	416,7
		Net payment	-798,3	302,8	-996,9	-52,1	-1047,9	45,0	-544,2	2138,9	-296,9	1776,5	444,8	-387,0	133,8	-240,9	-471,7	46,4	-252,1	662,7	-680,7
	WWT	Compensation	2316,0	203,9	2431,0	1029,8	4169,2	810,2	1177,2	1454,6	723,0	720,9	516,0	1299,2	171,7	265,6	780,6	304,3	1642,8	403,4	2445,2
		Charge	431,8	835,8	990,6	1476,3	1680,5	515,8	545,2	5418,5	329,1	3947,5	1275,0	580,6	600,0	54,7	263,2	218,0	171,3	1522,6	953,4
		Net payment	-1884,2	631,9	-1440,4	446,5	-2488,7	-294,3	-632,0	3963,9	-394,0	3226,5	759,0	-718,6	428,3	-210,9	-517,4	-86,2	-1471,6	1119,2	-1491,8
	AP	Compensation	1499,4	209,4	1749,3	936,3	2067,0	243,1	885,0	1416,6	249,2	1056,0	488,4	634,1	502,9	208,9	562,7	249,5	846,1	496,1	1669,6
		Charge	847,8	312,6	1109,6	1255,6	2403,8	209,7	736,0	1955,9	304,0	1677,8	259,9	920,1	531,9	241,1	660,4	119,3	472,1	876,0	1189,2
		Net payment	-651,7	103,2	-639,7	319,3	336,9	-33,4	-149,0	539,3	54,8	621,7	-228,5	286,0	29,0	32,3	97,7	-130,2	-374,1	379,9	-480,4
	MP	Compensation	3128,4	484,1	3103,0	1486,8	7332,0	118,4	2589,5	6105,2	341,8	1921,2	746,1	1571,2	539,5	388,9	787,5	153,1	1404,2	247,1	2013,3
		Charge	877,8	438,3	1201,7	2993,5	3543,6	1092,1	1076,9	4886,4	1005,2	8385,6	430,5	2359,7	1252,8	80,8	762,8	516,1	-391,3	2997,5	779,0
		Net payment	-2250,6	-45,9	-1901,3	1506,6	-3788,4	973,7	-1512,5	-1218,9	663,4	6464,4	-315,6	788,5	713,3	-308,1	-24,7	363,0	-1795,5	2750,4	-1234,3

Table 4.4: Compensation, charge and resulting net payment per entity for 2003 and 2004 data (all values expressed in km-related values). (Simulated figures based on 72 (64 for 2004) snapshots and on standard cost assumptions)

4.6.4.2 Comparison of results per entity

In the previous section the analysis of aggregate results (i.e. aggregated over all entities) has revealed notable differences between the allocation methods. Now we take the viewpoint of individual entities and assess how similar their results (e.g. in terms of net payment) are for the four methods.

This is achieved using the technique of linear regression. The so-called coefficient of determination (R^2) is used as an *aggregate* measure for the similarity of the *individual* entities' results: An R^2 of 1 would mean that two methods perfectly correlate (i.e. results are identical for all entities), while an R^2 of 0 would mean that the methods are totally uncorrelated.

The analysis based on the R^2 neglects differences between the averages over all entities. For example, if the net payments of method A were 5 times as high as those of method B for each entity, the R^2 would be 1. Therefore, the analyses in this section complement the findings of the previous section such that differences in the aggregate results are not discussed twice.

In the following, we first illustrate the regression analysis by means of a comparison between WWT and MP, AP and MP, and ETSO2005 and MP, respectively. These results are based on 2004 load flow data and standard cost assumptions. We then present an overview of the R^2 figures for all pairs of methods and for both regulated and standard cost.

More detailed results can be found in annex A.

Example 1: WWT vs. MP

Fig. 4.19 shows the average net payment per entity for the allocation methods MP and WWT; for each entity, two columns represent the net payments of the two methods. In fig. 4.20 each entity is represented by one dot, where the coordinates reflect the WWT (x axis) and MP (y axis) results. The regression analysis yields an R^2 of 41 %. (An R^2 of 1 would occur if all dots lied on a straight line.) While the absolute value of the R^2 provides only little information, we will return to it below when comparing different pairs of methods.

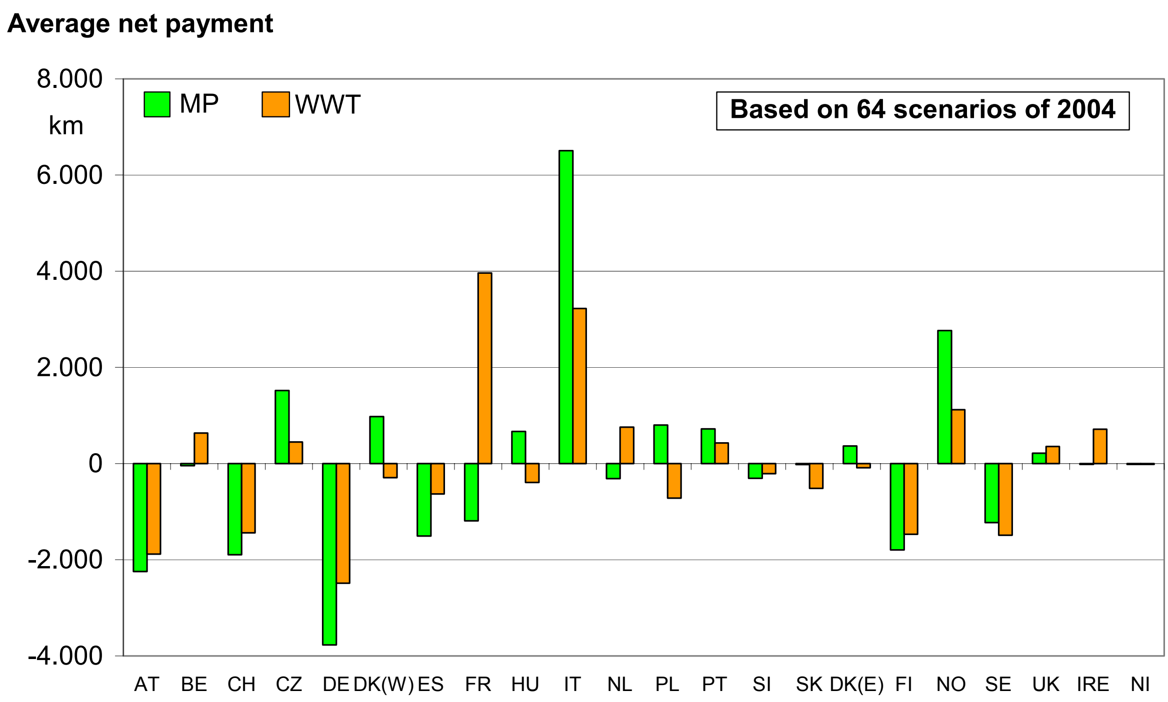

Fig. 4.19: Comparison of average net payment per entity for allocation methods MP and WWT

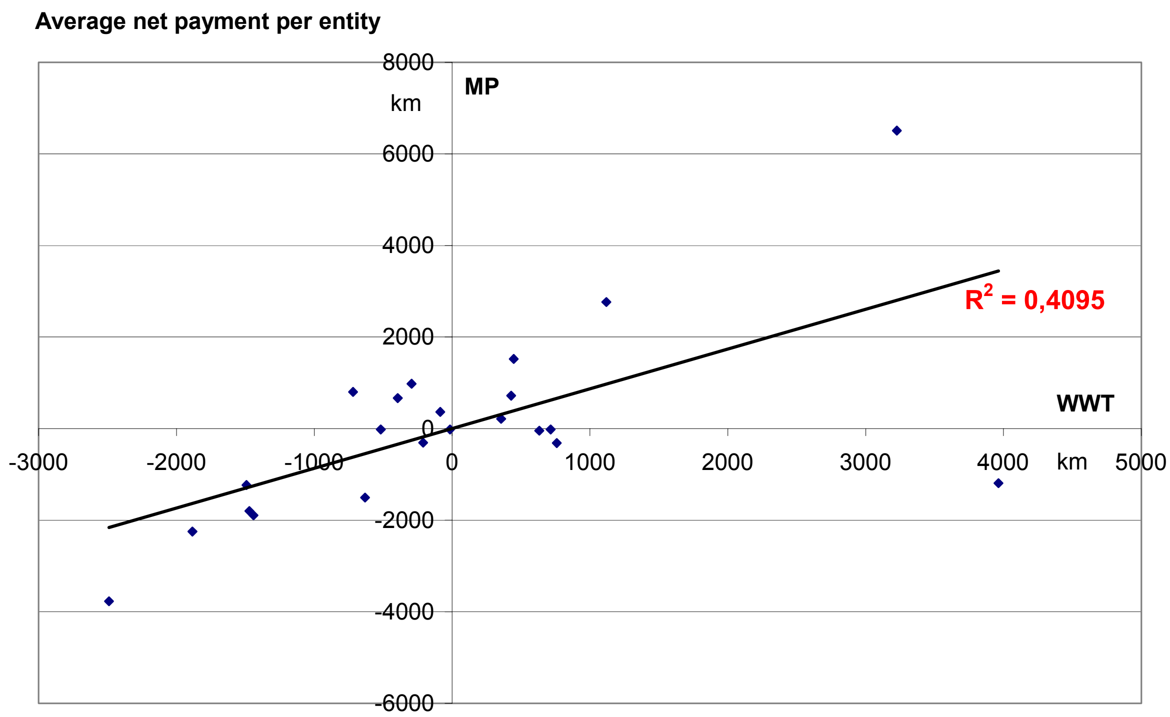

Fig. 4.20: Correlation of average net payment per entity for allocation methods MP and WWT (R^2 = coefficient of determination)

Comparing the results of WWT and MP one notices that the signs of payments per entity (and, less significant, the respective amounts) determined with WWT are often close to the MP results. However, there are also entities with large deviations, such as France, Italy, The Netherlands and Poland. The reason for this is probably that WWT does not explicitly take into account the impact of neighbouring entities but assumes that the mutual impact of these entities on each other is identical. Neither direct power exchange between neighbours nor loop flows (i.e. cases where an entity exports to *and* imports from a neighbour) are explicitly accounted for under WWT. Especially for entities that are importing (e.g. Italy) or exporting (e.g. France) for most of the time, this approximation seems to oversimplify the actual conditions. The fact that some countries have to pay more under MP and others under WWT is caused by the different relative importance of these aspects for the individual countries.

Example 2: AP vs. MP

The results of AP and MP differ more from each other than those of WWT and MP, which is reflected by the lower R^2 of 31 % (fig. 4.21).

