Winner Paper
2020 ERRA Regulatory Research Award

Three Levels of Gas Transport: Mitigating Effects of Improper Cost Allocation

Tobias Chasseur and Philipp Walla
Creos Deutschland GmbH, Germany

November 2020

The Energy Regulators Regional Association assumes no responsibility for the use that may be made of the information contained in this publication or any errors that may remain in the texts, despite the care taken in preparing them. All views, positions, and conclusions expressed in this publication are those of the authors and do not necessarily reflect the views of ERRA and its members. This text may be used only for personal research purposes. Any additional reproduction for any other purposes, whether in hard copies or electronically, requires the consent of ERRA. If cited or quoted, reference should be made to the full name of the author(s), the title, the year and the publisher.

Three levels of gas transport: mitigating effects of improper cost allocation

Tobias Chasseur
Dr.rer.nat.
Creos Deutschland GmbH
tobias.chasseur@creos-net.de
Am Zunderbaum 9, 66424 Homburg, Germany

Philipp Walla
M.Sc.
Creos Deutschland GmbH
netzzugangsmanagement@creos-net.de
Am Zunderbaum 9, 66424 Homburg, Germany

***Summary*:** A proper allocation of cost is key for a fair and liberal gas market both between intra- and cross-system transport as well as inside intra-system transport. Thus, we define three network levels of gas transport: transmission, domestic regional and domestic local – regardless of affiliation to system operators. We derive a tariffing model for those levels striking a balance between cost allocation, a liberal market and overall economic optimization. Relying on the example of Germany, an important gas network in different transport levels with a heterogeneous owner structure, we show how the proposed model can effectively reduce or prevent negative effects such as pancaking.

***Keywords*: gas network, tariff structure, cost allocation, cross-country-transit, pancaking**

I. INTRODUCTION

Gas network operators are usually either classified as transmission system operators (TSO) or distribution system operators (DSO). By basing a tariffing system solely on a system operator's legal status, regional integration and cross border trade may be hindered. These effects are due to tariff pancaking and improper cost allocation. Hence, our proposal is to classify gas networks into three levels. To find this classification, we examined network characteristics, using the example of the German gas grid. Germany has a largely developed and complex gas grid, operated by seventeen TSO and several hundred DSO (operating on regional and local level) and has significant transit as well as inner gas flows. The purpose of this paper is to find a definition of the three network levels and to link them to a tariff methodology, that reaches regulatory goals while mitigating effects of inappropriate allocation of cost. This paper should be seen as a contribution to the current discussion about network tariffs [1].

II. BODY

A classification of gas infrastructure as transport or distribution is ambiguous by definition as most pipelines do fulfil aspects of both. In contrast a differentiation as recommended by the EU Agency for the Cooperation of Energy Regulators (ACER) to the German regulatory body Bundesnetzagentur (BNetzA) is more accessible: '[an assessment …] including the unit cost differences related to infrastructure associated with the cross-system and intra-system use of the network.' [2]. To provide such an assessment and avoid cross-subsidisation within a gas-network we derive an assignment protocol for the transmission level gas infrastructure usable for cross-system transit on the example of Germany. This level of infrastructure is to be separated from the solely domestic level.

A further effect of the current regulation is the phenomenon of tariff pancaking. This happens when gas flows through the grid of various operators and the tariff of each operator is added successively. If these grids have a meshed structure, the final tariff will be way higher compared to a flow path within one single grid operator [3]. Such cases exist in Germany and could be avoided by a clear grid classification.

For a classification to fulfil the requirements of the European regulatory framework and to not hamper the goal of a successful incentive regulation we derive the following key conditions:

A. The transportation of energy to a cross-border-connection-point is to be treated equivalently to that to any other point, i.e. to exit-points to DSO, end users, storage or distribution level gas infrastructure within the TSO-network.
B. The classification of an individual pipeline cannot be depended on its assignment to a subsystem or its ownership. In the current German tariff system, a pipeline is attributed to the highest infrastructure level solely based on being operated by a TSO while comparable infrastructure operated by a DSO is not. (see figure 1)
C. An ideal classification of pipelines either cannot be influenced by system operators or does not have an influence on the system-operators profit. As neither condition can be met perfectly both shall be fulfilled approximately.

