Tariff Methodologies: Examples

Illustrating the document

Public Consultation on Draft Framework Guidelines on rules regarding harmonised transmission tariff structures for gas

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The aim of this document is to illustrate the cost allocation methodologies described in the chapter 3 of the Framework Guidelines for Harmonised Tariff Structures, and allow stakeholders taking part in the Public Consultation to better understand and comment the approach currently envisaged.

All examples depart from a simple network situation, and follow each step of the respective methodologies, as detailed in the draft Framework Guidelines submitted to public consultation.

These examples have been developed for illustration purposes only and cannot take precedence over the principles laid down in the draft Framework Guidelines.

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Table of content

1 Postage stamp

1.1 Inputs on the allowed revenues

i. **Allowed revenues: 100 000 €**

ii. **Capacity/commodity split: 85/15**

15% (15 000 €) of the revenue is to be recovered from commodity charge (based on NRA decision).

iii. **Entry-exit split: 50/50**

42 500 € is allocated to entries, 42 500 € is allocated to exits (including storage entry and exit points, exogenously and ex-ante, based on NRA decision).

iv. **Storage discount: 80%**

The discount for transmission to and from gas storages is set as 80% of the average fee rate at entry and exit points to and from the transmission system respectively (based on NRA decision).

v. **Additional remarks**

Total volume of gas fuel planed for transmission: $1.5*10^6$ GWh. Commodity charge is being collected at exit points excluding underground storages (NRA decision).

1.2 Transmission network characteristics

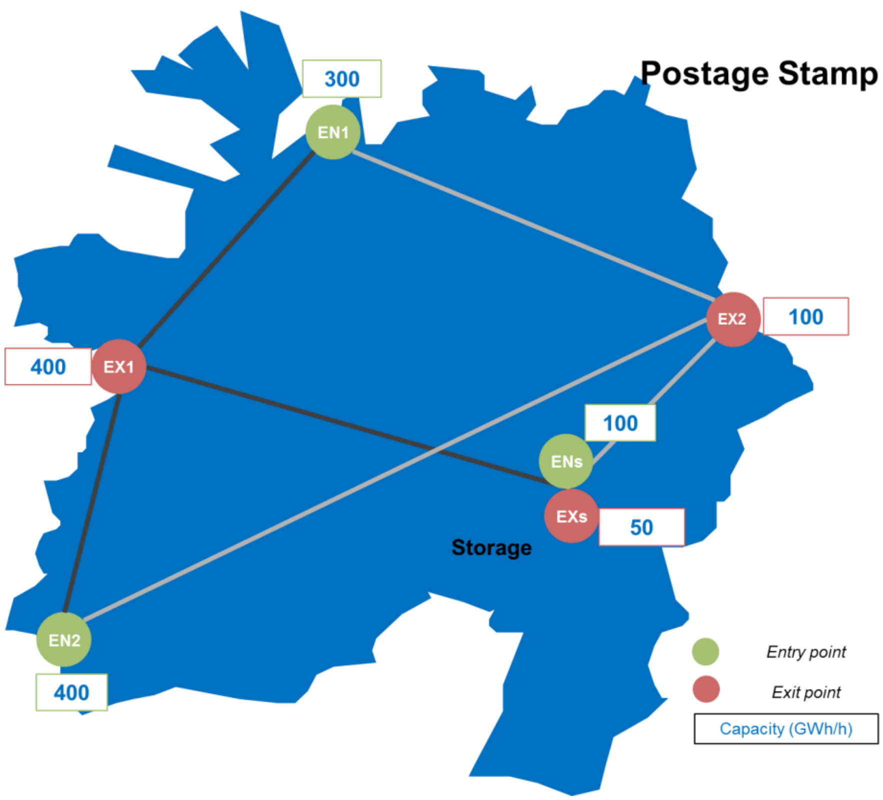

Figure 1: Transmission network characteristics - postage stamp

1.3 Main methodology[1]

$BC_{\sum En}$: Booked capacity at entry points

$BC_{\sum Ex}$: Booked capacity at exit points

$BC_{\sum EnST}$: Booked capacity at entry points from gas storages

$BC_{\sum ExST}$: Booked capacity at exit points to gas storages

$V_{\sum Ex}$: Volume of gas to be transmitted

$S_{\sum En/Ex}$: Number of entry and exit points where charge is being collected

R_{En}: Revenue to be collected from entry points

R_{Ex}: Revenue to be collected from exit points

R_{EnST}: Revenue to be collected from entry points from gas storages

R_{ExST}: Revenue to be collected from exit points to gas storages

R_{VEx}: Revenue to be collected from commodity charge

$R_{SEn/Ex}$: Revenue to be collected from subscription fee

ENTRY CHARGES

(1) $\boldsymbol{T_{En} = \frac{R_{En}}{BC_{\sum En}}}$, where T_{En} is the annual [a] capacity tariff at entry points to the system,

(2) $\boldsymbol{T_{EnST} = \frac{R_{EnST}}{BC_{\sum EnST}}}$, where T_{EnST} is the annual [a] capacity tariff at entry points from gas storages,

while (3) $\boldsymbol{T_{EnST} = 0,2 * T_{En}}$

and (4) $R_{EnST} + R_{En} = 42500$

Thus, from (1), (2), (3) and (4):

$$T_{En} * BC_{\sum En} + T_{EnST} * BC_{\sum EnST} = 42500$$

$$T_{En} * BC_{\sum En} + 0.2 * T_{En} * BC_{\sum EnST} = 42500$$

$$T_{En} = \frac{42500}{BC_{\sum En} + 0.2 * BC_{\sum EnST}}$$

Example:

$$T_{En} = \frac{\frac{42500}{300 + 400 + 0.2 * 100} = 59{,}02 \frac{€}{GWh/h}}{a}$$

[1] see section 3.4.1.1 of the Revised chapter on Cost Allocation and determination of the reference price

$$T_{EnST} = 0.2 * 59.02 = 11{,}81 \frac{\frac{€}{GWh/h}}{a}$$

EXIT CHARGES

$\boldsymbol{T_{Ex} = \frac{R_{Ex}}{BC_{\sum Ex}}}$, where $T_{Ex}$is the annual [a] capacity tariff at exit points from the system,

$\boldsymbol{T_{ExST} = \frac{R_{ExST}}{BC_{\sum ExST}}}$, where T_{ExST} is the annual [a] capacity tariff at exit points to gas storages,

$\boldsymbol{T_{VEx} = \frac{R_{VEx}}{V_{\sum Ex}}}$, where T_{VEx} is the commodity tariff at exit points from the system,

while $\boldsymbol{T_{ExST} = 0,2 * T_{Ex}}$

and $R_{ExST} + R_{Ex} = 42500$

again,

$$T_{Ex} = \frac{42500}{BC_{\sum Ex} + 0.2 * BC_{\sum ExST}}$$

Example:

$$T_{Ex} = \frac{\frac{42500}{400 + 100 + 0.2 * 50} = 83{,}33 \frac{€}{GWh/h}}{a}$$

$$T_{ExST} = \frac{0.2 * 83.33 = 16{,}66 \frac{€}{GWh/h}}{a}$$

$$T_{VEx} = \frac{15000}{1500000} = 0{,}01 \frac{€}{Gwh}$$

2 Capacity-Weighted Distance approach – Variant A

2.1 Inputs on the allowed revenues

i. **Allowed revenues:100 000 €**

ii. **Capacity/commodity split:100/0**

No commodity charge is applied.

iii. **Entry-exit split: 50/50**

50% (50.000 €) is allocated to entries, 50% (50.000 €) is allocated to exits (exogenously and ex-ante).