This seems astonishing because AP is – as MP – also able to explicitly consider the impact of neighbouring entities on each other. It seems that this advantage of AP over WWT is in numerical terms less significant than the roughness of the water flow algorithm used by AP to determine the influence of load and generation on the flow on lines and transformers. Since this algorithm follows a power source only “downstream” to sinks (and vice versa for sinks) the detected responsibilities are geographically limited (cf. section 4.5.1.1). For example, when France is exporting to Germany, under AP the flow starting in a German generator near the French border would possibly not reach the French grid because of “facing” only opposing flows. By contrast, MP would detect the impact on the French grid irrespective of the “net” flows on the tie lines (which more closely reflects network physics).

Example 3: ETSO2005 vs. MP

Comparing ETSO2005 and MP the R^2 measure is, for 2004 data and standard cost assumptions, between the R^2 for AP vs. MP and for WWT vs. MP (fig. 4.22).

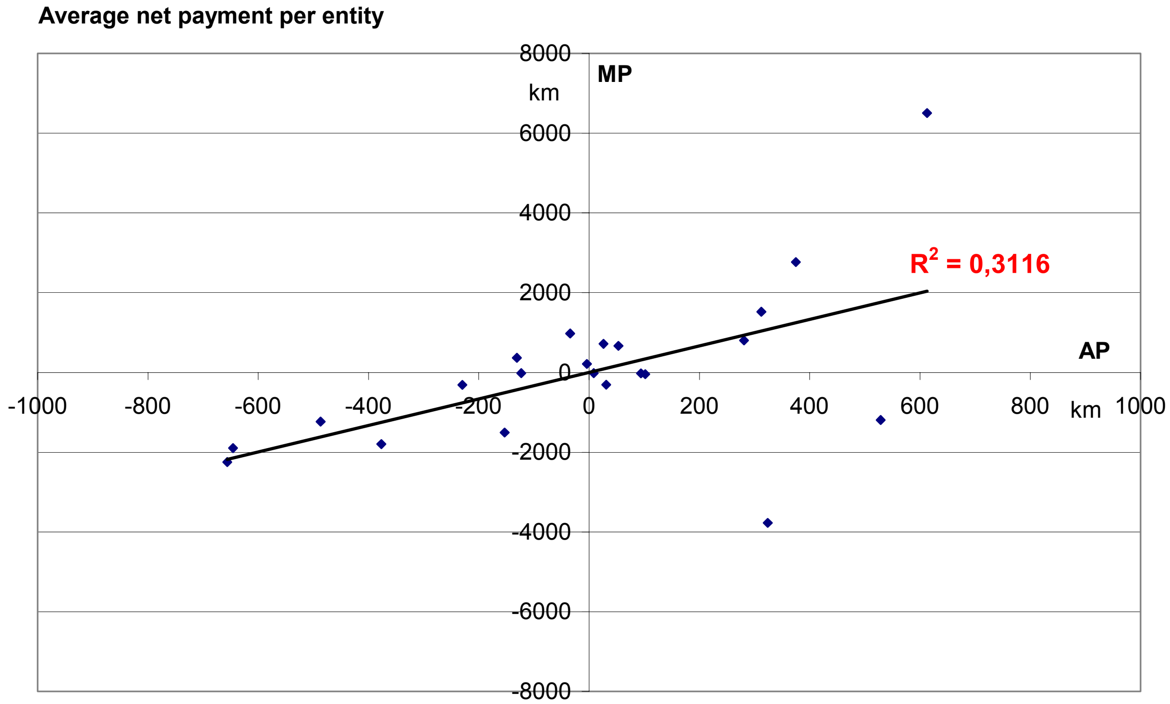

Fig. 4.21: Correlation of average net payment per entity for allocation methods MP and AP (R^2 = coefficient of determination)

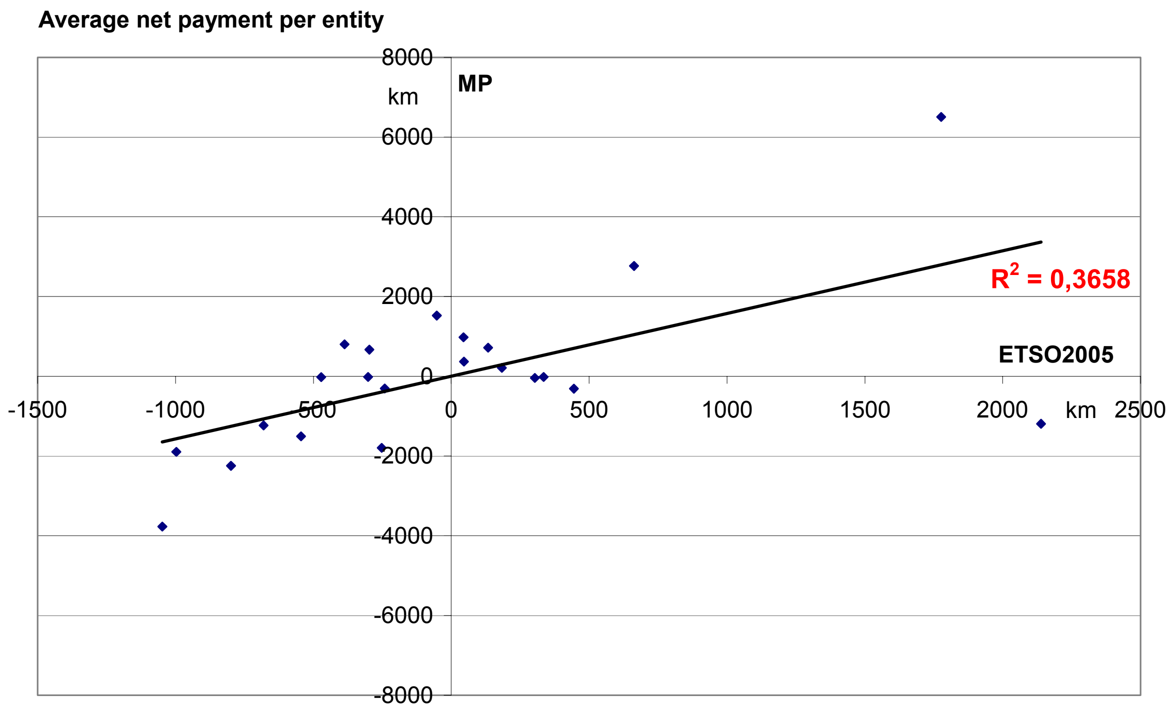

Fig. 4.22: Correlation of average net payment per entity for allocation methods MP and ETSO2005 (R^2 = coefficient of determination)

Comparison between all methods

Table 4.5 A) gives an overview of the R^2 figures for both 2003 and 2004 and for all pairs of methods. The results are relatively stable between 2003 and 2004. We note that ETSO2005 and WWT results yield the highest correlation. The similarity between WWT and MP is higher than between AP and MP in both years.

For 2004 data, we have repeated the regression analysis with net payments derived from regulated cost data instead of standard cost. The resulting R^2 figures underpin the strong dependency of the net payments on the cost assumptions (table 4.5 B). With regulated cost AP becomes almost uncorrelated to all other methods (R^2 < 10 %), while correlations between ETSO2005 and WWT and between WWT and MP remain relatively high.

A) Results based on standard costs

2003	MP	WWT	AP
MP			
WWT	46,7%		
AP	41,8%	40,3%	
ETSO2005	58,4%	92,1%	40,5%

2004	MP	WWT	AP
MP			
WWT	41,0%		
AP	31,2%	43,0%	
ETSO2005	36,6%	93,9%	41,0%

B) Results based on regulated costs

2004	MP	WWT	AP
MP			
WWT	34,1%		
AP	4,7%	2,0%	
ETSO2005	19,8%	76,6%	6,7%

Table 4.5: R^2 values regarding the pair-wise comparison of methods with respect to the net payment per entity

Relation between compensations and network cost

In order to provide some indication of the relative significance of the km-related values, fig. 4.23 shows for all considered methods the share of the network equipment that each entity is compensated for.

All results are determined for 2004.

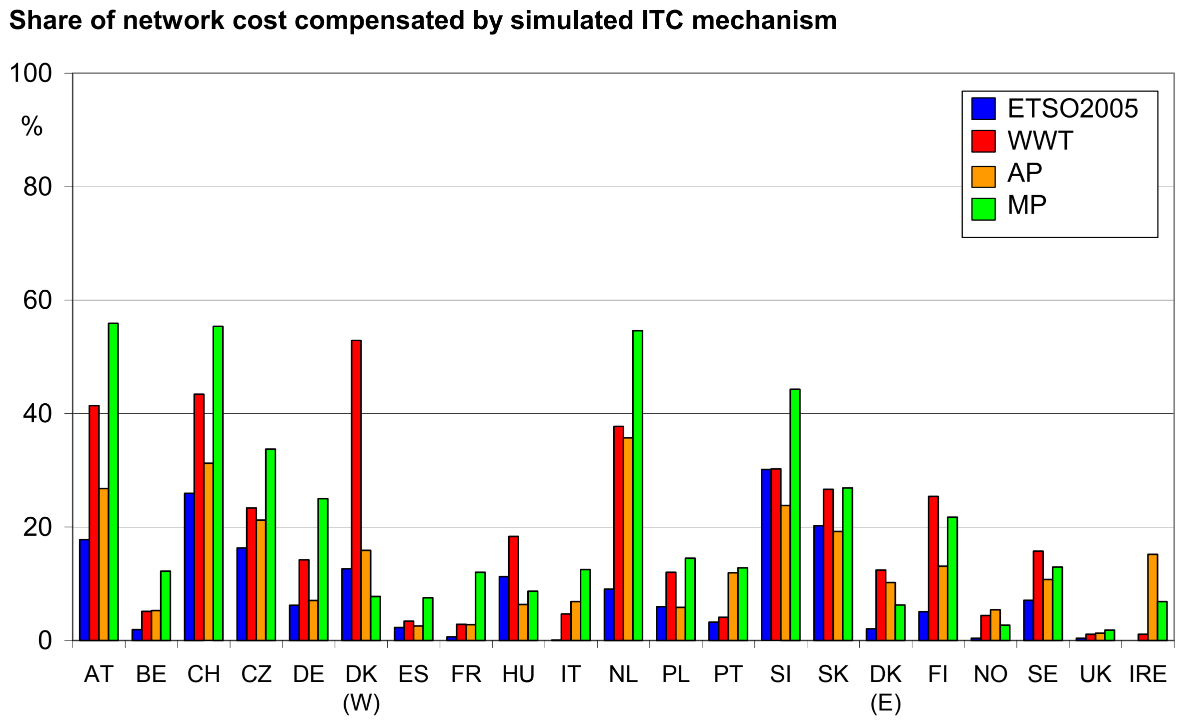

Fig. 4.23: Share of own network cost compensated by ITC mechanism per entity for all considered allocation methods (based on 2004 data and uniform unit cost)

A broad range of shares can be noticed. While for some entities only a few percent of their total network equipment is compensated through ITC (e.g. UK, Spain), other entities such as Austria, Switzerland or The Netherlands would be compensated for up to 55 % of their network equipment at least with the MP method. (Note: The above shares regarding the compensations must not be mixed up with the net payments. The latter ones reflect that each entity to some extent uses other entities' networks. Due to this mutual influence net payments are on average smaller than the mere compensations.)