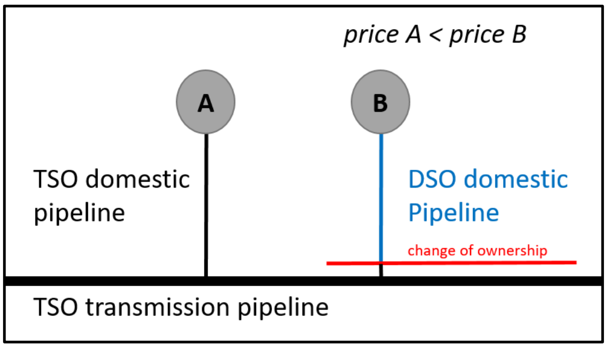

Figure 1: Schematic example of cross subsidization and pancaking effects: The tariff at exit-point B consists of postage stamps for the TSO and DSO network while at point A only the TSO stamp applies. The cost for the connection structure to point A is solidarized between intra-system and cross-system users of the TSO-network.

For the scope of this paper we refer to a pipeline as the vertices of the graph defined by the gas grid, i.e. any junction divides a pipeline into multiple pipes.

To classify the transmission and (at least one) domestic level meeting appropriate allocation of cost as well as conditions A, B, C we propose to use the associated flux or capacity of a pipeline. This approach raises two fundamental questions:

- Above which capacity can pipelines be used for cross-system-transit?
- How to assign a suitable capacity to all pipelines within the (TSO-)network?

To answer the first question, we analyse the capacities used for the network development plan of the German TSO (NEP) [4,5]. Those represent the use-case for which the German gas grid is designed and therefore allow for a fair comparison between varying temperature dependencies. Furthermore, they are approved by the regulation body BNetzA, thus meeting requirement C despite being derived by system operators. The exit capacities are aggregated for each cross-border-connection-point and displayed in figure 2.

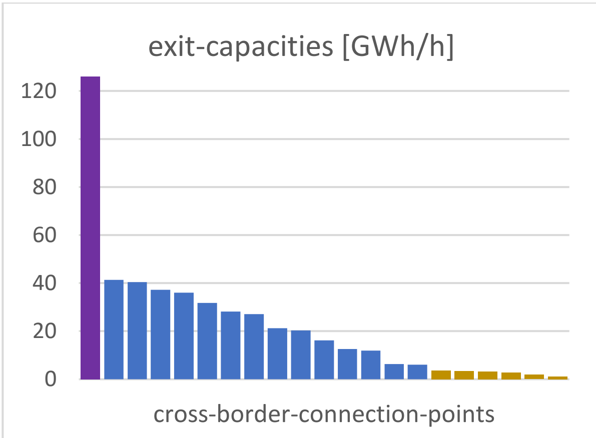

Figure 2: The aggregated 2021 exit-capacities of German cross-border-connection-points are clustered in three groups. The blue cluster between 6 and 42 GWh/h represents typical transit capacities.

The exit capacities can be clustered into three groups, one of which consists only of an atypically high capacity at the exit-point 'Deutschneudorf-EUGAL'. Similarly, the six smallest exit-capacities below 3.5 GWh/h can be associated with exit-points that either connect to distribution-like infrastructure or do connect to the European transport level with negligible impact. For example, the exit point Lindau (3.2 GWh/h) connects to a singular network which is classified as distribution level in Austria [6].

The remaining 14 'typical' cross-border-exit-points range between 6 and 42 GWh/h. To accommodate interconnection in the German gas grid we propose and assume a capacity limit of 4 GWh/h for pipelines to be feasible for typical transit points or transport which is equivalent according to requirement A. In a European adaptation the capacity limit may be constant or declining for downstream countries.

To be able to compare the capacities associated to pipelines to the capacity limit those need to refer to the same entry- and exit-capacities used for the NEP – attributing those to individual pipelines is neither unambiguous nor trivial due to nontrivial interconnections in the TSO gas grid. The necessary network simulation is done by the TSO on a regular basis as part of the network development process. However, to meet C, this either needs to be validated by a regulatory body or needs to be calculated or delegated by the regulator where the network operators have the possibility to validate the results. Either option needs to integrate those parts of the DSO gas grid which might be classified as transport level infrastructure.

The current tariff structure solidarizes cost between transit and regional components of TSO networks. This includes solidarizing with respect to distance. To dissolve the solidarization between national transport and transit it is necessary to assess the average network length used. This distance can be calculated in detail using the capacity weighted distance application [7].