iv. **Additional input: booked capacity (see Figure 2 below)**

Entry 1: 7,8

Entry 2: 13,8

Entry 3: 25

Exit 1: 14

Exit 2: 25

2.2 Transmission network characteristics

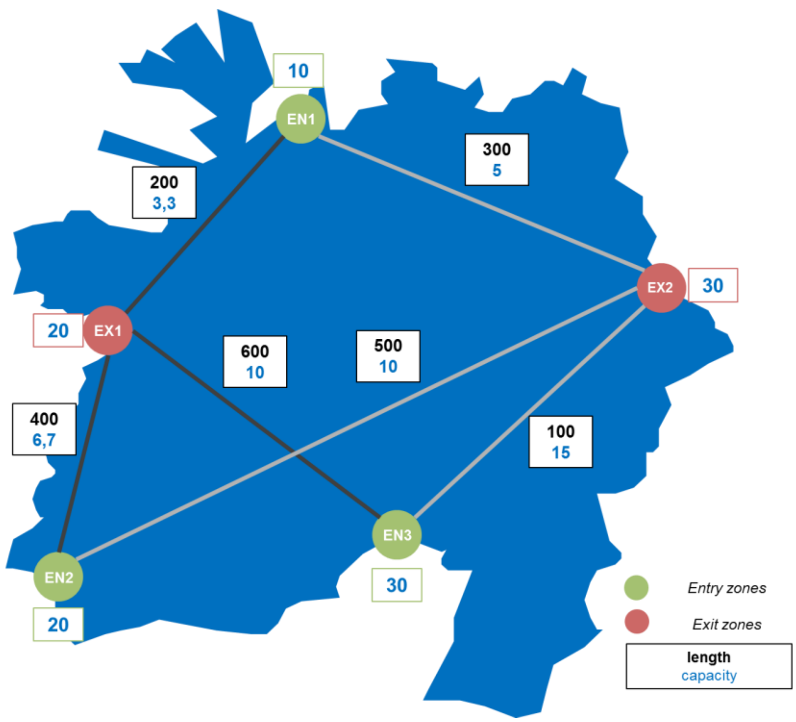

Figure 2 Transmission network characteristics - capacity weighted distance (variant A)

2.3 Main methodology[2]

i. Define technical capacity at each entry and exit point; define forecasted booked capacity at each entry and exit point; [define (ex ante) the share of revenue to be collected from entry points and the share of revenue to be collected from exit points].

<u>General:</u>

$C_{En_i}: Capacity\ at\ entry\ point\ i$

$C_{Ex_j}: Capacity\ at\ exit\ point\ j$

$BC_{En_i}: Forecasted\ Booked\ Capacity\ at\ entry\ point\ i$

$BC_{Ex_j}: Forecasted\ Booked\ Capacity\ at\ exit\ point\ j$

R_{En}: *Revenue to be collected from entry points*

R_{Ex}: *Revenue to be collected from exit points*

<u>Example:</u>

$C_{En_1} = 10$

$C_{En_2} = 20$

$C_{En_3} = 30$

$C_{Ex_1} = 20$

$C_{Ex_2} = 30$

$BC_{En_1} = 7{,}8$

$BC_{En_2} = 13{,}8$

$BC_{En_3} = 25$

$BC_{Ex_1} = 14$

$BC_{Ex_2} = 25$

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[2] see section 3.4.1.2 of the Revised chapter on Cost Allocation and determination of the reference price

$R_{En} = 50.000$ €

$R_{Ex} = 50.000$ €

ii. Calculate distance between each entry point and each exit point in the system [3];

General:

$\left[D_{En_i Ex_j}\right]: matrix\ of\ the\ distances\ from\ entry\ i\ to\ exit\ j$

Example:

$D_{En_1Ex_1} = D_{Ex_1En_1} = 200$

$D_{En_1Ex_2} = D_{Ex_2En_1} = 300$

$D_{En_2Ex_1} = D_{Ex_1En_2} = 400$

$D_{En_2Ex_2} = D_{Ex_2En_2} = 500$

$D_{En_3Ex_1} = D_{Ex_1En_3} = 600$

$D_{En_3Ex_2} = D_{Ex_2En_3} = 100$

iii. Calculate the proportion of technical entry (respectively exit) capacity at each point relative to the total technical entry (respectively exit) capacity;

General:

$P_{En_i} = \frac{C_{En_i}}{\sum C_{En}}\ where\ P_{En_i}\ is\ the\ proportion\ factor\ of\ entry\ point\ i$

$P_{Ex_j} = \frac{C_{Ex_j}}{\sum C_{Ex}}\ where\ P_{Ex_j}\ is\ the\ proportion\ factor\ of\ exit\ point\ j$

Example:

$$P_{En_1} = \frac{C_{En_1}}{C_{En_1} + C_{En_2} + C_{En_3}} = \frac{10}{10 + 20 + 30} = \frac{1}{6}$$

$$P_{En_2} = \frac{C_{En_2}}{C_{En_1} + C_{En_2} + C_{En_3}} = \frac{20}{10 + 20 + 30} = \frac{1}{3}$$

$$P_{En_3} = \frac{C_{En_3}}{C_{En_1} + C_{En_2} + C_{En_3}} = \frac{30}{10 + 20 + 30} = 0{,}5$$

[3] this can be done by calculating the shortest distance from each entry point to each exit point

$$P_{Ex_1} = \frac{C_{Ex_1}}{C_{Ex_1} + C_{Ex_2}} = \frac{20}{20+30} = 0{,}4$$

$$P_{Ex_2} = \frac{C_{Ex_2}}{C_{Ex_1} + C_{Ex_2}} = \frac{30}{20+30} = 0{,}6$$

iv. For each entry point (respectively exit point) , calculate capacity-weighted average distance to all exit points (respectively entry points); average distance is weighted by technical capacity

General:

$$AD_{En_i} = \sum P_{Ex_j} \times D_{En_iEx_j} where\ AD_{En_i}\ is\ the\ capacity\ weighted\ average\ distance\ from\ entry\ i$$

$$AD_{Ex_j} = \sum P_{En_i} \times D_{Ex_jEn_i} where\ AD_{Ex_j}\ is\ the\ capacity\ weighted\ average\ distance\ from\ exit\ j$$

Example:

Capacity Weighted Average Distance from Entry 1 to all Exits:

$AD_{En_1} = P_{Ex_1} * D_{En_1Ex_1} + P_{Ex_2} * D_{En_1Ex_2} = 0{,}4 * 200 + 0{,}6*300 = 260$

Capacity Weighted Average Distance from Entry 2 to all Exits:

$AD_{En_2} = \cdots = 460$

Capacity Weighted Average Distance from Entry 3 to all Exits:

$AD_{En_3} = \cdots = 300$

Capacity Weighted Average Distance from Exit 1 to all Entries:

$AD_{Ex_1} = P_{En_1} * D_{Ex_1En_1} + P_{En_2} * D_{Ex_1En_2} + P_{En_3} * D_{Ex_1En_3} = \frac{1}{6} * 200 + \frac{1}{3}*400+0{,}5*600 = 466{,}67$

Capacity Weighted Average Distance from Exit 2 to all Entries:

$AD_{Ex_2} = \ldots = \frac{1}{6} * 200 + \frac{1}{3}*400+0{,}5*600 = 266{,}67$

v. Determine the weight of each entry point (respectively exit point) as the ratio between the product of its technical capacity with its average distance and the sums of such products for all entry points (respectively exit point)

General:

$$W_{En_i} = \frac{C_{Eni} \times AD_{En_i}}{\sum C_{Eni} \times AD_{En_i}}\ whereW_{En_i}\ is\ the\ weight\ of\ entry\ point\ i$$

$$W_{Ex_j} = \frac{C_{Ex_j} \times AD_{Ex_j}}{\sum C_{Ex_j} \times AD_{Ex_j}}\ where W_{Ex_j}\ is\ the\ weight\ of\ exit\ point\ j$$

Example:

The products of capacity and average distance are:

$$C_{En_1} * \ AD_{En_1} = 10 * 260 = 2.600$$

$$C_{En_2} * \ AD_{En_2} = 20 * 460 = 9.200$$

$$C_{En_3} * \ AD_{En_3} = 30 * 300 = 9.000$$

$$C_{Ex_1} * \ AD_{Ex_1} = 20 * 466{,}67 = 9.333{,}33$$

$$C_{Ex_2} * \ AD_{Ex_2} = 30 * 266{,}67 = 8.000$$

$$W_{En_1} = \frac{C_{En_1} * AD_{En_1}}{C_{En_1} * AD_{En_1} + C_{En_2} * AD_{En_2} + C_{En_3} * AD_{En_3}} = \frac{2.600}{2.600+9.200+9.000} = 0{,}125$$

$$W_{En_2} = \frac{C_{En_2} * \ AD_{En_2}}{C_{En_1} * \ AD_{En_1} + C_{En_2} * \ AD_{En_2} + C_{En_3} * \ AD_{En_3}} = \frac{9.200}{2.600 + 9.200 + 9.000} = 0{,}442$$

$$W_{En_3} = \frac{C_{En_3} * \ AD_{En_3}}{C_{En_1} * \ AD_{En_1} + C_{En_2} * \ AD_{En_2} + C_{En_3} * \ AD_{En_3}} = \frac{9.000}{2.600 + 9.200 + 9.000} = 0{,}433$$

$$W_{Ex_1} = \frac{C_{Ex_1} * AD_{Ex_1}}{C_{Ex_1} * AD_{Ex_1} + C_{Ex_2} * AD_{Ex_2}} = \frac{9.333{,}33}{9.333{,}33+8.000} = 0{,}538$$

$$W_{Ex_2} = \frac{C_{Ex_2} * AD_{Ex_2}}{C_{Ex_1} * AD_{Ex_1} + C_{Ex_2} * AD_{Ex_2}} = \frac{8.000}{9.333{,}33+8.000} = 0{,}462$$

vi. Allocate entry cost (respectively exit costs) by multiplying the total revenue to be collected from entry points by the weight of each entry point (respectively exit point)