4.6.5 Sensitivity analyses

4.6.5.1 Limitation of payments due to opposing flow directions (Capping)

On a qualitative basis we already discussed this aspect (cf. section 4.5.1.2) and have come to the conclusion that the consideration of relieving effects of external network use requires some kind of capping in order to limit the payments with the goal to eliminate singularities.

We found out that without limiting the payments, the identified compensation for one single line can make a complete scenario useless (or even worse, that a single scenario can significantly distort the overall results). Based on a WWT calculation for the scenario 12.10.2003, 19:30 h, Germany would have received a compensation for the line between the nodes D2AUDO22 and D2FLEN21 due to external network use of 180 times the total line costs attributed to the scenario. (This effect is mitigated by the fact that a single scenario determines only about 1/72 of the ITC payments. Nevertheless, in this example more than twice the line cost would have been determined as compensation due to this single scenario.) The reason for that is that the resulting load on that line was only 0.2 % but the single flow shares (with opposing directions) of external and domestic users amounted to a multitude of that load.

For the TSO the choice of capping factors has no effect on being compensated for its complete network costs to be paid by both domestic and external network users as long as the sum of upper and lower capping factor is 100 %. The specific magnitude of the capping factor is a degree of freedom and could be set to any value. Nevertheless, in the discussion we led during the study a certain range of alternatives was commonly considered reasonable (fig. 4.24):

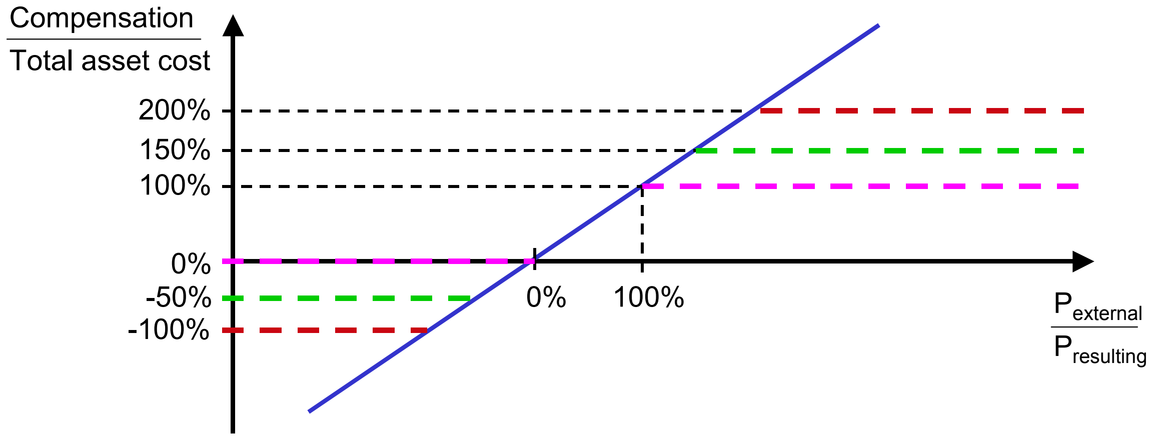

Fig. 4.24: Considered range of capping factors for proportional approach

- In one extreme case the external network users never pay more than the total asset costs in case that they contribute to the resulting flow. This means that in case that the external flow contribution is in opposite direction to the resulting flow the external users will not receive any reward but get the network utilisation for free (upper capping factor: 100 %; lower capping factor: 0 %). A numerical example is given below (fig. 4.25).

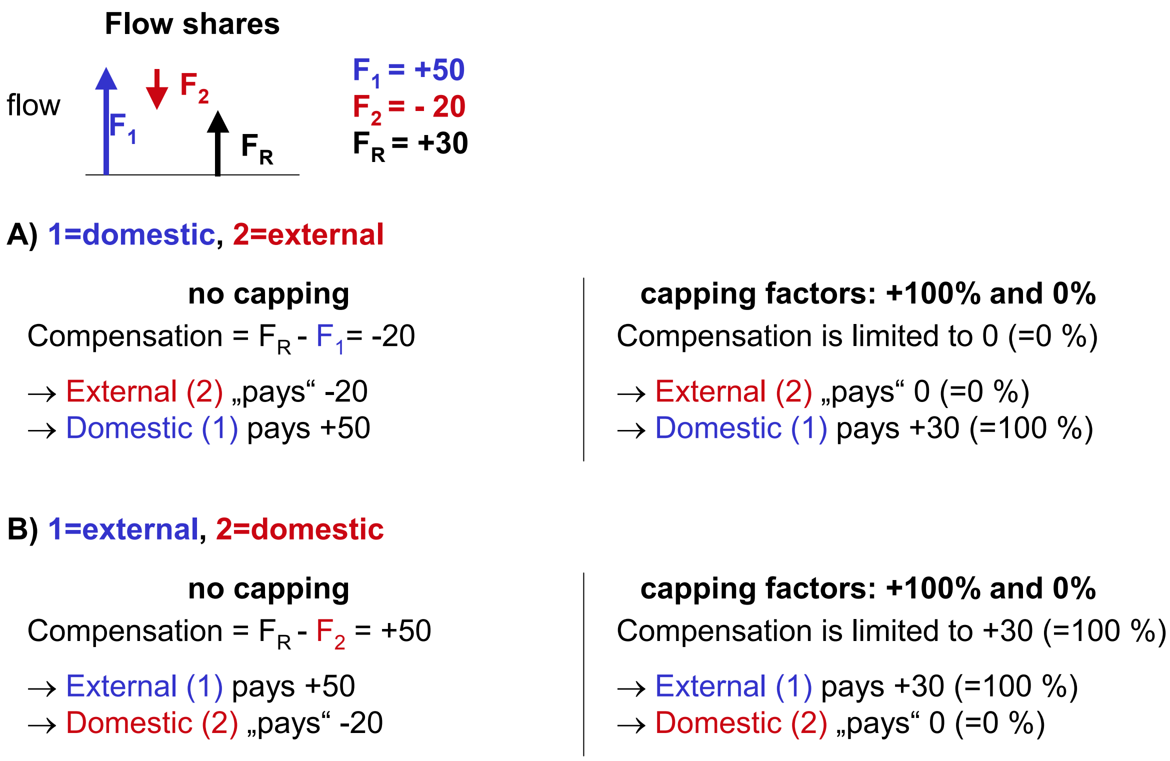

Fig. 4.25: Influence of capping factors – example for factors of 100 % and 0 %

- As another extreme the payments are limited such that an external network user is never rewarded more than 100 % of the total asset costs in case that his flow share is in opposite direction to the resulting flow. In case that an external network user contributes to the resulting flow this means that he has to pay up to 200 % of the asset costs while 100 % of asset costs will then be rewarded to domestic users because of the relieving effect due to their network use (upper capping factor: 200 %; lower capping factor: -100 %).

We also considered capping factors of 150 % and -50 %, respectively, for covering a case between the aforementioned extreme scenarios.

In the following we demonstrate the impact of the different capping factors on the total ITC fund as well as on the average net payments when applied to 6 out of the 72 load flow scenarios for WWT and MP (being the only methods that are able to determine relieving effects of network use). In fig. 4.26 we also illustrate the case of "almost no" capping (actually there has been some very wide capping in order to avoid completely implausible or even infinite results).

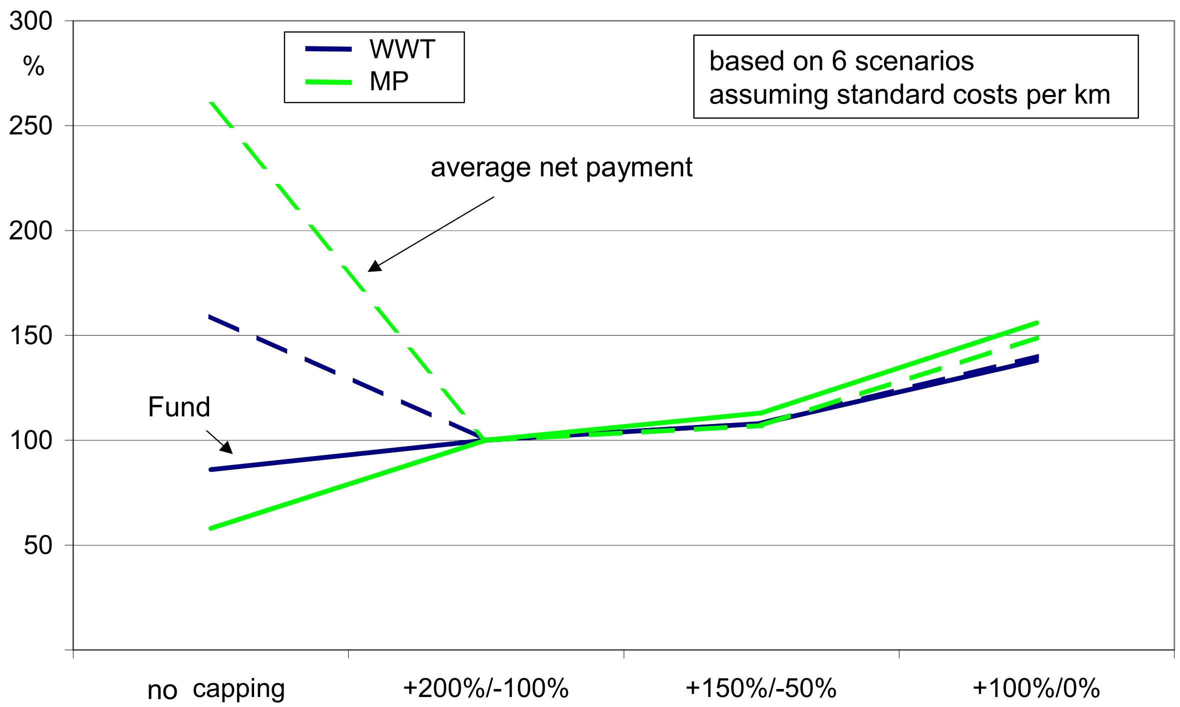

Fig. 4.26: Size of fund and average net payments (normalised with values for capping factors +200/-100%)

There are two main conclusions that can be drawn:

1. Capping obviously reduces the impact of singularities. Therefore, we recommend to introduce capping factors for WWT and MP in order to achieve reasonable results.
2. Stronger capping increases the fund and the average net payments because the impact of relieving effects is less honoured than for “wider” capping factors.