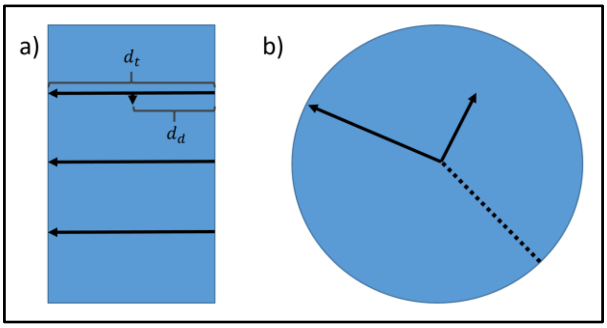

Figure 3: Country models to determine a realistic range for transport distance ratios d_r in the tranmission level infrastructure by comparing the distance from entry to domestic level exit d_d with distnace to cross-border-connections d_t. a) depicts a model with a distinct flow direction – in this example the average distance to a domestic exit is half of d_t – while b) is fed by a singular entry or source connecting domestic level and cross-border-connection points assumed at homogeneous density.

For an idealized network boundaries for realistic distance ratios can be derived: If a distinct transmission direction is defined as depicted for a model country in figure 3 a) and homogeneous density of exit to the domestic level is assumed, the average distance from entry to domestic exit d_d is half of the distance between entry and transmission d_t, thus setting the ratio

$$d_r = \frac{d_t}{d_d} = 2\,.$$

As gas transport is characterized by having more exit points than sources, an extreme counter example is constructed in figure 3 b): A circular country with radius r_0 is fed by a singular entry connected to the centre by a pipeline without junctions. With a given base distance r_0, a given centre-transmission-exit distance r_0 and an average centre-domestic distance of $2/3\, r_0$ the distance ratio amounts to $d_r = 1.2$, for a centre gas source (or while decreasing the weight of the efficient entry pipeline) that value shifts to $d_r = 1.5$. In conclusion, the possible ratio range spans between 1.2 and 2 while higher values seem more probable for a real country.[1]

Classifying pipelines into transmission and domestic level infrastructure in the previously described way, enables the regulator to set tariff methodologies for each of these categories and to better allocate associated cost. In a revenue cap regulated system, the associated costs, i.e. the corresponding share of the revenue cap, has to be determined for each category. If costs of each category are only allocated to this categories users, cross- subsidization can be avoided. With a given distance ratio d_r, either calculated using capacity weighted distance or set for the characteristic gas grid structure, exit from the transmission level at

[1] It is possible to construct an example where $d_r < 1.2$, however, that example allows for entry and transmission exit to be within close proximity which seems unlikely as it indicates a reversion of flow direction. Small restrictions on entry-transmission proximty result in values $d_r > 1.2$.

cross-border-connection-points and to the domestic level is comparable at equal capacities. To avoid an entry barrier for cross-border-connection and therefore promote a liberal gas market a uniform per capacity tariff is necessary. Furthermore, this model provides equal transport cost to all downstream countries and a well-defined transition to the domestic level at $1/d_r$ of the cross-border connection postage stamp. This reference price method is according to EU regulation 2017/460 ("TAR NC").

Because the network classification between the transmission and domestic level is crucial for determining cross-border tariffs, a tariff system should be set by similar regulation across connected countries. In contrast, the methodology for the solely domestic level does not have to be determined by uniform regulation, but can be set individually by the national regulatory framework and in such differ in every state. Cost allocation on the domestic levels usually does not influence costs related to cross-border trade.

The German national regulatory authority decided to implement regulation (EU) 2017/460 ("TAR NC") by setting a postage stamp methodology. In simplifying words, the postage stamp is calculated by dividing the sum of the allowed revenue of every TSO by the sum of all predicted capacities, applying the entry-exit-split, and finally adapted with a rescaling factor. This postage stamp is predicted to be 3,67 €/kWh/h/a in the 4th quarter 2021 in the German-wide market area [8].

This calculation takes every grid part in the legal ownership of a TSO into account. In this example, implementing the proposed tariff system means excluding the domestic level part of the TSO grid and introducing the distance ratio factor d_r.

The allocation and pricing of the transmission level introduces direct implications for the domestic level infrastructure:

a) As for the transmission level, the domestic tariff model is applied by all TSO jointly, i.e. a consumer should pay the same tariff no matter to which TSO the consumer is connected. This ensures a level-playing field, promotes reasonable use of the existing infrastructure, prevents market entry barriers and reflects that all TSO collaborate and should therefore distribute their costs collaboratively.

b) The domestic level the capacity price consists of the transmission level post stamp and a domestic exclusive component. To assure a continuous tariff model i.e. to avoid a jump in capacity pricing, the total domestic tariff is set to converge to transmission level near the limit capacity. A declining unit cost progression of the domestic component as discussed e.g. in [9] is implied. A domestic tariff can never be cheaper than a transmission tariff as it always contains the transmission component.