General:

$$R_{En_i} = W_{En_i} \times \ R_{En}\ where\ \ R_{En_i}\ is\ the\ revenue\ to\ be\ collected\ from\ entry\ point\ i$$
$$R_{Ex_j} = W_{Ex_j} \times \ R_{Ex}\ where\ \ R_{Ex_j}\ is\ the\ revenue\ to\ be\ collected\ from\ exit\ point\ j$$

Example:

$$R_{En_1} = W_{En_1} * R_{En} = \ \ 0{,}125 * 50.000€ = 6.250{,}00\ €$$

$$R_{En_2} = W_{En_2} * R_{En} = 0{,}442 * 50.000€ = 22.115{,}38\ €$$

$$R_{En_3} = W_{En_3} * R_{En} = 0{,}433 * 50.000€ = 21.634{,}62\ €$$

$R_{Ex_1} = W_{Ex_1} * R_{Ex} = \ 0{,}538 * 50.000€ = 26.923{,}08\ €$

$R_{Ex_2} = W_{Ex_2} * R_{Ex} = 0{,}462 * 50.000€ = 23.076{,}92\ €$

vii. Determine tariffs by dividing revenue to be collected from a point by its forecasted booked capacity

General:

$T_{En_i} = \frac{R_{En_i}}{BC_{En_i}}$ *where* T_{En_i} *is the tariff at entry point i*

$T_{Ex_j} = \frac{R_{Ex_j}}{BC_{Ex_j}}$ *where* T_{En_i} *is the tariff at exit pont i*

Example:

$T_{En_1} = \frac{R_{En_1}}{BC_{En_1}} = \frac{6.250}{7{,}8} = 801{,}28\ \frac{€}{kWh/h}\ /\ a$

$T_{En_2} = \frac{R_{En_2}}{BC_{En_2}} = \frac{22.100}{13{,}8} = 1.602{,}56\ \frac{€}{kWh/h}\ /\ a$

$T_{En_3} = \frac{R_{En_3}}{BC_{En_3}} = \frac{21.650}{25} = 865{,}38\ \frac{€}{kWh/h}\ /\ a$

$T_{Ex_1} = \frac{R_{Ex_1}}{BC_{Ex_1}} = \frac{26.900}{14} = 1.923{,}08 \frac{€}{kWh/h}\ /\ a$

$T_{Ex_2} = \frac{R_{Ex_2}}{BC_{Ex_2}} = \frac{23.100}{25} = 923{,}08\ \frac{€}{kWh/h}\ /\ a$

Alternatively, step5 can be executed in a similar way by relying on forecasted booked capacity. In a first step (steps 1-4), capacity weighted average distance is calculated based on technical capacity. In a second step, costs are/ revenue is allocated considering forecasted booked capacity: the weight of each point is determined by using forecated booked capacity, not technical capacity. This is justified by the fact that only a part of the technical capacity is booked and that network load is rather based on booked capacities than on technical capacity.

v. Determine the weight of each entry point (respectively exit point) as the ratio between the product of its ***forecasted booked capacity*** with its average distance and the sums of such products for all entry points (respectively exit point)

General:

$$W_{En_i} = \frac{BC_{E_{ni}} \times AD_{En_i}}{\sum BC_{E_{ni}} \times AD_{En_i}}\ where W_{En_i}\ is\ the\ weight\ of\ entry\ point\ i$$

$$W_{Ex_j} = \frac{BC_{Ex_j} \times AD_{Ex_j}}{\sum BC_{Ex_j} \times AD_{Ex_j}}\ where W_{Ex_j}\ is\ the\ weight\ of\ exit\ point\ j$$

Example:

The products of capacity and average distance are:

$BC_{En_1} * AD_{En_1} = 7{,}8 * 260 = 2.028$

$BC_{En_2} * AD_{En_2} = 13{,}8 * 460 = 6.348$

$BC_{En_3} * AD_{En_3} = 25 * 300 = 7.500$

$BC_{Ex_1} * AD_{Ex_1} = 14 * 466{,}67 = 6.533{,}33$

$BC_{Ex_2} * AD_{Ex_2} = 25 * 266{,}67 = 6.666{,}67$

$$W_{En_1} = \frac{BC_{En_1} * AD_{En_1}}{BC_{En_1} * AD_{En_1} + BC_{En_2} * AD_{En_2} + BC_{En_3} * AD_{En_3}} = \frac{2028}{2028+6348+7500} = 0{,}128$$

$$W_{En_2} = \frac{BC_{En_2} * AD_{En_2}}{BC_{En_1} * AD_{En_1} + BC_{En_2} * AD_{En_2} + BC_{En_3} * AD_{En_3}} = \frac{6348}{2028+6348+7500} = 0{,}400$$

$$W_{En_3} = \frac{BC_{En_3} * AD_{En_3}}{BC_{En_1} * AD_{En_1} + BC_{En_2} * AD_{En_2} + BC_{En_3} * AD_{En_3}} = \frac{7500}{2028+6348+7500} = 0{,}472$$

$$W_{Ex_1} = \frac{BC_{Ex_1} * AD_{Ex_1}}{BC_{Ex_1} * AD_{Ex_1} + BC_{Ex_2} * AD_{Ex_2}} = \frac{6533{,}33}{6533{,}33+6666{,}67} = 0{,}495$$

$$W_{Ex_2} = \frac{BC_{Ex_2} * AD_{Ex_2}}{BC_{Ex_1} * AD_{Ex_1} + BC_{Ex_2} * AD_{Ex_2}} = \frac{6666{,}67}{6533{,}33+6666{,}67} = 0{,}505$$

vi. Allocate entry cost (respectively exit costs) by multiplying the total revenue to be collected from entry points by the weight of each entry point (respectively exit point)

General:

$R_{En_i} = W_{En_i} \times R_{En}$ $where$ R_{En_i} $is\ the\ revenue\ to\ be\ collected\ from\ entry\ point\ i$

$R_{Ex_j} = W_{Ex_j} \times R_{Ex}$ $where$ R_{Ex_j} $is\ the\ revenue\ to\ be\ collected\ from\ exit\ point\ j$

Example:

$R_{En_1} = W_{En_1} * R_{En} = 0{,}128 * 50.000€ = 6.387{,}00\ €$

$R_{En_2} = W_{En_2} * R_{En} = 0{,}400 * 50.000€ = 19.992{,}44\ €$

$R_{En_3} = W_{En_3} * R_{En} = 0{,}472 * 50.000€ = 23.620{,}56\ €$

$R_{Ex_1} = W_{Ex_1} * R_{Ex} = 0{,}495 * 50.000€ = 24.747{,}47\ €$

$R_{Ex_2} = W_{Ex_2} * R_{Ex} = 0{,}505 * 50.000€ = 25.252{,}53\ €$

vii. Determine tariffs by dividing revenue to be collected from a point by its forecasted booked capacity,

General:

$T_{En_i} = \frac{R_{En_i}}{BC_{En_i}}$ *where* T_{En_i} *is the tariff at entry point i*

$T_{Ex_j} = \frac{R_{Ex_j}}{BC_{Ex_j}}$ *where* T_{Ex_j} *is the tariff at exit pont j*

Example:

$T_{En_1} = \frac{R_{En_1}}{BC_{En_i}} = \frac{6.387}{7,8} = 818,85 \frac{€}{kWh/h} \; / \; a$

$T_{En_2} = \frac{R_{En_2}}{BC_{En_2}} = \frac{19.992}{13,8} = 1.448,73 \frac{€}{kWh/h} \; / \; a$

