ENERGY POLICY RESEARCH SEMINAR
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Transmission issues in cross-border trading of electricity

Internal compensation charges in the EU

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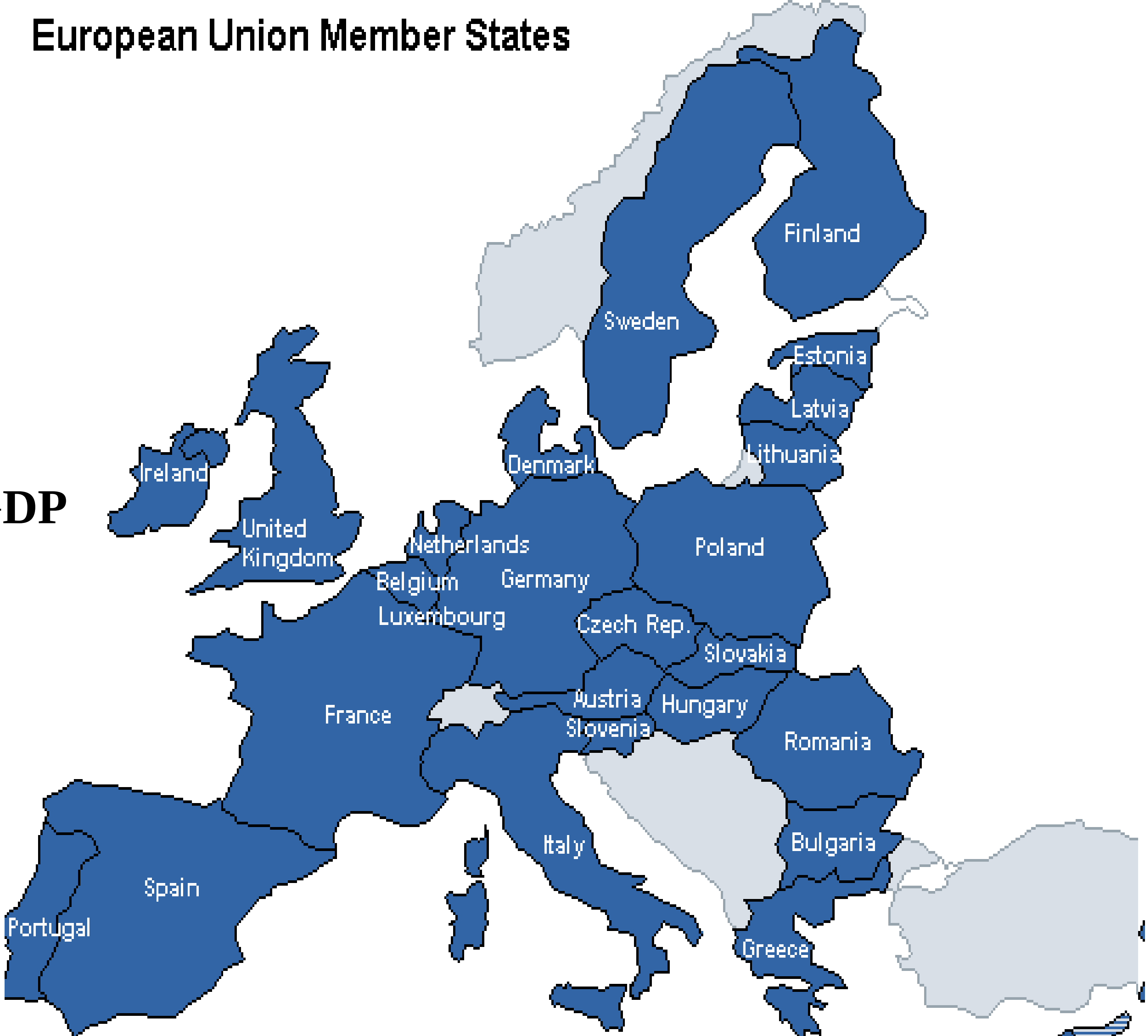
European Union Member States