4.6.5.2 Stability of results over time

One important issue for an entity is to have some certainty that the results are stable over a period of time, i.e. to be able to anticipate the compensations or charges from the ITC mechanism. Fig. 4.27 and fig. 4.28 show the range of relative deviations from the average net payment per entity related to the scenarios of 2003 and 2004 for MP and WWT, respectively.

WWT leads to more stable results than MP for nearly all countries, which is also illustrated by the average relative difference indicated in the above diagrams. Comparing all four methods, WWT comes closest to the current ITC mechanism in terms of stability (fig. 4.29).

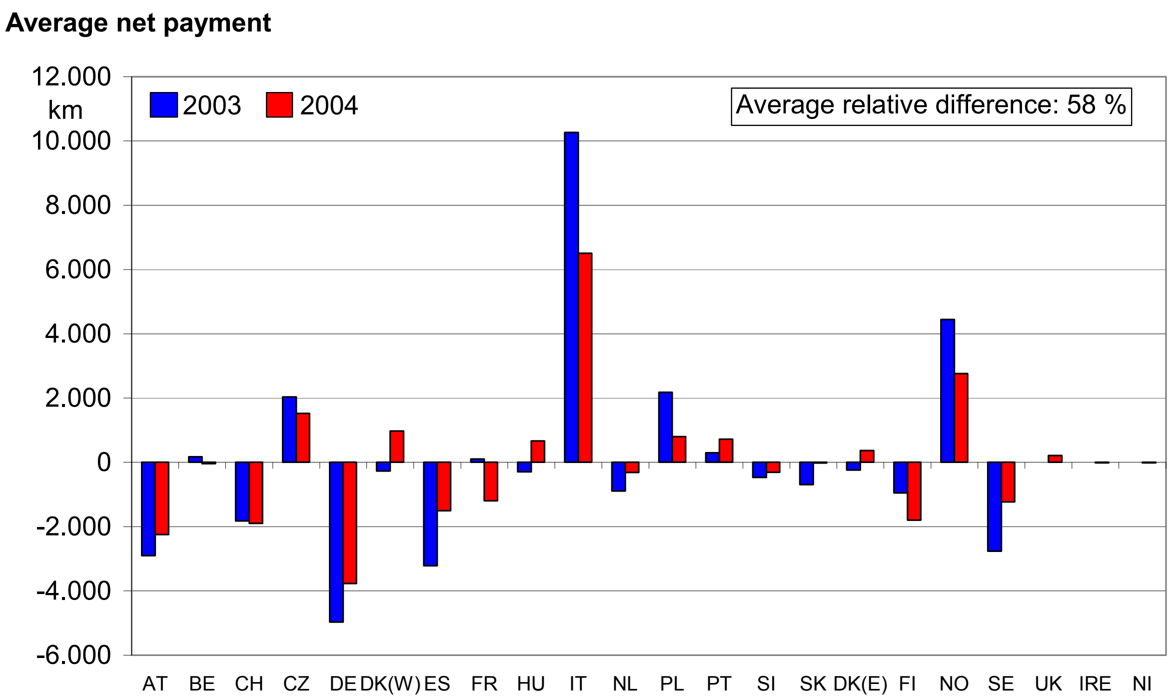

Fig. 4.27: Average net payment per entity 2003 vs. 2004 for allocation method MP

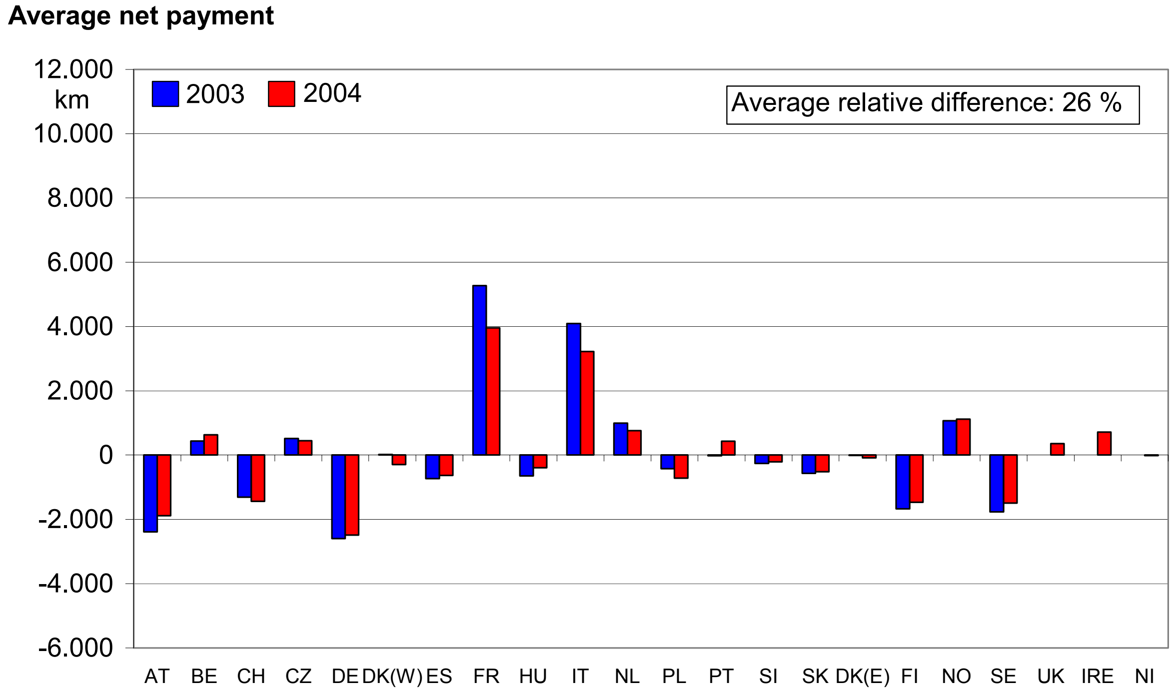

Fig. 4.28: Average net payment per entity 2003 vs. 2004 for allocation method WWT

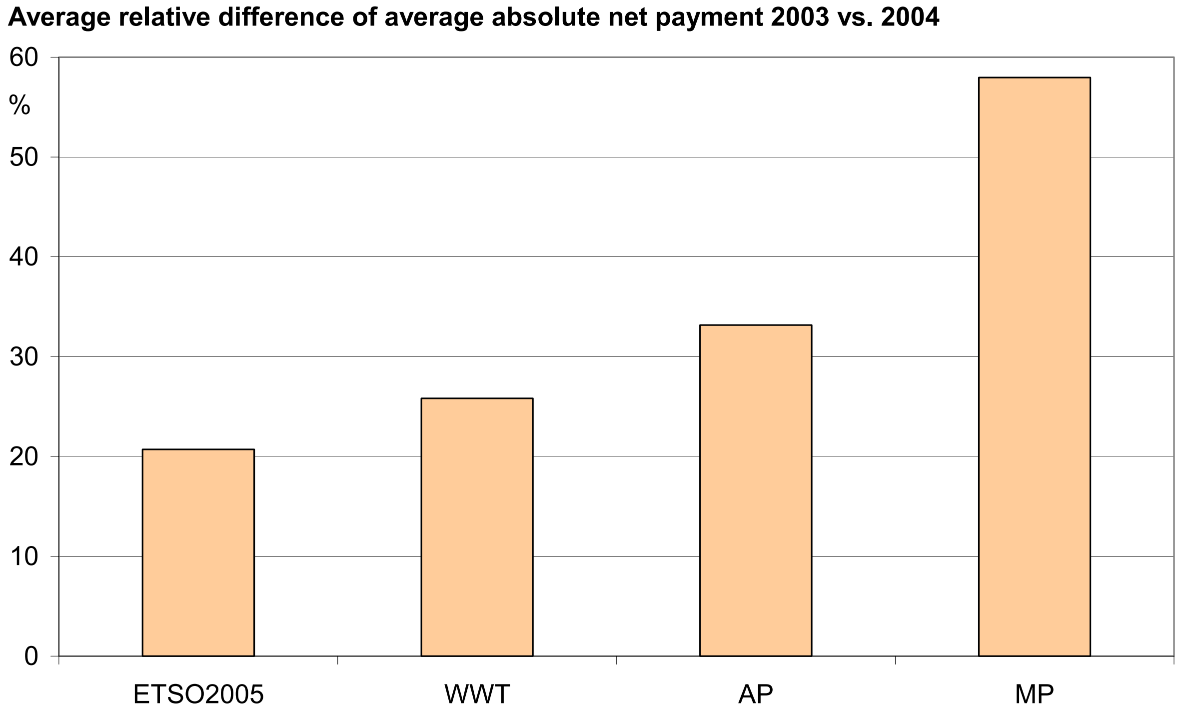

Fig. 4.29: Relative differences of average absolute net payment per entity for considered allocation methods between 2003 and 2004

4.6.5.3 Dependency on split of nodal balance into generation and load

Regarding the issue already discussed on a qualitative basis (cf. section 4.5.3.2), in this section the impact on the net payments will be demonstrated.