$T_{En_3} = \frac{R_{En_3}}{BC_{En_3}} = \frac{23.621}{25} = 944,82 \frac{€}{kWh/h} \; / \; a$

$T_{Ex_1} = \frac{R_{Ex_1}}{BC_{Ex_1}} = \frac{24.747}{14} = 1.767,68 \frac{€}{kWh/h} \; / \; a$

$T_{Ex_2} = \frac{R_{Ex_2}}{BC_{Ex_2}} = \frac{25.253}{25} = 1.010,10 \frac{€}{kWh/h} \; / \; a$

3 Capacity-Weighted Distance approach – Variant B

3.1 Inputs on the allowed revenues

i. **Allowed revenue: 500 000 000 €**

ii. **Entry-exit split: the Entry-Exit split results from the methodology (see below)**

3.2 Transmission network characteristics

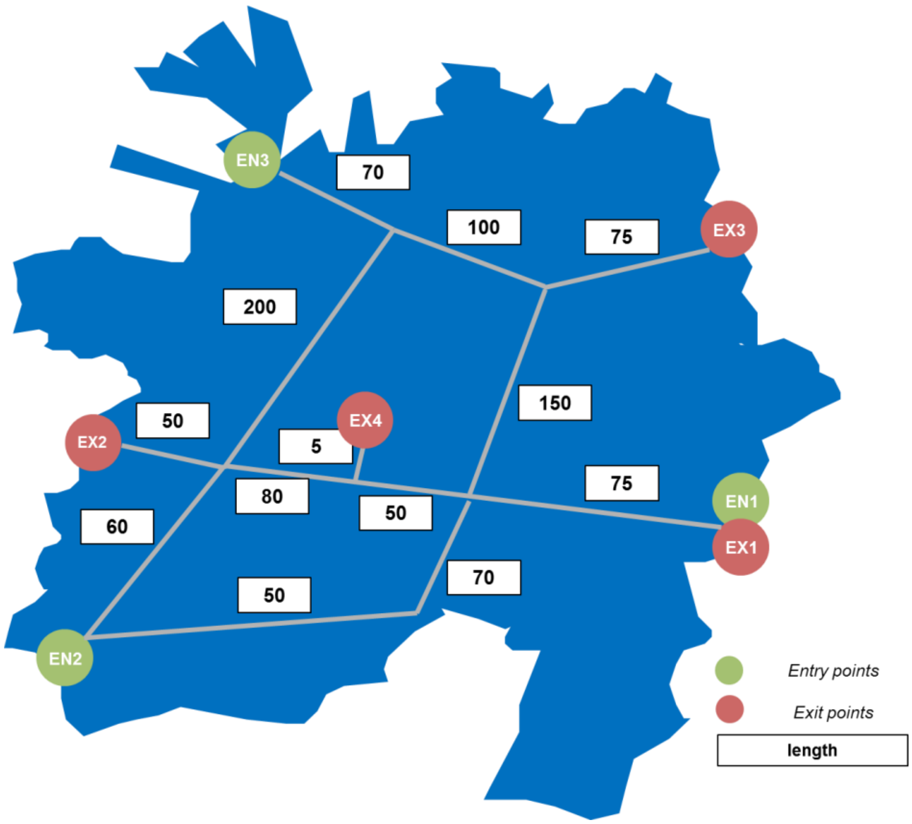

Figure 3: Transmission network characteristics - capacity weighted distance (variant B)

3.3 Main methodology[4]

i. Step 1: capacities

Table 1: capacities (in GWh/h/year)

Capacities	Expected bookings	Technical	flow at peak scenario 1	flow at peak scenario 2
Entry 1	10	13	10	0
Entry 2	10	12	10	12
Entry 3	5	10	5	10
Exit 1	10	12	0	12
Exit 2	5	8	6.5	0
Exit 3	5	8	6.5	5
Exit 4	10	12	12	5

ii. Step 2: distances calculation

Remark: when several options are possible, the shortest path is used

Table 2: distances

From	To	distance
Entry 1	Exit 1	-
Entry 1	Exit 2	255
Entry 1	Exit 3	300
Entry 1	Exit 4	130
Entry 2	Exit 1	195
Entry 2	Exit 2	110
Entry 2	Exit 3	345
Entry 2	Exit 4	145
Entry 3	Exit 1	395
Entry 3	Exit 2	320
Entry 3	Exit 3	245
Entry 3	Exit 4	355

[4] see section 3.4.1.2 of the Revised chapter on Cost Allocation and determination of the reference price

iii. Step 3: calculation of the proportion of the capacities

Table 3: capacities depending on the flow scenario

	based on the flow at peak scenario 1	based on the flow at peak scenario 2
Entry 1	0.4	0.0
Entry 2	0.4	0.5
Entry 3	0.2	0.5
Exit 1	0.0	0.5
Exit 2	0.3	0.0
Exit 3	0.3	0.2
Exit 4	0.5	0.2

iv. Step 4: calculation of the weighted average distance

Table 4: weighted average distances

From	To	Capacity at peak flow	Distance	Weighted average distance	Scenario used (see step 1)
Entry 1	Exit 1	0.0		206.7	1
	Exit 2	0.3	255.0		
	Exit 3	0.3	300.0		
	Exit 4	0.5	130.0		
Entry 2	Exit 1	0.5	195.0	217.7	2
	Exit 2	0.0	110.0		
	Exit 3	0.2	345.0		
	Exit 4	0.2	145.0		
Entry 3	Exit 1	0.5	395.0	351.8	2
	Exit 2	0.0	320.0		
	Exit 3	0.2	245.0		
	Exit 4	0.2	355.0		
Exit 1	Entry 1	0.0	-	285.9	2
	Entry 2	0.5	195.0		
	Entry 3	0.5	395.0		
Exit 2	Entry 1	0.4	255.0	210.0	1
	Entry 2	0.4	110.0		
	Entry 3	0.2	320.0		
Exit 3	Entry 1	0.4	300.0	307.0	1
	Entry 2	0.4	345.0		
	Entry 3	0.2	245.0		
Exit 4	Entry 1	0.4	130.0	181.0	1
	Entry 2	0.4	145.0		
	Entry 3	0.2	355.0		

v. Step 5: determination of the weight of each entry & exit point

No a priori split is defined for E/X split

Table 5: wheight

Wheight	
Entry 1	2067
Entry 3	2177
Entry 3	1759
Exit 1	2859
Exit 2	1050
Exit 3	1535
Exit 4	1810

Total	13257

Table 6: share of costs

Share of costs	
Entry 1	15.59%
Entry 3	16.42%
Entry 3	13.27%
Exit 1	21.57%
Exit 2	7.92%
Exit 3	11.58%
Exit 4	13.65%

vi. Step 6: Entry/exit allocated costs

Table 7: allocated costs

Entry 1	€ 77,956,141
Entry 3	€ 82,115,036
Entry 3	€ 66,343,464
Exit 1	€ 107,829,557
Exit 2	€ 39,600,362
Exit 3	€ 57,891,958
Exit 4	€ 68,263,481

vii. Step 7: tariffs for each E/X point

Table 8: tariffs (in €/kWh/h/year)

Entry 1	€ 8
Entry 3	€ 8
Entry 3	€ 13
Exit 1	€ 11
Exit 2	€ 8
Exit 3	€ 12
Exit 4	€ 7

4 Virtual point-based approach – Variant A

4.1 Inputs on the allowed revenues

i. **Allowed revenues: 100m €**

In this example this is not used to calculate the marginal cost, however, the allowed revenues will be factored into the tariff setting process as a secondary step by means of rescaling the tariffs to recover allowed revenue.

ii. **Entry-exit split: 50/50**

50% is allocated to entries, 50% is allocated to exits (exogenously and ex-ante.