493 M hab

11.597 b€ GDP

4,3 M km2



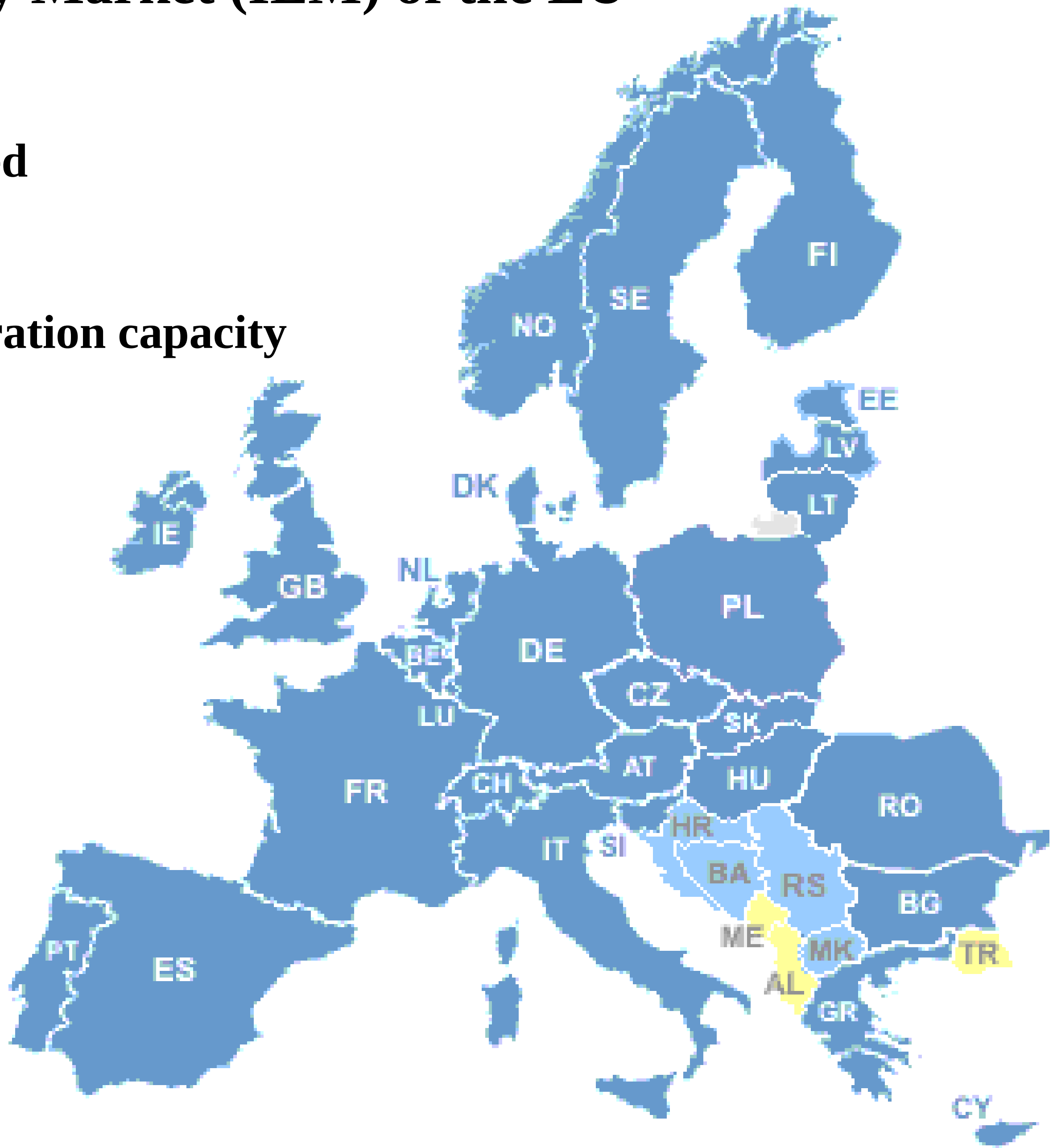
The Internal Electricity Market (IEM) of the EU

ETSO statistics:

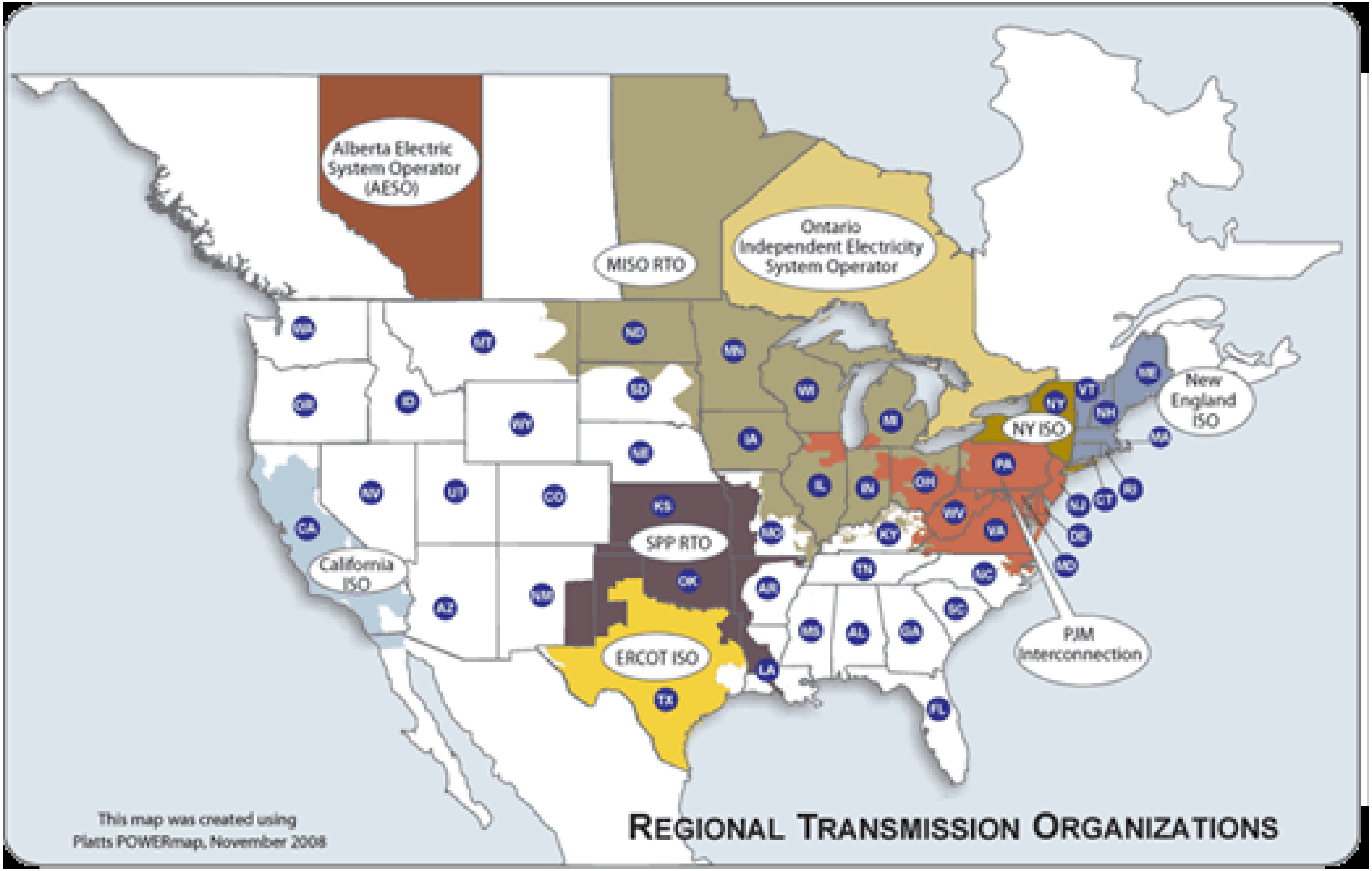
490 million people supplied

3200 TWh/year

741 GW of installed generation capacity



US & Canada Regional Transmission Organizations



EU & USA
Just to have a clearer picture...

- EU-27 & IEM
  - 4,3 Mkm2, 493 Mhab, 11597 b€ GDP
  - 741 GW installed capacity
  - 3309 TWh/year
- *(Installed capacity, annual production)*
  - Germany (124 GW, 620 TWh)
  - France (116 GW, 578 TWh)
  - UK (81 GW, 398 TWh)
  - Italy (85 GW, 304 TWh)
  - Spain (70 GW, 294 TWh)

- USA
  - 9,8 Mkm2, 300 Mhab, 13195 b$ GDP
  - 1076 GW installed capacity
  - 4200 TWh/year
- *(Installed capacity, annual production)*
  - PJM (163 GW, 763 GWh)
  - ERCOT (90 GW, 290 TWh)
  - California (53 GW, 240 TWh)
  - NY-ISO (39 GW, 167 TWh)
  - NE-ISO (33 GW, 134 TWh)

Cross-border trade in the IEM of the EU
Objectives & challenges

- The objective
  - An operating Internal Electricity Market (IEM) where electric energy is delivered at the lowest cost that is compatible with a satisfactory quality of supply & environmental sustainability
- The challenge
  - How to implement it, taking the current situation as the starting point

The challenge for transmission regulation

- Producers & consumers in the Internal Electricity Market (IEM) of the EU have the right to buy & sell electricity freely, but …
  - How much to charge for the use of the network?
  - Who pays for network losses?
  - What to do if the network is congested?
  - Who upgrades the network when needed?