To describe the tariff progression on the domestic level tariff qualitatively we examined various datasets regarding capacity bookings at various grid points, revenue caps and cost driver analyses. In order to form a tariff system that leads to a cost recovery while respecting the distribution of capacities through various grid points, our assessment results in a tariff progression as shown in figure 4.

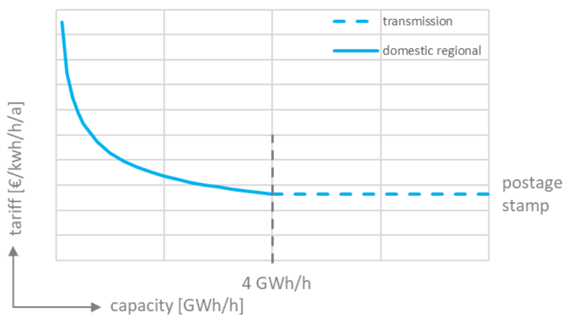

Figure 4: Progression of the TSO-tariff at the transmission and domestic level

The introduced tariff structure ensure costs of the transmission level are not mixed with the domestic level and therefore prevents cross-subsidization between intra- and cross-system-usage limiting negative effects on cross-border trade. Market entry barriers for cross-border traders are avoided due to the equal postage stamp at all cross-border-connection points. Furthermore, it has positive effects on cost allocation in the domestic level by mitigation of the problematic pancaking effects: A local grid user (either a locally distributing DSO or an end-consumer, in this example attributed with a comparably low capacity) can be directly downstream to either a TSO network with relatively distinct regional distribution or a regional DSO connected to the TSO network. The latter case is typically worse-dispositioned (at least in the example of the current German regulation): The first grid user is only attributed with the TSO tariff while the second also pays the tariff of the upstream DSO. In the derived pricing model, the effect diminishes as in the second case the TSO tariff is determined by the capacity of the upstream DSO – as the TSO network is only used up to that capacity. The effect is illustrated in figure 5.

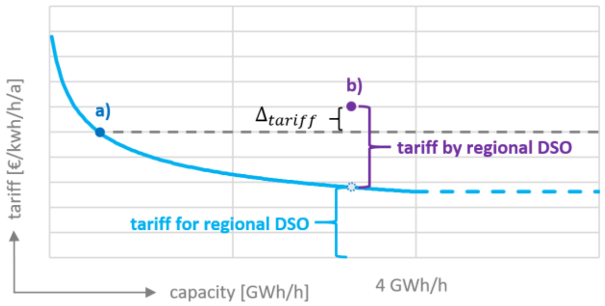

Figure 5: Tariff comparison for two different options of an example local user to connect to the upstream network under a unit cost progression model in the domestic TSO network. A direct connection to the TSO network (a)) is priced relatively high due to low capacity. Option b) describes connecting to a regional DSO who in turn is connected to the TSO system. The tariff then consists of a lower TSO postage stamp due to higher capacity and the intrinsic tariff for the regional DSOs network. The tariff gap Δ – defined as the price difference of options a) and b) – describes the remainder of the pancaking effect.

The above example of the local user shows a fairer allocation of cost, however, in a regulatory discussion analyzing the gas grid as a whole is advised. For the local user a lower tariff is an important incentive (especially for end users) when connecting to upstream grids, however to maximize overall efficiency, the cost of connection is likely the deciding factor. The incentive for potentially inefficient structures increases with the tariff gap – therefore it is important to minimize this incentive.

To accomplish that the domestic component of the TSO network and a – to be defined – regional component of the DSO network can be priced together as described. Therefore, the definition needs to address that parts of the DSO network might be an alternative access point to upstream gas grids. As in the DSO network the maximum operating pressure (MOP) decreases downstream and as the pressure is a reliable indicator for the capability of a pipeline we define the domestic regional level of the DSO network as having MOP above a limit pressure. While any limit below typical MOP in TSO and regional networks is applicable, to meet condition C a limit that arises naturally from technical rules and associated operating expense is preferable. For the German example the limit of 16 bar arises from the technical framework 'Gashochdruckleitungsverordnung' as it applies for MOP above that level.