4.2 Transmission network characteristics

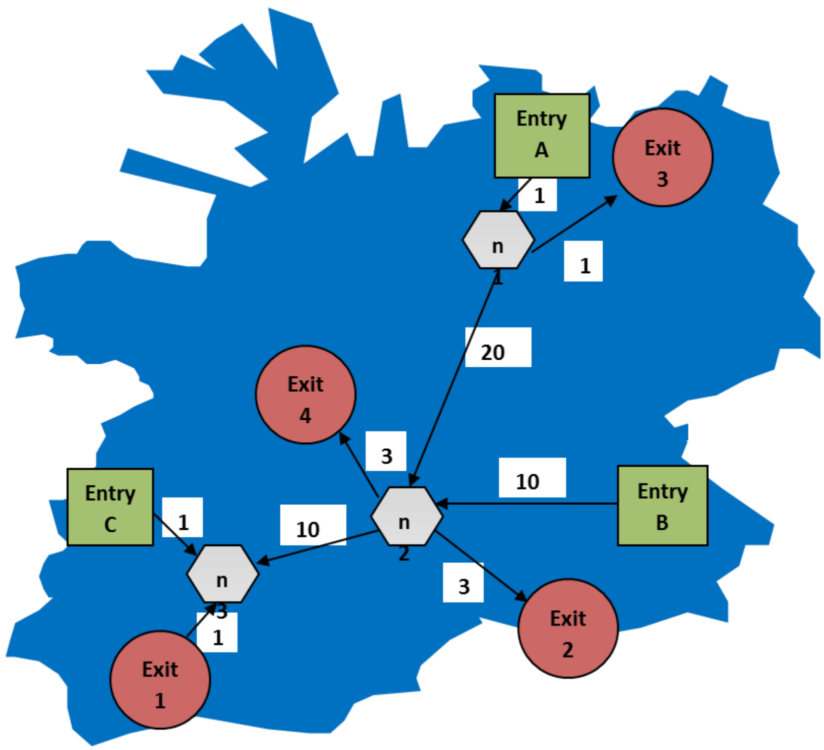

Figure 4: Transmission network characteristics -distance to the virtual point (variant A)

4.3 Main methodology[5]

i. **A network representation is developed and divided into segments. See Figure 4.**

ii. **Capacity used at peak at each of these segments is then identified.**

If total peak demand is X GWh then we use the entry flow assumptions to find out how much flows from each entry point so that total entry flows equals X GWh. The entry flow assumptions are developed in a separate process, which may be in the form of a list of entry points which order where gas flows from i.e. a merit order. We find the network capacity used at peak by minimising the flow multiplied by the distance (i.e. flow distance) for the whole network such that the peak exit flows (X GWh) is matched by the individual entry flows as set above. This gives a flow distance and the direction of flow for each segment. In Figure 4, the values in yellow show these flow distances (and the arrows the direction of flow) after this minimisation has been completed.

iii. **Next we calculate the marginal distance for each point to/from a reference node.**

Building on the above scenario, we then arbitrarily select a reference node on the network and consider the flow distances of a marginal unit of gas (in our worked example one unit). In the worked example we select node n2 and sum the flow distances at peak (in the diagram) for a marginal unit of gas at each entry point to the reference node (and exit point from the reference node) for each exit point in turn. For example, a marginal unit of gas flowing from Entry A to reference node n2 has a flow distance of 21 GWhkm. From Entry Point C to the reference node the marginal flow distance is -9 GWhkm. This is because it has a flow distance of 1 GWhkm from Entry Point C to n3, and 10 GWhkm from n3 to n2. As this requires a flow from n3 to n2 which is against the direction of flow at peak then it is represented as a negative flow distance.

iv. **Completing this for all points, gives you the flow distance values (in GWhkm)**

The flow distance values for all points are specified in the yellow boxes Figure 5 below. The purple boxes indicate the flow distance to travel from all entry to all exit point combinations via the reference node. As this looks at the flow distance for a single marginal unit of flow in GWh the values in the table also show the value of the marginal distance (which is equal to the flow distance divided by the difference in flow of the marginal unit).

[5] see section 3.4.1.3 of the Revised chapter on Cost Allocation and determination of the reference price

Entry A	Entry B	Entry C
21	10	-9

Exit 1	11	32	21	2
Exit 2	3	24	13	-6
Exit 3	-19	2	-9	-28
Exit 4	3	24	13	-6

Figure 5: flow distance values before adjustment of the reference node (GWh*Km)

v. As the reference node is chosen arbitrarily we now adjust for the virtual point

This step is done so that average distance for entry and exit points reflects the entry exit split and so locates the virtual point. This is done by taking the marginal distances for entry and adding a constant to each and taking the marginal distances for exit and subtracting the same constant.

To establish what the constant (d) is when we want a 50:50 entry split we must solve the following equation (note that when determining this constant we do not consider those points where those marginal distances plus or minus that constant are negative):

$$\boldsymbol{Split_{en}} \cdot \frac{\sum \boldsymbol{max(0, en_i + d)}}{\boldsymbol{N_i}} = \boldsymbol{Split_{ex}} \cdot \frac{\sum \boldsymbol{max(0, ex_j - d)}}{\boldsymbol{N_j}}$$

Solve for d, where:

$Split_{en}$ is the share of revenue to be collected from entry points (assume 50%)

$Split_{ex}$ is the share of revenue to be collected from entry points (assume 50%)

en_i is the marginal distance for all entry points i

ex_j is the marginal distance for all exit points j

N_i is the number of entry points

N_j is the number of entry points

d is the constant factor to adjust the marginal distances

$$0.5 \times \left[\frac{max[0,(21+d)] + max[0,(10+d)] + max[0,(-9+d)](removed)}{3}\right]$$
$$= 0.5 \times \left[\frac{max[0,(11-d]) + max[0,(3-d)] + max[0,(-19-d)](removed) + (3-d)}{4}\right]$$

$$\frac{(21+d) + (10+d)}{3} = \frac{(11-d) + (3-d) + (3-d)}{4}$$

4[21+d+10+d] = 3[11-d+3-d+3-d]

4(31+2d) = 3(17-3d)

124+8d = 51-9d

17d = -73

This gives a value for (d) of 4.3.

vi. Adding the constant (d) to all entry points, and subtracting from exit points gives us the new values in Figure 6.

Note the points (in the purple section) which show marginal distance between all entry points is unchanged.

Entry A	Entry B	Entry C
16.7	5.7	-13.3

Exit 1	15.3
Exit 2	7.3
Exit 3	-14.7
Exit 4	7.3

32	21	2
24	13	-6
2	-9	-28
24	13	-6

Figure 6: flow distance values after adjustment of the reference node

vii. To set our tariffs, the unit cost per entry and exit point we multiply the marginal distance at all entry and exit points in Figure 6 by the expansion constant and annuitisation factor.

Assuming an expansion constant of 1.5 (£m/GWhkm) and an annuitisation factor of 0.9. For exit point 1 therefore the tariff would be: 15.3*0.9*1.5 = 20.7 £/GWh. Complete this process for all points.

5 Virtual point-based approach – Variant B

5.1 Inputs on the allowed revenues

i. **Allowed revenue : 1000**

ii. **Entry/exit split : this is an outcome of the methodology (see below)**

5.2 Transmission network characteristics

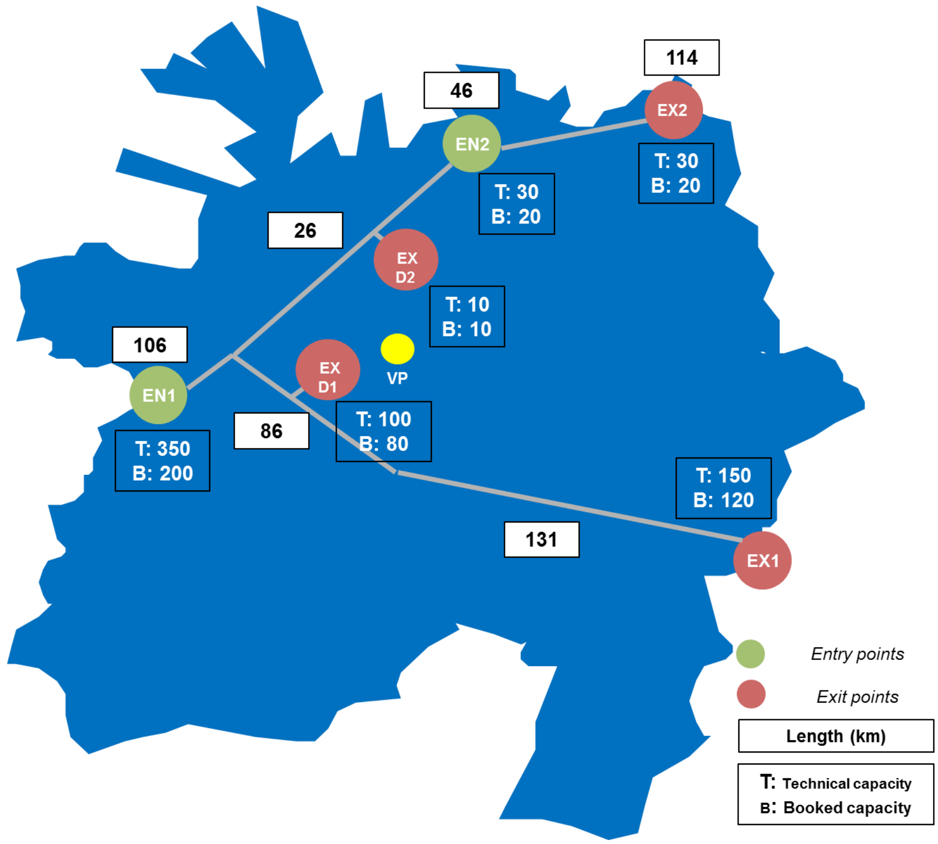

Figure 7: Transmission network characteristics -distance to the virtual point (variant B)

