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# Gas transmission networks in Europe: Connections between different entry-exit tariff methodologies ☆

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## HIGHLIGHTS

- This paper presents a discussion of different methodologies for computing entry-exit tariffs.
- Explicit formulas for the computation of two of the main methodologies are derived.
- It is shown that, after a natural adjustment, they coincide.
- An important issue about the use of weighted or unweighted methodologies is discussed.
- The findings are illustrated on an example and the policy implications are discussed.

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## ABSTRACT

Following a request of the European Commission in 2012, different bodies within the gas energy sector have been working on a Network Code for transmission tariffs. The final goal is to get a more harmonized structure within the European Union. This paper complements those efforts by developing a formal treatment of some methodological aspects arising in past and present drafts of the Network Code.

First, the analysis provides simple formulas for the computation of the tariffs resulting from the application of two of the main methodologies that have been discussed in the official documents: the capacity-weighted distance approach and the least squares approach. Second, it is shown that the tariffs delivered by the two approaches are perfectly correlated with each other. Maybe more importantly, if a natural adjustment is performed to control tariff dispersion, then both approaches lead to exactly the same tariffs.

Moreover, the analysis highlights an issue that may have been overlooked by regulators and also by past publications: the difference between weighted and unweighted versions of the methodologies under study and the reasons why weighted versions should be preferred. The paper concludes with a brief comparison with other methodologies and discussing some policy implications.

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## 1. Introduction

Since the 3rd EU Energy Package entered into force in 2009, there has been a growing interest in the design of the access tariffs to the different transmission networks in the European Union. This interest has led to an increase in the related literature, which ranges from reports and regulations at the national and European levels to more academic papers published in peer-reviewed journals. In these contributions the emphasis is normally put on the so called *entry-exit methodologies*, which assign tariffs to all entry and exit points of the network. Thus, the final tariff associated with a given flow depends both on the chosen point of entry and on the destination of the flow.

Regulation [1] of the European Commission prescribes that the methodologies used to calculate tariffs should be transparent, cost-reflective, non-discriminatory and, moreover, should preserve system integrity and provide appropriate return on investment. Following a request of the European Commission in June 2012, and building upon the guidelines in the above regulation and

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related ones, the Agency for the Cooperation of Energy Regulators elaborated the "*Framework Guidelines on Rules Regarding Harmonised Transmission Tariff Structures in European Gas Transmission Networks*" (ACER [2]), hereafter FG-2013. Four main methodologies were proposed in this document. FG-2013 was then submitted to the European Network of Transmission System Operators for Gas (ENTSOG), who prepared several drafts of the Network Code since then. The last one of such documents was released in July 2015 (ENTSOG [3]) and sent to the European Commission, who published a new draft in February 16 (EC [4]), hereafter NC-2016. The process is now in its final stages and a regulation from the EU regulating tariff design in gas transmission networks should be approved soon.

The first of the methodologies discussed in FG-2013 is the traditional *postage stamp methodology*, but it is only considered acceptable under special circumstances (its main drawback is that it is not cost-reflective). A second methodology, named *virtual point-based approach*, is based on marginal costs and is very similar to the *long run marginal cost methodology* that has been in place for several years in the UK (see, for instance, the report of the National Grid [5]). The other two methodologies, called *capacity-weighted distance approach* and *matrix approach*, are built upon average costs. Since the matrix approach has already been widely discussed in the literature under the name of *least squares approach*, the present paper also sticks to this name. For some papers on this methodology the reader may refer, for instance, to Deliberata [6], Alonso et al. [7], National Energy Comission of Spain [8], Apolinário et al. [9], and Bermúdez et al. [10].

The focus of this paper is on the two methodologies based on average costs. One of the main contributions consists in formally developing the definitions in FG-2013, obtaining closed-form expressions to easily compute the associated tariffs. Importantly, relying on these expressions it can be shown that both the capacity-weighted distance and the least squares approaches deliver very similar tariffs. The previous claim is formalized in Section 5. In particular, it is shown that if a natural dispersion control is imposed on the tariffs as a secondary adjustment, then the two methodologies deliver exactly the same tariffs.