The results in fig. 4.30 are based on an exemplary calculation for the scenario 12.01.2003, 03:30h (only UCTE area), with the AP method. In the figure the net payment per entity is presented, calculated for different treatments of generation and load per network node:

- Consideration of the nodal balance, i.e. the aggregate of generation and load
- Consideration of separated values for generation and load as they are modelled in the load flow file

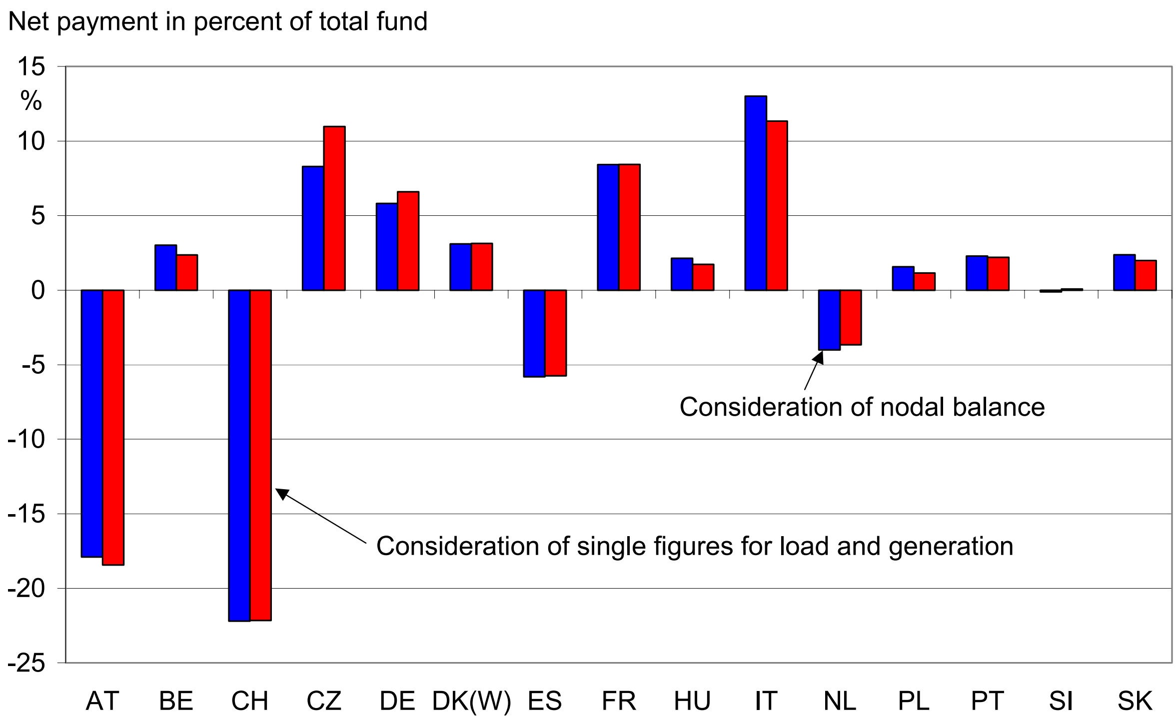

Fig. 4.30: Net payment per entity for different treatment of generation and load per network node (exemplary calculation with AP method)

It is obvious that different treatments of generation and load lead to different results. In total the differences are quite small but for single entities (such as CZ) the relative changes can reach up to 20 %. This shows that the impacts are not negligible.

As qualitatively argued, a similar effect also occurs for calculations with the MP method.

The given example confirms the benefit of a harmonised treatment of nodal balances both under AP and MP, as suggested in section 4.5.3.2, in terms of increasing the stability and consistency of results.

4.6.6 Treatment of perimeter countries

The two methods based on the consideration of transits (ETSO2005 and WWT) require a special treatment for the flows from perimeter countries into the ITC area, i.e. into an edge-country. For the current mechanism this is be done by defining an explicit import fee (currently 1 €/MWh). The payments due to perimeter flows are part of the compensation fund (cf. [5]). For WWT this approach can be adopted.

AP and MP allow a direct allocation of responsibilities so that no special algorithm is needed to take into account the influence of perimeter countries. Exchanges between perimeter and edge countries can be modelled like „normal“ injection/loads, such that a fixed injection fee can be dropped because the level of charges for perimeter countries can be determined with the method.

On the backdrop of the aim to limit the number of methodical variants to be chosen from, it was outside the scope of this study to explicitly discuss alternative ways for the treatment of perimeter countries within the ETSO2005 or WWT methods. However, a comparison of the uniform 1 €/MWh charge to country-specific charges that can be derived using AP or MP could be useful to inform future considerations on perimeter country charges for any method.

A comparative analysis of the treatment of perimeter countries can only be done on the basis of actual cost data because neither ETSO2005 nor WWT are able to determine the network utilisation of perimeter countries in grids of ITC entities (cf. section 4.6.1).

In order to allow for an appropriate comparison between the methods, for both MP and AP we only considered power exchanges from perimeter countries into the ITC area, which is compliant to the treatment of perimeter countries in the currently applied mechanism (ETSO2005), and which has been adopted for WWT. Details are described in [5].

Fig. 4.31 and fig. 4.32 show the contribution of all perimeter countries (Croatia, Morocco, Romania, Russia, Serbia and Ukraine) in m€ or related to the total ITC fund, respectively, for 2003 and 2004.

The total absolute contribution of perimeter countries to the fund for ETSO2005 and WWT is identical by definition. Regarding relative contributions, WWT is lowest since the ITC fund under WWT is significantly larger as under ETSO2005.

Regarding the relative contribution to the fund, AP and MP results are similar to each other, yet significantly higher than the results for ETSO2005 and WWT.

As mentioned above, it is not necessary to introduce a fixed injection fee for AP and MP because the level of charges for perimeter countries can be determined with the method. Fig. 4.33 and fig. 4.34 show the actual charges for 2003 and 2004, respectively. (For Morocco and Serbia no charges appear in the figures because in all available snapshots both countries never export to the ITC area, neither in 2003 nor in 2004.)

The figures show that for both AP and MP significantly higher charges than the currently applied injection fee of 1 € per MWh are calculated. Except for Croatia, MP leads to significantly higher charges as AP. Comparing the charges of 2003 and 2004, the relation between the methods stays relatively stable.

The results must, however, be interpreted with care. As mentioned earlier, AP and MP share the property that they lead to a large ITC fund, but net payments are damped because the mutual impact of entities on each other allows to net off compensations and charges to a certain degree. In contrast to this, the impact of the ITC members on the perimeter countries' networks cannot be considered neither by AP nor MP since there are no networks models available for these countries. Hence, the damping counterpart is missing in the case of a perimeter country.

Therefore, the absolute level of perimeter country charges should reflect the fact that there is a mutual impact between ITC area and perimeter area. The "pure" results from the AP and MP methods as illustrated above could, however, provide input to a discussion on a regional differentiation of perimeter charges.

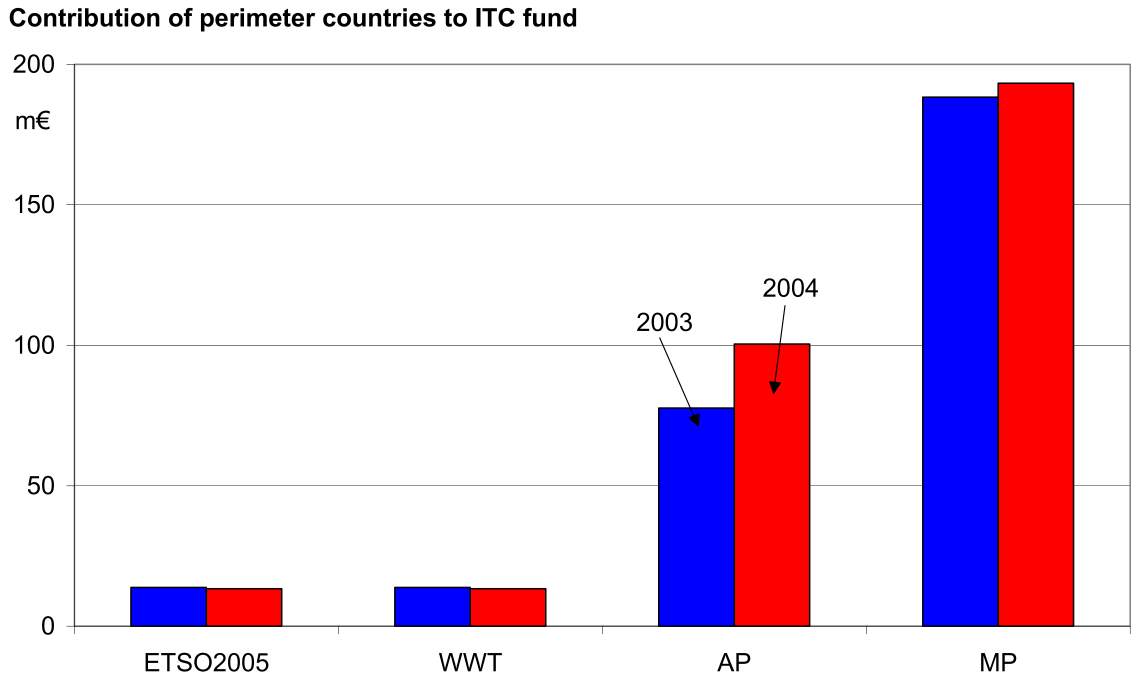

Fig. 4.31: Aggregate contribution of perimeter countries to the ITC fund

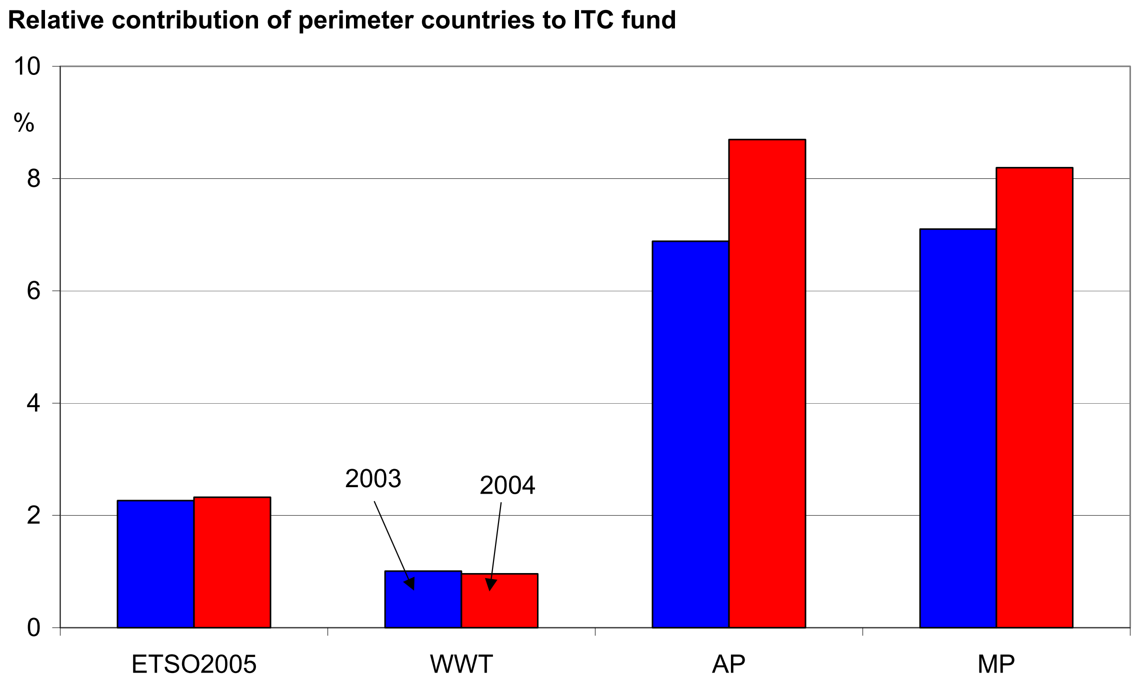

Fig. 4.32: Aggregate contribution of perimeter countries to the ITC fund related to the total fund