T … Technical capacity

B … Booked capacity

5.3 Main methodology[6]

i. **Define capacity at each entry and exit point:**

C_{E_i}: *Technical capacity at entry point i*

C_{X_j}: *Technical capacity at exit point j*

[6] see section 3.4.1.3 of the Revised chapter on Cost Allocation and determination of the reference price

$BC_{E_i}: Booked\ capacity\ at\ entry\ point\ i$

$BC_{X_j}: Booked\ capacity\ at\ exit\ point\ j$

Technical Capacities:

Entry 1: $C_{E_1} = 350$

Entry 2: $C_{E_2} = 30$

Exit 1: $C_{X_1} = 150$

Exit 2: $C_{X_2} = 30$

Exit D1: $C_{XD_1} = 100$ (domestic exit)

Exit D2: $C_{XD_2} = 10$ (domestic exit)

Booked Capacities:

Entry 1: $BC_{E_1} = 200$

Entry 2: $BC_{E_2} = 20$

Exit 1: $BC_{X_1} = 120$

Exit 2: $BC_{X_2} = 20$

Exit D1: $BC_{XD_1} = 80$

Exit D2: $BC_{XD_2} = 10$

ii. Determine the geographical location of the virtual trading point:

The virtual point can be determined geographically by selecting a dominant node in the network where most flows occur. The virtual point can be also determined geographically based on the capacity weighted average geographical locations of all entry and exit points.

a. Calculate the proportion of entry (or exit) capacity at each point relative to the total entry and exit capacity:

$$P_{E_i} = \frac{C_{E_i}}{\sum C_E + \sum C_X}\ where\ P_{E_i} is\ the\ proportion\ factor\ of\ entry\ point\ i$$

$$P_{X_j} = \frac{C_{X_j}}{\sum C_E + \sum C_X} \ where\ P_{X_j} is\ the\ proportion\ factor\ of\ exit\ point\ j$$

$P_{E_1} = \frac{C_{E_1}}{\sum C_E + \sum C_X} = \frac{350}{350+30+150+30+100+10}$ = 0,522

$P_{E_2} = \frac{C_{E_2}}{\sum C_E + \sum C_X} = \frac{30}{350+30+150+30+100+10}$ = 0,045

$P_{X_1} = \frac{C_{X_1}}{\sum C_E + \sum C_X} = \frac{150}{350+30+150+30+100+10}$ = 0,224

$P_{X_2} = \frac{C_{X_2}}{\sum C_E + \sum C_X} = \frac{30}{350+30+150+30+100+10}$ = 0,045

$P_{XD_1} = \frac{C_{XD_1}}{\sum C_E + \sum C_X} = \frac{100}{350+30+150+30+100+10}$ = 0,149

$P_{XD_2} = \frac{C_{XD_2}}{\sum C_E + \sum C_X} = \frac{10}{350+30+150+30+100+10}$ = 0,015

b. Multiply the geographical locations (longitude and latitude) of each entry (and exit) point with its proportion factor:

$$L_{E_i} = \left[long_{E_i} \times P_{E_i}; lat_{E_i} \times P_{E_i}\right],$$
$$where\ L_{E_i}\ is\ the\ capacity\ weighted\ geographic\ location\ of\ entry\ point\ i$$
$$L_{X_j} = \left[long_{X_j} \times P_{X_j}; lat_{X_j} \times P_{X_j}\right],$$
$$where\ L_{X_j}\ is\ the\ capacity\ weighted\ geographic\ location\ of\ exit\ point\ j$$

$L_{E_1} = [12{,}80 \times 0{,}522; 47{,}83 \times 0{,}522]$ = [6,68; 24,97]

$L_{E_2} = [14{,}30 \times 0{,}045; 48{,}24 \times 0{,}045]$ = [0,64; 2,17]

$L_{X_1} = [15{,}42 \times 0{,}224; 46{,}98 \times 0{,}224]$ = [3,45; 10,52]

$L_{X_2} = [15{,}66 \times 0{,}045; 48{,}19 \times 0{,}045]$ = [0,70; 2,17]

$L_{XD_1} = [13{,}07 \times 0{,}149; 47{,}73 \times 0{,}149]$ = [1,95; 7,11]

$L_{XD_2} = [14{,}06 \times 0{,}015; 48{,}04 \times 0{,}015]$ = [0,21; 0,72]

c. Summing of the capacity weighted geographic locations to determine location of the virtual point:

$$L_{VP} = \sum L_E + \sum L_X \ where\ \ L_{VP}\ is\ the\ location\ of\ the\ virtual\ point$$

After summing the capacity weighted geographic locations of all entry and exit points, the location of the virtual point is determined to be at the following coordinates:

L_{VP} = [13,64; 47,66]

iii. Calculate distance between each entry point and the virtual point as well as each exit point and the virtual point:

$$[D_{E_iVP}]: distance\ from\ entry\ point\ i\ to\ VP$$

$$[D_{X_jVP}]: distance\ from\ exit\ point\ j\ to\ VP$$

Entry 1: $D_{E_1VP} = 106{,}03$

Entry 2: $D_{E_2VP} = 45{,}84$

Exit 1: $D_{X_1VP} = 131{,}27$

Exit 2: $D_{X_2VP} = 114{,}44$

Exit D1: $D_{XD_1VP} = 86{,}30$

Exit D2: $D_{XD_2VP} = 25{,}97$

Note: several approaches to distance calculation are possible. The one applied here is as follows:

-take the latitude and longitude (in degrees) of each point and convert it to radians.

-calculate the average of all latitudes and the average of all longitudes (this is in radians as well)

-then use the following formula for each point:
*(ARCCOS(SIN(LatitudePoint1)*SIN(AverageLatitude)+COS(LatitudePoint1)*COS(AverageLatitude)*COS(AverageLongitude-LongitudePoint1)))*6378,137*
with 6378,137 = equatorial radius in kilometers

iv. Calculate the capacity-weighted distance to the virtual point to determine the entry-exit split and the revenue to be collected from all entry points and all exit points:

a. Calculate the capacity-weighted distance to the virtual point for entry and exit points separately

$$DC_{E_iVP} = D_{E_iVP} \times \frac{C_{E_i}}{\sum C_E};$$

$$where\ DC_{E_iVP}\ is\ the\ capacity - weighted\ distance\ from\ entry\ point\ i\ to\ the\ virtual\ point$$

$$DC_{X_jVP} = D_{X_jVP} \times \frac{C_{X_j}}{\sum C_X};$$
$$where\ DC_{X_jVP}\ is\ the\ capacity - weighted\ distance\ from\ exit\ point\ j\ to\ the\ virtual\ point$$

$$DC_{E_1VP} = D_{E_1VP} \times \frac{C_{E_1}}{\sum C_E} = 106{,}03 \times \frac{350}{350 + 30} = 97{,}66$$

$$DC_{E_2VP} = D_{E_2VP} \times \frac{C_{E_2}}{\sum C_E} = 45{,}84 \times \frac{30}{350 + 30} = 3{,}62$$

$$DC_{X_1VP} = D_{X_1VP} \times \frac{C_{X_1}}{\sum C_X} = 131{,}27 \times \frac{150}{150 + 30 + 100 + 10} = 67{,}90$$

$$DC_{X_2VP} = D_{X_2VP} \times \frac{C_{X_2}}{\sum C_X} = 114{,}44 \times \frac{30}{150 + 30 + 100 + 10} = 11{,}84$$