In the analysis, special attention is devoted to an aspect that is very relevant for an adequate tariff design and that has been overlooked by most of the literature so far.[1] Setting aside the postage stamp methodology, all other methodologies require to perform, in one way or another, computations that deal with averages associated to the entry and exit points in the network. These averages may be either weighted or unweighted, with the former taking into account that more important points should have more influence in the final average. This paper presents some arguments in favor of the weighted versions of the different methodologies. It is worth noting that the two methodologies of the original FG-2013 document in which this issue was not handled in a consistent way, virtual point-based and least squares approaches, are not present in NC-2016.

Finally, Section 6 presents a brief comparison of the methodologies discussed in this paper with other tariff methodologies. Although this comparison is made on a simple example, it helps to get a sense for the differences between the approaches regarding potential policy implications.

To conclude this introduction it is worth mentioning that the main insights from this paper were presented to ENTSOG in early 2014.[2] Remarkably, the main suggestions that can be extracted from these insights have been incorporated into NC-2016, namely, i) removal of one of the two methodologies that have been shown to be essentially equivalent and ii) disregarding the unweighted versions of the discussed methodologies.

## 2. Related literature: contribution to the state of the art

Academic research on energy networks is rapidly growing. In particular, the increasing consumption of natural gas within the European Union has led to an even sharper growth of the literature on this specific source of energy. Research focuses on a wide variety of topics such as broad regulatory aspects [11–13], security of supply and socio-economic risks [14,15], optimization models accounting for operational costs of the transmission network [16,17, and references therein] and network expansions [18–21].

This paper deals with tariff design, which is another important aspect in transmission networks.[3] More specifically, it studies the so-called entry-exit tariffs in the specific context of gas networks. Related aspects have also been discussed for electricity networks, but normally from a very descriptive perspective, dealing with specific implementations and not so much with normative approaches [22,23]. The recent European regulations, promoting the use of entry-exit tariffs, have led to the appearance of more detailed models and methodological discussions within the context of gas transmission networks.[4]

This paper contributes to the literature on tariff design by studying the capacity-weighted distance and the least squares approaches. The latter has already been studied before [7,9,10], but we do not know of any formal analysis of the former one.

### 2.1. Contribution to the state of the art

To the best of our knowledge this is the first paper in which a formal comparison of the two above methodologies is developed and, more importantly, the first one noticing that the two methodologies yield very similar tariffs. Thus, the approach in NC-2016, in which only one of them is included, seems more natural than having both of them as in FG-2013.

From the computational point of view, there is also an important addition to the existing literature. In previous works and regulations, the calculation of the tariffs associated with the least squares methodology required to solve an optimization problem. This task may be computationally demanding and, moreover, the problem is known to have infinitely many optimal solutions. The closed-form expressions obtained in this paper allow to easily characterize the solution set. More importantly, with them one can effortlessly compute the unique optimal solution associated with each desired entry-exit split.[5]

On the other hand, this paper raises an issue that is quite relevant for its policy implications: the use of weighted or unweighted methodologies. A formal analysis is presented, along with arguments in favor of weighted methodologies. This contrasts with the common practice nowadays, since most of the papers and regulations, including FG-2013, rely mainly on unweighted methodologies [6–9]. Two exceptions are Bermúdez et al. [10] and NC-2016.

Finally, the analysis also includes a comparison between the entry-exit methodologies discussed in this paper and other tariff methodologies that have been discussed in the literature. Although

[1] An exception is Bermúdez et al. [10].

[2] This presentation was made by one of the current authors in a meeting of ENTSOG's tariffs working group in Brussels.

[3] It is worth mentioning that tariff design has also been studied in distribution networks. Yet, given the "proximity" to the final consumer, regulations and general objectives are of a different nature. Thus, distribution networks are normally dealt with independently (refer to [24,25]).

[4] Interestingly, some of these discussions do not deal with the properties of specific entry-exit schemes, but with the overall limitations of the entry-exit model; see, for instance, Hewicker and Kesting [26] and Hallack and Vázquez [27].

[5] The entry-exit split specifies how much of the total revenue has to be collected at entry points and how much at exit points (see Section 3.2).

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