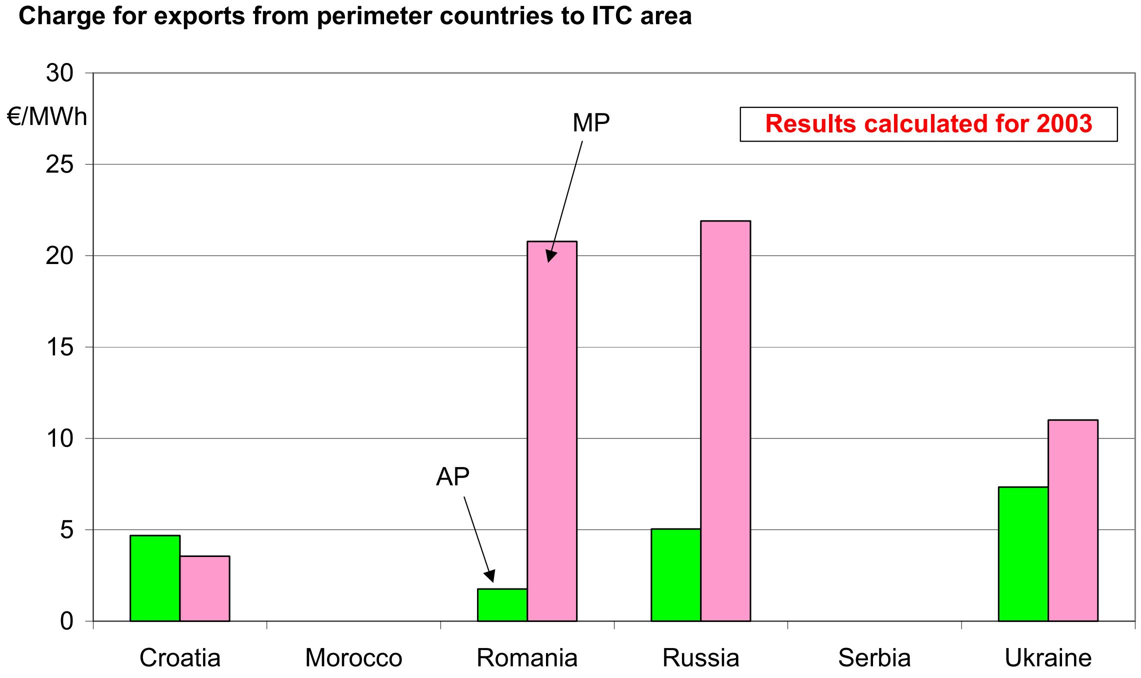

Fig. 4.33: Charge per MWh for exports from perimeter countries to the ITC area calculated for 72 scenarios of 2003 determined with AP and MP

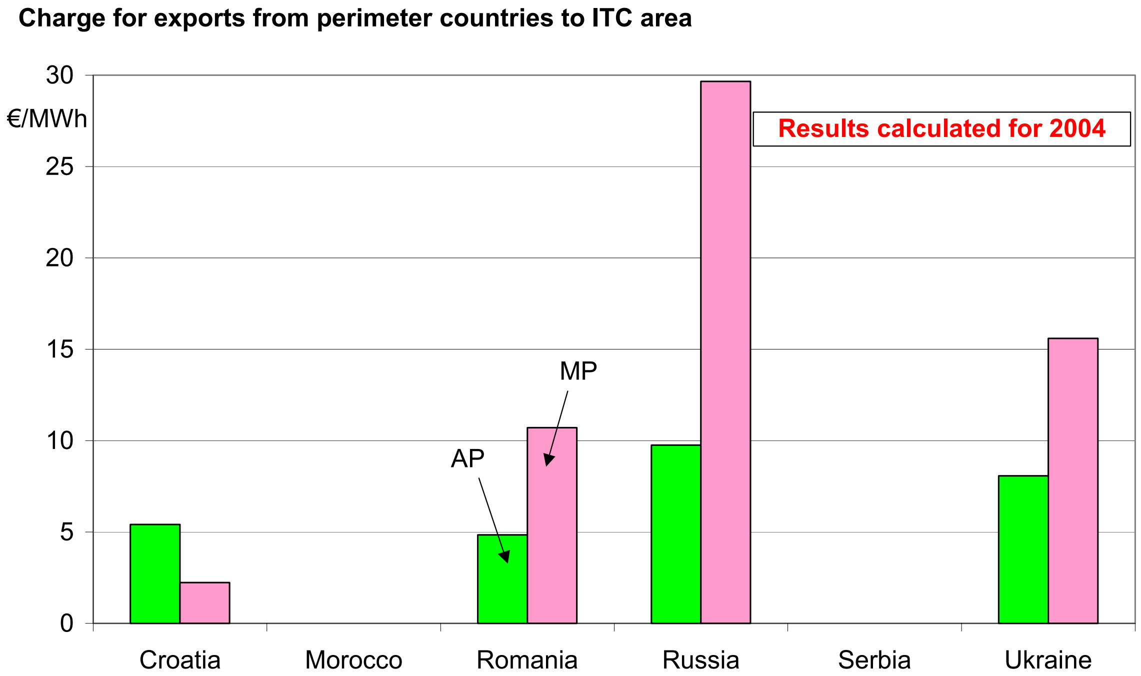

Fig. 4.34: Charge per MWh for exports from perimeter countries to the ITC area calculated for 64 scenarios of 2004 determined with AP and MP

5 Overall conclusions

As mentioned in chapter 1 the aim of this report is to provide an informed analysis as an input into the coming ERGEG / EC considerations, in particular in relation the preparation of Draft Guidelines on ITC. Its aim is not to provide a specific recommendation, especially insofar as final decisions need to be based on the relative weightings placed on sometimes competing objectives.

In relation to the cost basis for the ITC mechanism, we conclude that:

- If it is accepted that the economic objective of the ITC mechanism is principally one of cost recovery, then the cost basis used should be heavily weighted towards the cost of existing infrastructure (as measured by regulated values);
- Where used, a "thin" approach should be adopted towards the calculation of forward looking long run incremental costs in order to increase the probability of consistent interpretation across countries;
- To derive robust cost values to be used in any enduring ITC mechanism, significant further work will need to be undertaken by national regulatory authorities.

In relation to the method used to allocate the cost to ITC participants, we conclude that:

- Infrastructure cost and cost of losses should be allocated according to the same key.
- When considering benefits of cross-border flows due to a partial reduction of flows on lines/transformers one should adopt a proportional approach, i.e. determine (positive and/or negative) compensation payments that are proportional to the contribution of external network users to the actually observed flow. In order to avoid implausible results, payments due to a single line in a single scenario should be limited to a certain cap. (Note that the explicit consideration of benefits due to cross-border flows is only possible with the WWT and the MP methods.)
- Out of the six allocation methods we have been asked to analyse, four could theoretically be the basis of the future ITC mechanism, depending on the relative weighting of the different assessment criteria.
- The presently applied method (ETSO2005) is by far the simplest one and clearly wins in terms of practicality and ease of implementation. On the other hand it has clear conceptual

drawbacks. Due to its numerous simplifications it is less accurate than the other methods. However, if practicality is rated very high and the potential gain in accuracy is not considered to outweigh the effort of providing load flow files (instead of metered flows), there could be some reason in continuing to apply the present method.

- In contrast, the method called Marginal Participations (MP) is the most accurate among the considered methods. Nevertheless, it is far from being ideal. For example, its results depend on the way in which TSOs model the nodal power balances. (This also applies to the AP method.) Moreover, the results are relatively unstable over time. Finally, MP is the most complex method in terms of implementation and data provision and thus hard to comprehend.

- With-and-Without-Transits (WWT) is from a conceptual point of view a compromise between MP and ETSO2005. From MP it adopts the load flow algorithm, enabling it to consider the partial benefits of cross-border flows and avoiding the strong dependency on the size of the participating entity (one of the problems of ETSO2005). On the other hand, it inherits two major simplifications from ETSO2005: The assumption that the mutual impact of neighbouring entities on each other is identical (by considering only transits) and the neglect of the geographical constellation of the different entities (by using the "net flow" concept for determining the charges). In terms of complexity it requires load flow files (making it significantly more complex than ETSO2005), but processes them one by one (i.e. entity by entity), thereby being more transparent and less onerous in terms of data preparation than MP (and to a smaller extent, than AP).

- The method called Average Participations (AP) can be seen as an attempt to overcome some of the aforementioned drawbacks of WWT. For example, it does – like MP – explicitly consider all cross-border flows and takes account of the geographical constellation of networks. Being compared to MP, it avoids some aspects of complexity, like the need for special treatment of DC links and the requirement to provide merged data sets of synchronous networks. However, AP achieves these advantages by sacrificing the load flow algorithm as the fundamental basis of the algorithm. Instead, it is based on a water flow algorithm that significantly differs from the laws of physics in electricity networks.

Quantitatively, the exemplary analysis of two years shows that when comparing any two methods, even if the overall tendencies of the results remain similar, there are always particular countries whose results differ significantly between methods. On aggregate, MP gives the highest average net payments and AP the lowest. Quantitative results, including the relative differences between countries, significantly depend on the underlying cost data.

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Annex

A Comparison of results

A.1 Results for 2003

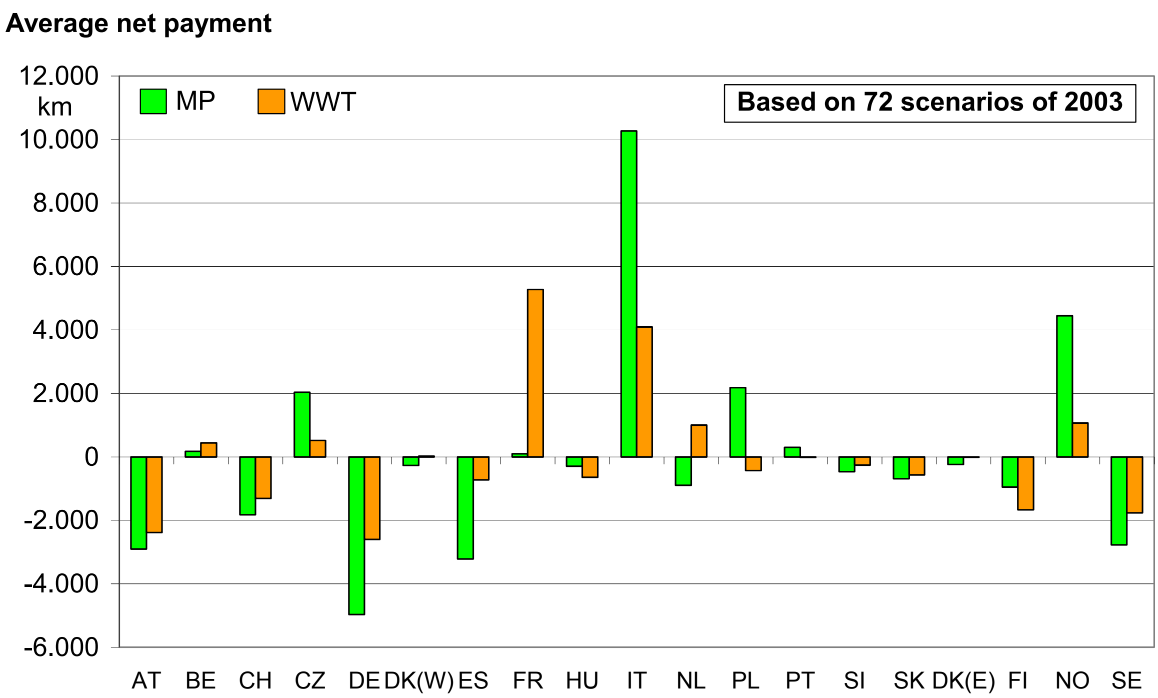

Fig. A.1: Comparison of average net payment per entity for allocation methods MP and WWT based on data for 2003