$$DC_{XD_1VP} = D_{X_{D_1}VP} \times \frac{C_{XD_1}}{\sum C_X} = 86{,}30 \times \frac{100}{150 + 30 + 100 + 10} = 29{,}76$$

$$DC_{XD_2VP} = D_{X_{D_2}VP} \times \frac{C_{XD_2}}{\sum C_X} = 25{,}97 \times \frac{10}{150 + 30 + 100 + 10} = 0{,}90$$

b. Use the sum of capacity-weighted distances for entry points and the sum of capacity-weighted distances for exit points to determine the Entry-Exit split

$$\frac{\sum DC_{EVP}}{\sum DC_{EVP} + \sum DC_{XVP}} = \%E;$$
$$where\ \%E\ is\ the\ percentage\ of\ revenue\ collected\ at\ entry\ points\ in\ an\ Entry - Exit\ system$$

$$\frac{\sum DC_{XVP}}{\sum DC_{EVP} + \sum DC_{XVP}} = \%X;$$
$$where\ \%X\ is\ the\ percentage\ of\ revenue\ collected\ at\ exit\ points\ in\ an\ Entry - Exit\ system$$

$$\frac{\sum DC_{EVP}}{\sum DC_{EVP} + \sum DC_{XVP}} = \frac{101{,}28}{101{,}28 + 110{,}39} = 0{,}48$$

$$\frac{\sum DC_{XVP}}{\sum DC_{EVP} + \sum DC_{XVP}} = \frac{110{,}39}{101{,}28 + 110{,}39} = 0{,}52$$

c. Calculate the revenue collected from all entry points as well as the revenue collected from all exit points

Assuming revenue (R) to be 1000:

$$R_E = 1000 \times \%E = 478{,}47;$$
$$where\ R_E\ is\ the\ revenue\ collected\ from\ all\ entry\ points$$

$$R_X = 1000 \times \%X = 521{,}53;$$
$$where\ R_X\ is\ the\ revenue\ collected\ from\ all\ exit\ points$$

v. Determine tariffs by minimizing the difference between the calculated revenue from entries and exits on the one hand and the revenue to be obtained by multiplying tariffs by booked capacities on the other hand:

a. By selecting one entry point as a reference, set the ratio of the tariffs for entry points to be the same as the ratio of the distances between these entry points and the virtual point. Use the same methodology for exit points.

Selecting Entry 2 and Exit D2 as references:

$$RT_{E_1} = \frac{D_{E_1VP}}{D_{E_2VP}} = \frac{106{,}03}{45{,}84} = 2{,}31;$$
$$where\ RT_{E_1}\ is\ the\ tariff\ ratio\ between\ Entry\ 1\ and\ the\ reference\ Entry\ (Entry\ 2)$$
$$RT_{E_2} = 1$$

$$RT_{X_1} = \frac{D_{X_1VP}}{D_{XD_2VP}} = \frac{131{,}27}{25{,}97} = 5{,}05;$$
$$where\ RT_{X_1}\ is\ the\ tariff\ ratio\ between\ Exit\ 1\ and\ the\ reference\ Exit\ (Exit\ D2)$$
$$RT_{X_2} = \frac{D_{X_2VP}}{D_{XD_2VP}} = \frac{114{,}44}{25{,}97} = 4{,}41;$$
$$where\ RT_{X_2}\ is\ the\ tariff\ ratio\ between\ Exit\ 2\ and\ the\ reference\ Exit\ (Exit\ D2)$$
$$RT_{XD_1} = \frac{D_{XD_1VP}}{D_{XD_2VP}} = \frac{86{,}30}{25{,}97} = 3{,}32;$$
$$where\ RT_{XD_1}\ is\ the\ tariff\ ratio\ between\ Exit\ D1\ and\ the\ reference\ Exit\ (Exit\ D2)$$
$$RT_{XD_2} = 1$$

b. Set the reference point (Entry 2 and Exit D2) tariffs to 1 and then calculate the tariffs at other points by using the ratios determined in the previous step.

$$T_{E_1} = 2{,}31 \times T_{E_2};$$
$$where\ T_{E_1} is\ the\ tariff\ at\ entry\ point\ 1\ and\ T_{E_2} the\ tariff\ at\ entry\ point\ 2$$

$$T_{X_1} = 5{,}05 \times T_{XD_2};$$
$$where\ T_{X_1} is\ the\ tariff\ at\ exit\ point\ 1\ and\ T_{XD_2} the\ tariff\ at\ exit\ point\ D2$$
$$T_{X_2} = 4{,}41 \times T_{XD_2};$$
$$where\ T_{X_2} is\ the\ tariff\ at\ exit\ point\ 2\ and\ T_{XD_2} the\ tariff\ at\ exit\ point\ D2$$
$$T_{XD_1} = 3{,}32 \times T_{XD_2};$$
$$where\ T_{XD_1} is\ the\ tariff\ at\ exit\ point\ D1\ and\ T_{XD_2} the\ tariff\ at\ exit\ point\ D2$$

c. Calculate the revenue collected at every point by multiplying tariffs by booked capacities. Use this result to adjust the tariffs to minimise the difference between combined revenue from all entry points and the revenue R_E calculated in step 4c. Repeat the step for exit points.

Setting T_{E_2} to 0,99:

$$REV_{E_2} = T_{E_2} \times BC_{E_2} = 0{,}99 \times 20 = 19{,}80;$$
$$where\ REV_{E_2}\ is\ the\ revenue\ collected\ at\ entry\ point\ 2$$

Then,

$$T_{E_1} = 2{,}31 \times T_{E_2} = 2{,}29$$

$$REV_{E_1} = T_{E_1} \times BC_{E_1} = 2{,}29 \times 200 = 458{,}01;$$
$$where\ REV_{E_1}\ is\ the\ revenue\ collected\ at\ entry\ point\ 1$$

$$\sum REV_E = REV_{E_1} + REV_{E_2} = 477{,}81$$

This result is very close to the previously calculated R_E of 478,47

Setting T_{XD_2} to 0,54:

$$REV_{XD_2} = T_{XD_2} \times BC_{XD_2} = 0{,}54 \times 10 = 5{,}40;$$
$$where\ REV_{XD_2}\ is\ the\ revenue\ collected\ at\ exit\ point\ D2$$

Then,

$$T_{X_1} = 5{,}05 \times T_{XD_2} = 2{,}73$$

$$REV_{X_1} = T_{X_1}\ X\ BC_{X_1} = 2{,}73\ X\ 120 = 327{,}56;$$
$$where\ REV_{X_1}\ is\ the\ revenue\ collected\ at\ exit\ point\ 1$$

$$T_{X_2} = 4{,}41 \times T_{XD_2} = 2{,}38$$

$$REV_{X_2} = T_{X_2} \times BC_{X_2} = 2{,}38 \times 20 = 47{,}59;$$
$$where\ REV_{X_2}\ is\ the\ revenue\ collected\ at\ exit\ point\ 2$$

$$T_{XD_1} = 3{,}32 \times T_{XD_2} = 1{,}79$$

$$REV_{XD_1} = T_{XD_1} \times BC_{XD_1} = 1{,}79\ X\ 80 = 143{,}57;$$
$$where\ REV_{XD_1}\ is\ the\ revenue\ collected\ at\ exit\ point\ D1$$

$$\sum REV_X = REV_{X_1} + REV_{X_2} + REV_{XD_1} + REV_{XD_2} = 524{,}13$$

This result is very close to the previously calculated R_X of 521,53

6 Matrix approach

This matrix model is a simplified version of the Italian entry-exit matrix model, and it is based on the same assumptions of the capacity-weighted distance – variant A (CWD) model, in order to favour comparability of outcomes.

It must be stressed, however, that many inputs which are needed for our model were missing in the CWD example, therefore we had to make further assumptions in order to make the model work. Since these assumptions have a degree of arbitrariness, and they may strongly influence the outcomes, we believe comparability is a questionable issue as long as a full set of common, and possibly realistic, inputs is not given as the starting point of each model. In particular, our model requires a full "map" of the physical network whereby each portion of grid ("segment") is associated a physical capacity, a length and, if needed for the purposes of cost driver calculation, a corresponding standard investment cost; also, a representation of all entry/exit paths (and the segments they are composed of) is needed.

We derived the missing inputs from the CWD model as follows:

- we assume virtual and physical paths correspond, thus there are no shared network segments;
- each entry-exit path capacity is the exit capacity averaged with the corresponding entry capacity;
- the sum of all entry-exit path capacities leading to an exit point is the exit point capacity.