With both capacity and pressure limit a countries gas network divides into transmission, domestic regional and domestic local level infrastructure. On the domestic local level, each DSO should raise an individual tariff as the operation of gas grids on that level typical have no little to no effect on each other, however, a solidarization of cost is also possible. The resulting tariff structure is summarized in table 1.

grid point	applied tariff
intra-system transmission level	transmission level postage stamp
cross-border-connection point	postage stamp × d_r
domestic regional level (TSO or DSO)[2]	transmission level postage stamp + domestic regional tariff (capacity dependent)
domestic local	postage stamp + domestic regional component at connection point + individual local tariff

Table 1: Three level tariff stystem

[2] Including exit points to domestic levels in neighbouring countries, i.e., the lowest cluster in figure 2. The minimal tariff at those points should equal that at cross-border-connection points.

III. Conclusions

This paper derived that tariffing of a gas network based on the classification of network operators as TSO or DSO can result in undue effects of cross-subsidisation and pancaking. We showed that a solution can be provided by differentiating three network levels: transmission, domestic regional and domestic local. We derived three key parameter (limit capacity [4 GWh/h], limit pressure [MOP 16 bar] and distance ratio [$1.2 \leq d_r \leq 2$]) of a gas network and used those to set an accurate tariff model.

The transmission level can be found by forming clusters of the capacity, while the tariff system takes distances and cost drivers into account. Our assessment bases on the wide network and heterogeneous owner structure in Germany. We encourage policy makers to take this paper into consideration as contribution to the current discussion about network tariffs.

References

[1] Agency for the Cooperation of Energy Regulators, "The internal gas market in Europe: The role of transmission tariffs" *Agency for the Cooperation of Energy Regulators*, 2020. [Online]. Available: https://nra.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/The%20internal%20gas%20market%20in%20Europe_The%20role%20of%20transmission%20tariffs.pdf. [Sep. 26, 2020].

[2] Agency for the Cooperation of Energy Regulators, "Agency report - analysis of the consultation document for Germany" *Agency for the Cooperation of Energy Regulators*, 2019. [Online]. Available: acer.europa.eu [Accessed: Sep. 26, 2020]

[3] C-K. Chyong, "Challenges to the Future of European Single Market in Natural Gas" Cambridge Working Papers in Economics 1918, 27, February 2019. Available: http://www.econ.cam.ac.uk/research-files/repec/cam/pdf/cwpe1918.pdf. [Accessed Sept. 24, 2020].

[4] Vereinigung der Fernleitungsnetzbetreiber Gas e.V. "NEP-Gas-Datenbank" ongoing. [Online]. Available: https://www.nep-gas-datenbank.de/app/#!/ [Accessed: Sep. 10, 2020]

[5] Vereinigung der Fernleitungsnetzbetreiber Gas e.V., „Netzentwicklungsplan Gas 2020–2030 Entwurf", 2020. [Online]. Available: https://www.fnb-gas.de [Accessed Sept. 24, 2020].

[6] Austrian Gas Grid Management AG, "Erdgasinfrastruktur von Oesterreich". [Online]. Available: www.aggm.at. [Accessed Aug. 13, 2020].

[7] European network of transmission system operators for gas. "Implementation Document for the Network Code on Harmonised Transmission Tariff Structures for Gas Second Edition (revised)," 2018. [Online]. Available: www.entsog.eu [Accessed: Sep. 20, 2020].

[8] Bundesnetzagentur, "BK9-19-610 "REGENT 2021"" September, 2020. Available: https://www.bundesnetzagentur.de/DE/Service-Funktionen/Beschlusskammern/1_GZ/BK9-GZ/2019/2019_bis0999/BK9-19-607_BK9-19-610_BK9-19-612/BK9-19-0610_Beschluss.html?nn=364474. [Accessed Sept. 24, 2020].

[9] Swiss Economics SE AG, "Kostentreiberanalyse und Effizienzvergleich der Gasfernleitungsnetzbetreiber. Gutachten für die dritte Regulierungsbehörde" March, 2018. Available: https://www.bundesnetzagentur.de/DE/Service-Funktionen/Beschlusskammern/BK09/BK9_01_Aktuell/Downloads/Kostentreiberanalyse%20und%20Effizienzvergleich%20der%20Gasfernleitungsnetzbetreiber.html. [Accessed Sept. 24, 2020].