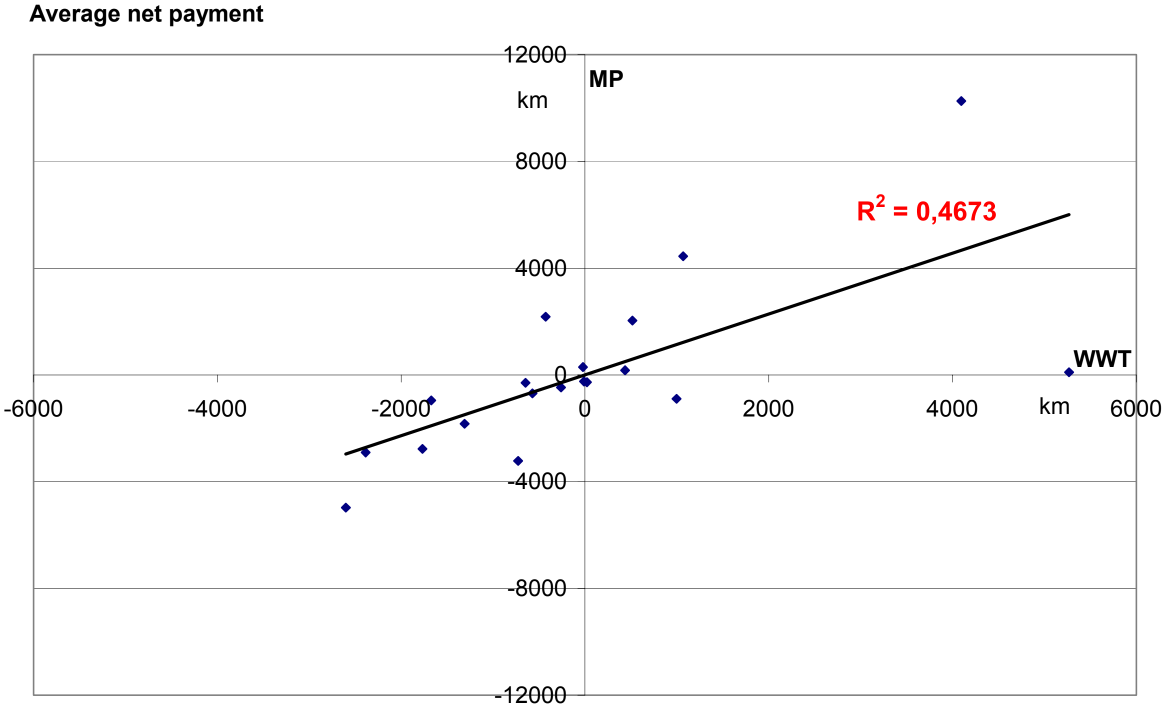

Fig. A.2: Correlation of average absolute net payment per entity for allocation methods MP and WWT for 2003 (R^2 = coefficient of determination)

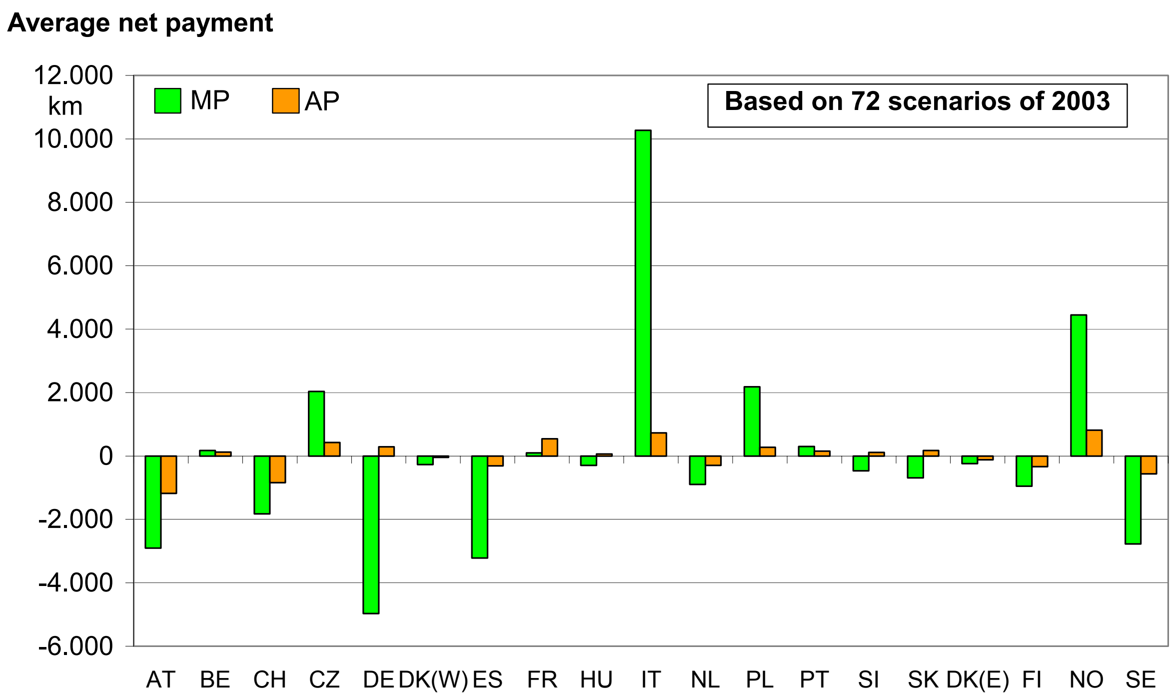

Fig. A.3: Comparison of average net payment per entity for allocation methods MP and AP based on data for 2003

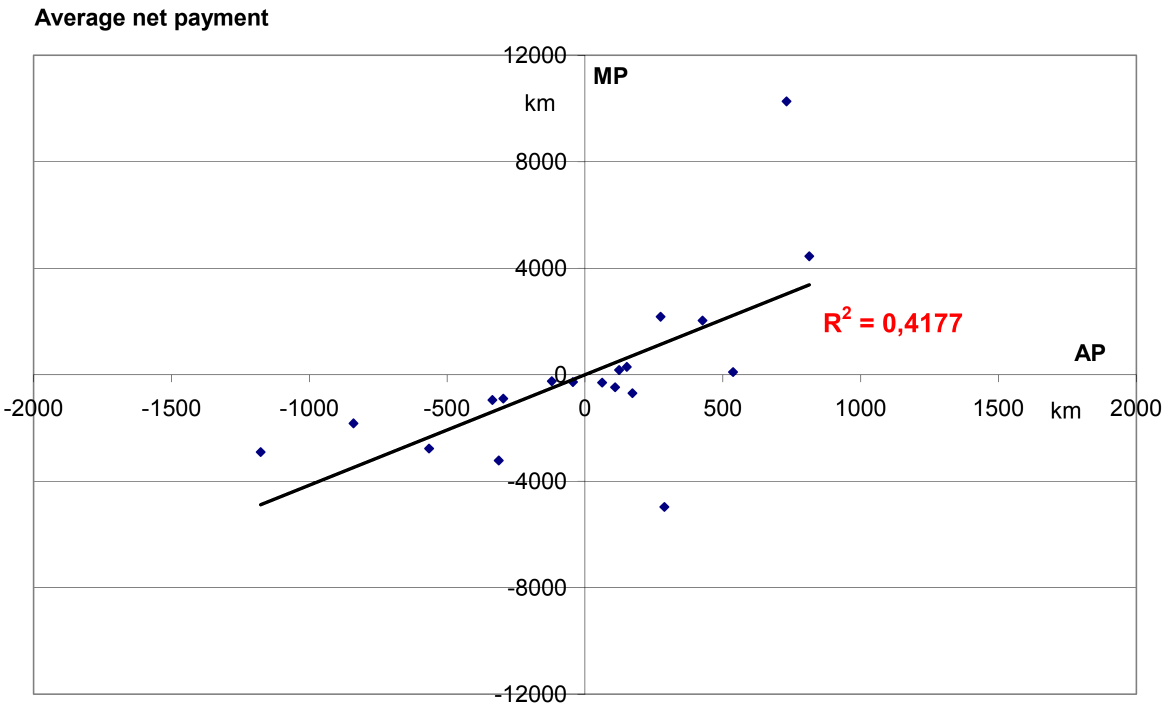

Fig. A.4: *Correlation of average absolute net payment per entity for allocation methods MP and AP for 2003 (R^2 = coefficient of determination)*