Regarding the standard investment costs, we used an index derived from the actual index used in the Italian model.

This simplified model simply requires forecasts on booked capacity at entries and exits. However, in case of a different treatment of counter-flow segments in an entry/exit path (which is accounted for in the Italian case), assumptions on gas flows at peak would be needed.

It must be pointed out that such a network structure (where each entry is connected to each exit, but without shared segments) is rarely observed in practice. Nonetheless, we developed our model based on these assumptions in order to provide a certain degree of comparability with the CWD model.

6.1 Assumptions on the allowed revenue

Total Allowed revenue (€)		115000
Capacity/commodity split	%	€
revenue to be collected from capacity charges	87	100000
revenue to be collected from commodity charges	13	15000
Entry/Exit split	%	€
Entry	50	50000
Exit	50	50000

6.2 Network Situation

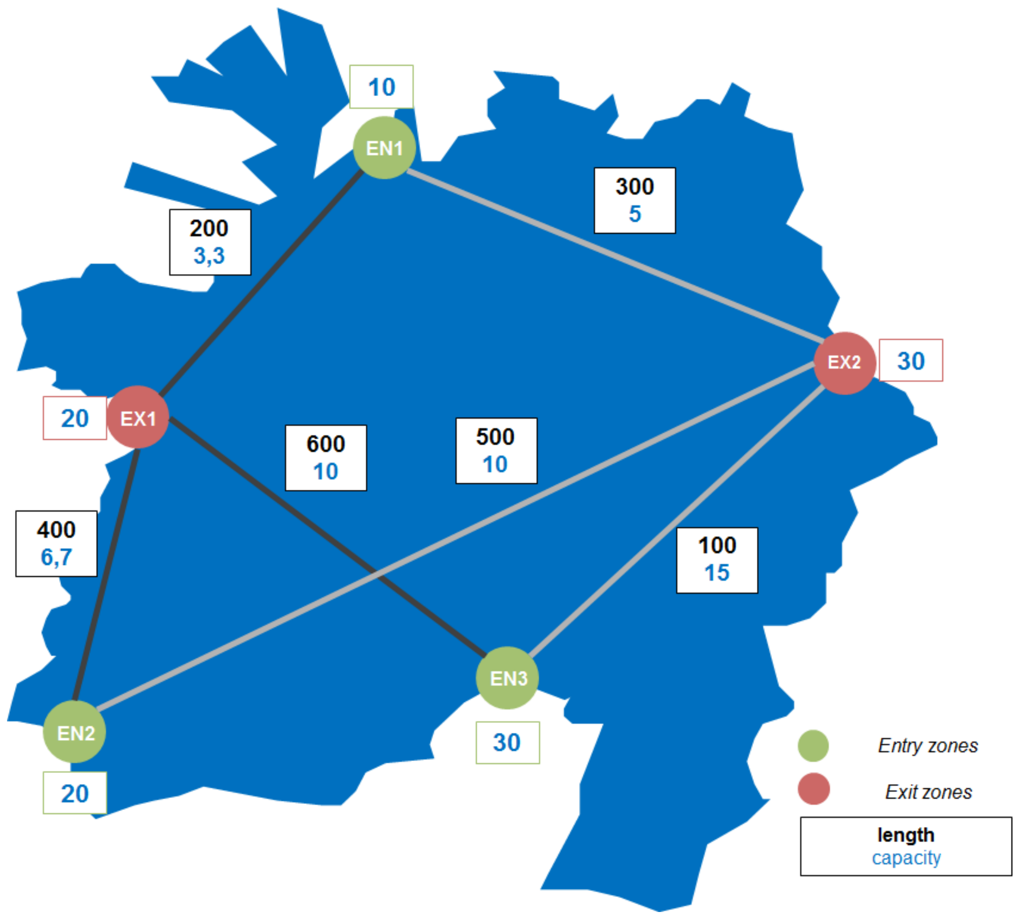

Figure 8: Network Topology

Table 9: Network Segments

From	To	Code	Length (km)	Capacity
EN1	EX1	EN1EX1	200	3.3
EX1	EN1	EX1EN1		
EN1	EX2	EN1EX2	300	5
EX2	EN1	EX2EN1		
EN2	EX1	EN2EX1	400	6.7
EX1	EN2	EX1EN2		
EN2	EX2	EN2EX2	500	10
EX2	EN2	EX2EN2		
EN3	EX1	EN3EX1	600	10
EX1	EN3	EX1EN3		
EN3	EX2	EN3EX2	100	15
EX2	EN3	EX2EN3		

Table 10: Capacity at Entry and Exit points

	Point	Technical	Booked
C_{En}	EN1	10	7.8
	EN2	20	13.8
	EN3	30	25.0
	Tot	***60***	***46.6***
C_{Ex}	EX1	20	14.0
	EX2	30	25.0
	Tot	***50***	***39.0***

Table 11: Capacity of each segment

			C_{En}		
			20	**30**	***50***
			EX1	**EX2**	
C_{En}	**10**	**EN1**	3.3	5.0	***8.3***
	20	**EN2**	6.7	10.0	***16.7***
	30	**EN3**	10.0	15.0	***25.0***
	60		***20.0***	***30.0***	***50.0***

6.3 Main methodology[7]

i. Defining a cost driver and applying the cost driver to network segments

When defining a cost driver (which we called "Normalized Transport Cost", *TC*), our simplified model takes into account the following features of each segment:

a) technical capacity (Mcm/day);

b) standard investment cost index in relation to capacity (*IC*);

c) length.

The *IC* index can be defined by the TSO and refers to investment costs in relation to capacity, which means taking into account mainly economies of scale. The *TC* is defined as:

$$uTC = IC/capacity$$

$$TC = (IC/capacity)*length$$

Table 12 provides an overview of the *uTC* for our model, while

[7] see section 3.4.1.4 of the Revised chapter on Cost Allocation and determination of the reference price

Table 9 defines the *TC* for each network segment, based on capacity and length.

Table 12: Unit transport cost computation

Technical capacity	Std investment cost Index	uTC
3.3	0.40	0.12
5	0.50	0.10
6.7	0.70	0.10
10	0.80	0.08
15	1.00	0.07

ii. Creating a matrix of cost drivers

Usually, each entry-exit path is assigned a *TC* which is the sum of the segments *TC* composing the path. However, in this simplified model each entry-exit path is only composed of one segment, therefore the matrix of cost driver is easily built (Table 13).

Table 13: Matrix of cost drivers

TC	EX1	EX2
EN1	24.2	30.0
EN2	41.8	40.0
EN3	48.0	6.7

iii. Defining entry/exit tariffs

Tariffs at entry (T_{En}) and exit (T_{Ex}) are defined by solving the following function:

$$min \sum_{en,ex} \varepsilon_{en,ex}^2$$

Whereby

$$TC_{en,ex} = T_{en} + T_{ex} + \varepsilon_{en,ex}$$

Therefore, the function to be solved can also be seen as

$$min \sum_{en,ex} (T_{En} + T_{Ex} - TC)^2$$

A constraint also applies to avoid negative tariffs.

Results of the minimization function are given in Table 14.

Table 14: results of the minimization function

T_{En}	EN1	7.3
	EN2	24.9
	EN3	2.2
T_{Ex}	EX1	16.9
	EX2	4.5

iv. Scaling, entry exit split

Tariffs must then be scaled to meet allowed revenues (100 000), according to forecasts on booked capacity (Table 15).

Table 15: tariffs after rescaling, before entry-exit split

		Tariff	Booked capacity (Mmc/year)	Revenues (€)
Entry	EN1	911.9	7.8	7113
	EN2	3094.7	13.8	42707
	EN3	275.0	25.0	6875
	Tot		**46.6**	**56694**
Exit	EX1	2103.6	14.0	29450
	EX2	554.3	25.0	13856
	Tot		**39.0**	**43306**
		Allowed revenues		*100000*

Finally, tariffs are further scaled to meet the 50/50 entry/exit split target (Table 16).

Table 16: final tariff

		Tariff	Booked capacity (Mmc/year)	Revenues (€)
Entry	EN1	804	7.8	6 273
	EN2	2729	13.8	37 664
	EN3	243	25.0	6 063
	Tot		**46.6**	**50 000**
Exit	EX1	2429	14.0	34 002
	EX2	640	25.0	15 998
	Tot		**39.0**	**50 000**
		Allowed revenues		*100 000*