Our case example
Inter-TSO payments

- Let us choose this specific problem in transmission regulation & pull out of this thread
  - Theory of transmission regulation
  - The EU IEM global approach
  - EU regulatory institutions
  - The current solution
  - Other related problems. What is next?

Inter-TSO payments: What’s the problem?

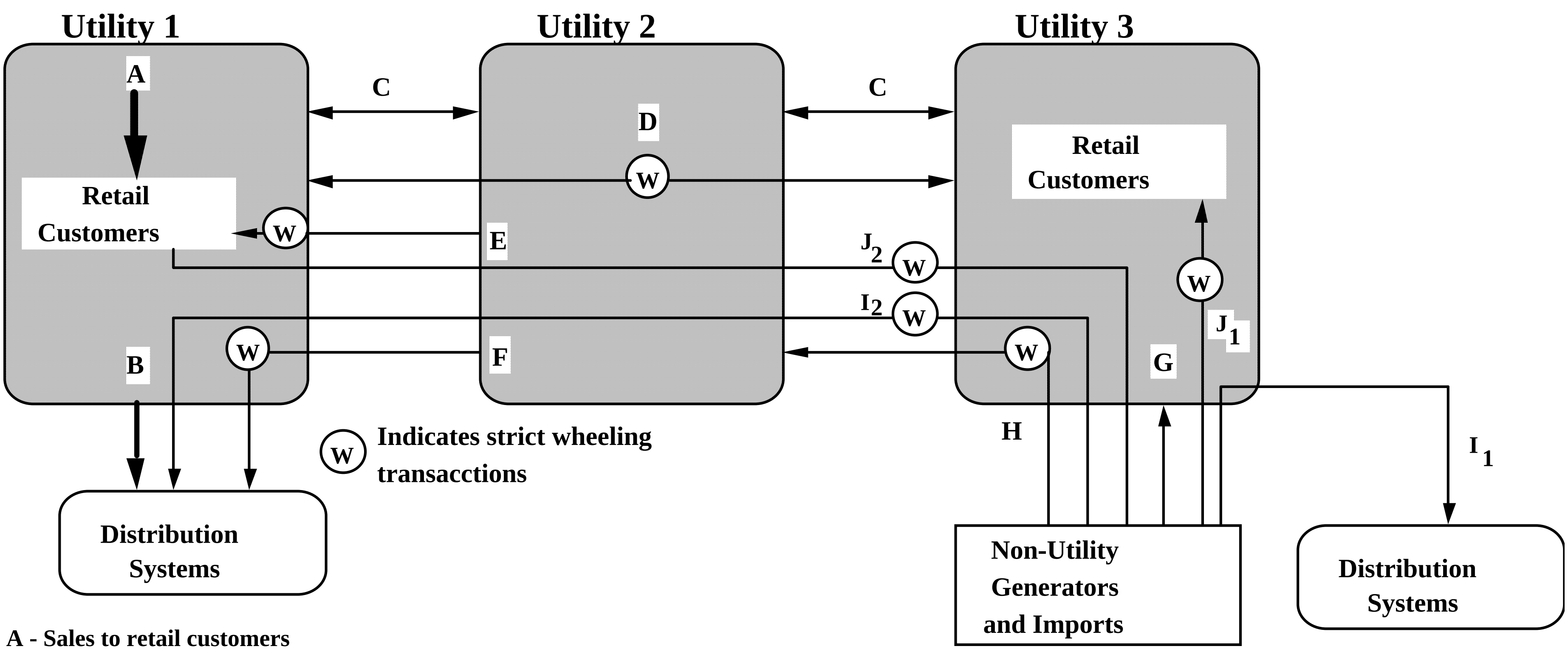
Cross-border transmission charges

- In order to account for the costs incurred in a country because of the utilization of its network by agents located in other countries:
  - Any country C should be compensated for the costs associated to the use that market agents in other countries make of its networks: additional losses & some measure of network use
  - But country C should also be charged for the cross-border transaction costs that its market agents cause in other countries

➔ **Inter-TSO payments**

Note that Inter-TSO payments do not have the objective nor the capability of emulating precise EU-wide long-term locational signals in transmission tariffs

The initial approach *(by the TSOs in mid 90s)* was inspired by the US “wheeling” mentality…