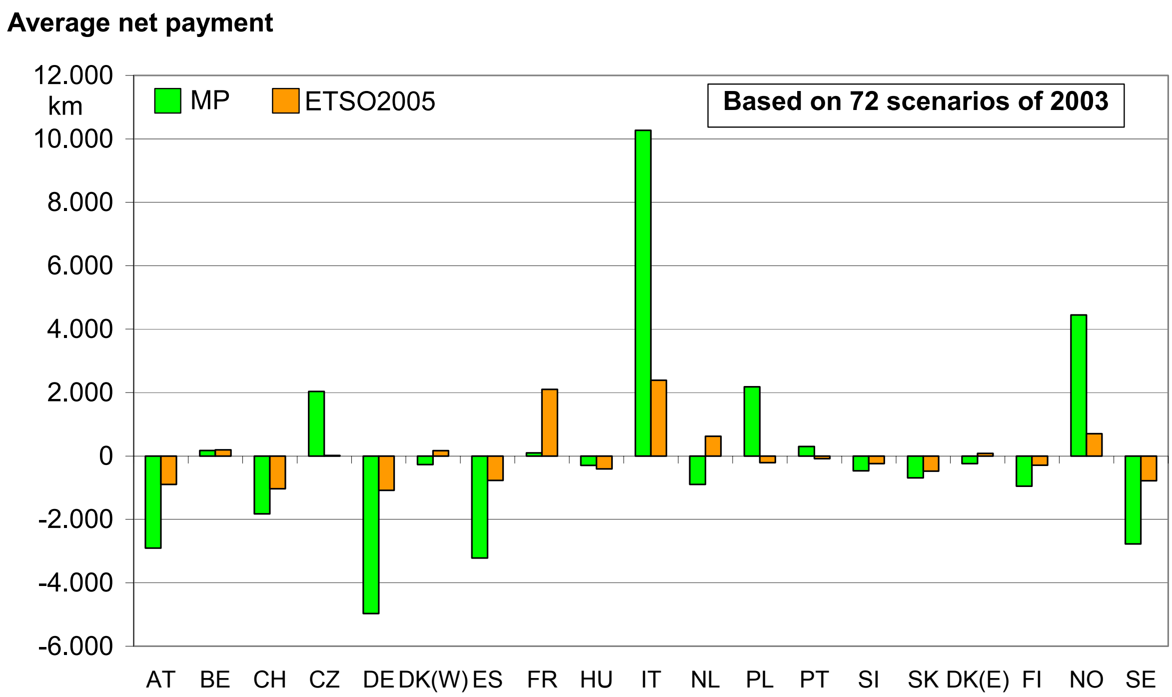

Fig. A.5: *Comparison of average net payment per entity for allocation methods MP and ETSO2005 based on data for 2003*

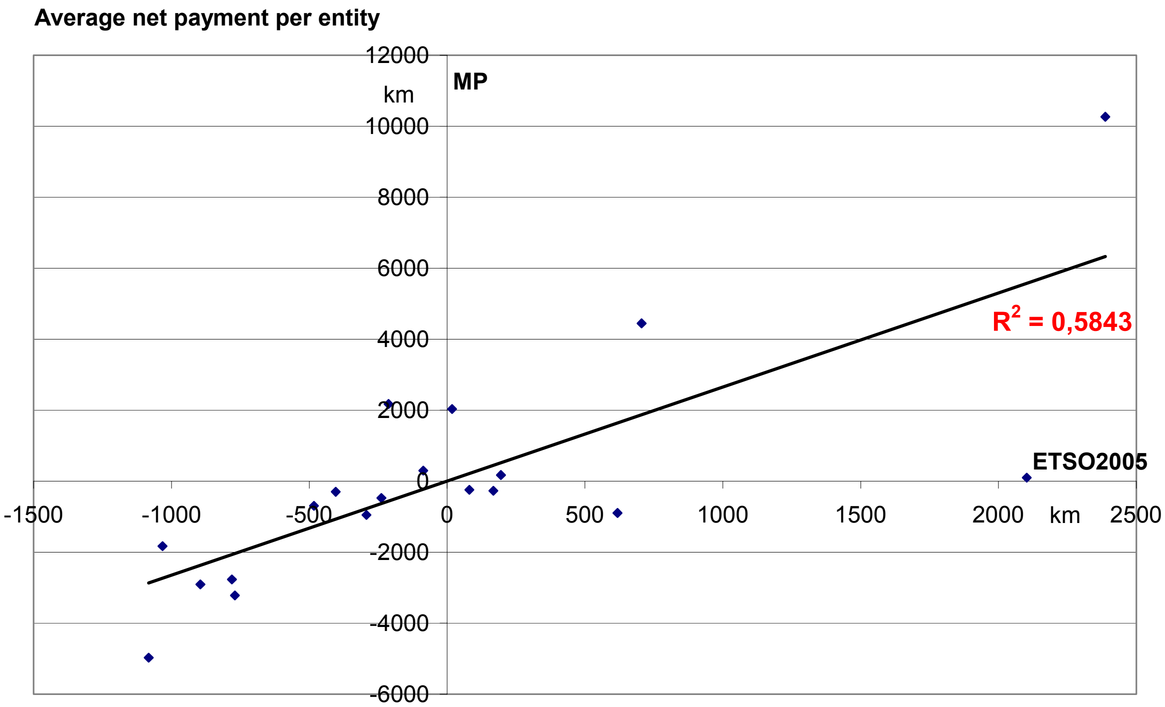

Fig. A.6: Correlation of average absolute net payment per entity for allocation methods MP and ETSO2005 for 2003 (R^2 = coefficient of determination)

A.2 Results for 2004

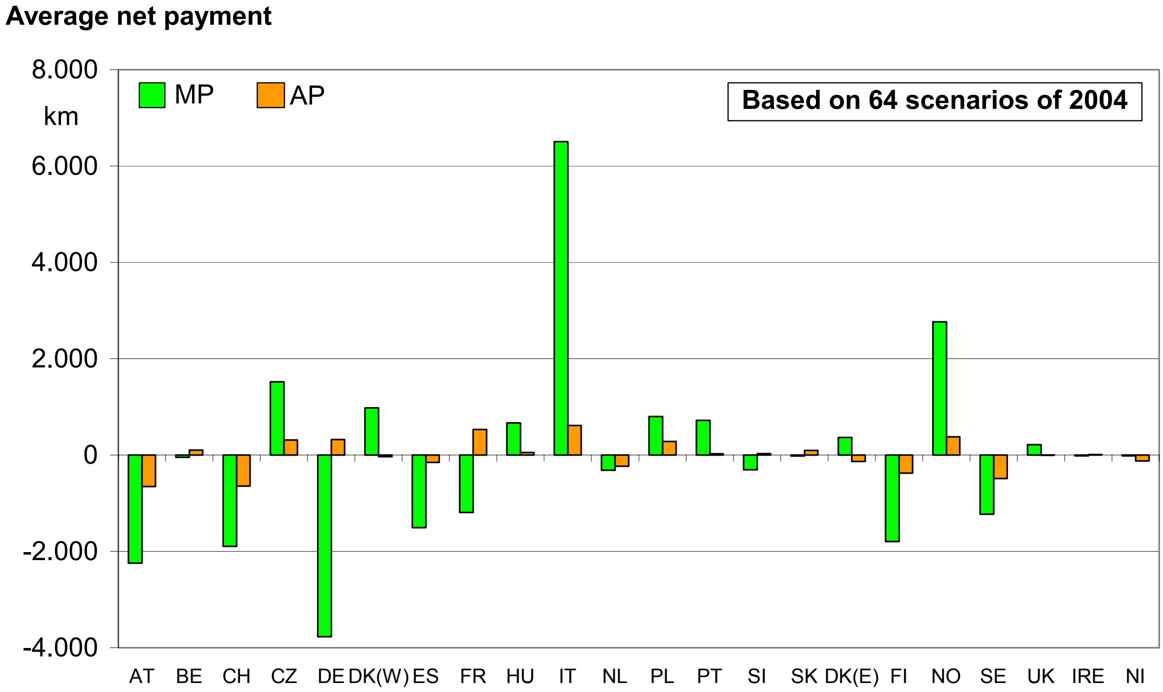

Fig. A.7: Comparison of average net payment per entity for allocation methods MP and AP based on data for 2004

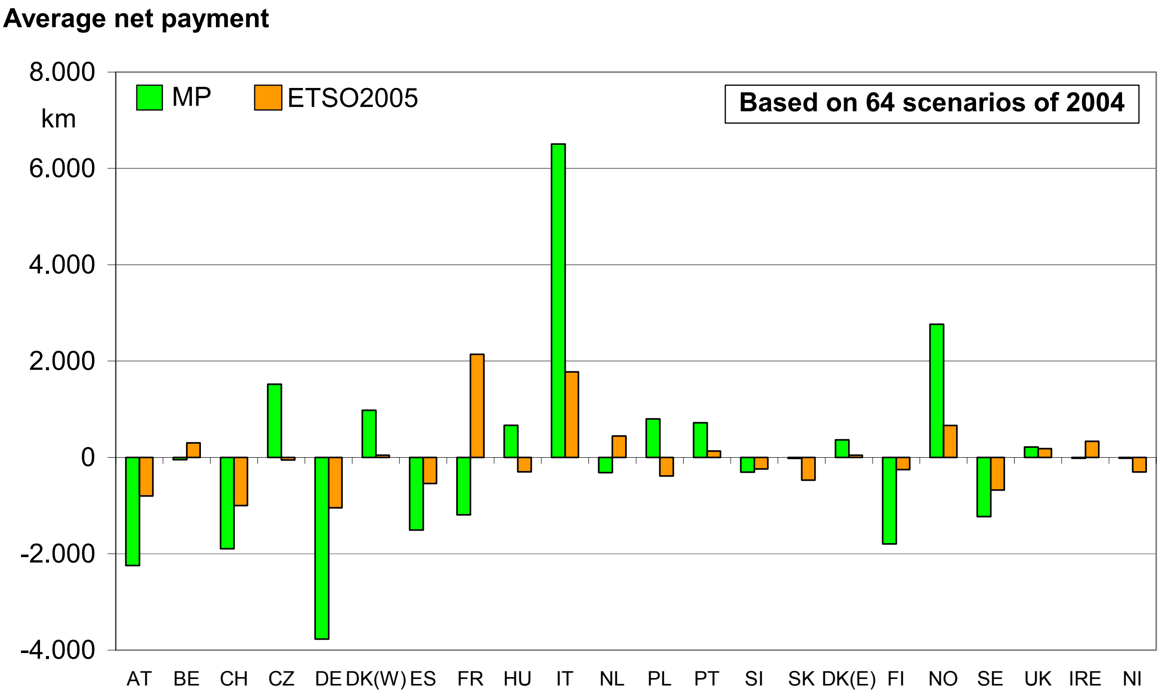

Fig. A.8: Comparison of average net payment per entity for allocation methods MP and ETSO2005 based on data for 2004

B Computation of unit cost – Worked example

Total regulated revenue: Euro 500m

Length of line assets

A	800	km
B	500	km
C	100	km
D	50	km

MVA of transformer assets

E	10,000	MVA
F	5,000	MVA

Weighting factors

A (by definition)	1
B	0.67
C	0.4
D	5
E	0.03
F	0.025

Unit of other asset classes expressed in km of class A

A	800 * 1=	800	km of class A
B	500 * 0.67 =	335	km of class A
C	100 * 0.4 =	40	km of class A
D	50 * 5 =	250	km of class A
E	10000 * 0.03 =	300	km of class A
F	5000 * 0.025 =	125	km of class A
Total		**1,850**	**km of class A**

Unit cost of class A assets = €500m / 1,850 km **= €270,270**

Unit cost of class B	UCa * 0.67	€181,081
Unit cost of class D	UCa * 5	€1,351,351
Unit cost of class E	UCa *1	€8,108