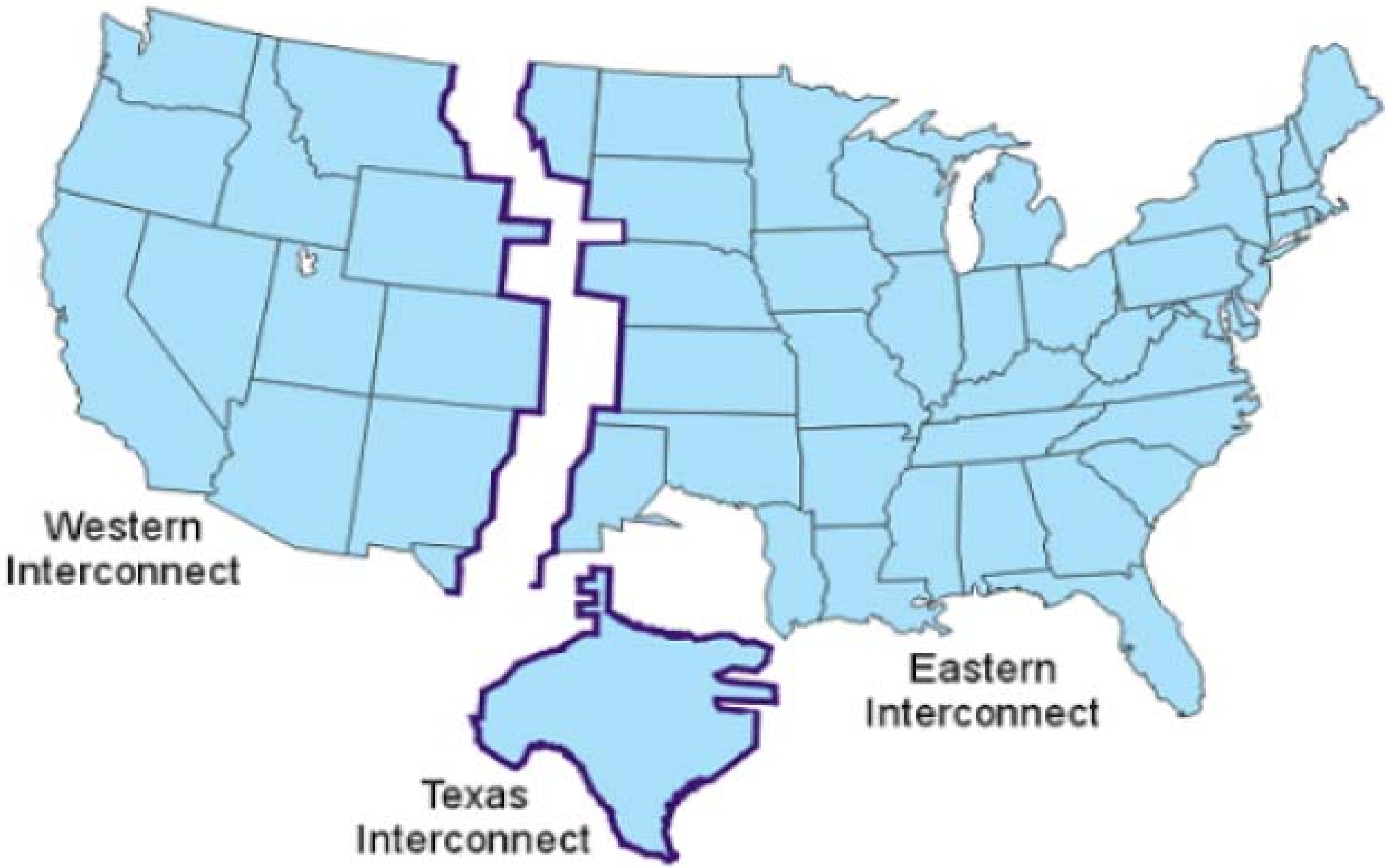


A - Sales to retail customers
B - Sales to distribution system
C - Coordination sales between two utilities
D - Wheeling of power between two utilities through a third
E - Wheeling of power to retail customer
F - Wheeling of power to distribution
G - Utility purchase of power from non-utility generators and imports
H - Wheeling of power from non-utility generators and imports
I - Wheeling from NUG to distribution
J - Wheeling fron NUG to retail customer

… and it led to tariff pancaking & no cross-border trade

The EU Internal Electricity Market (IEM)

North American Electric Power Grids

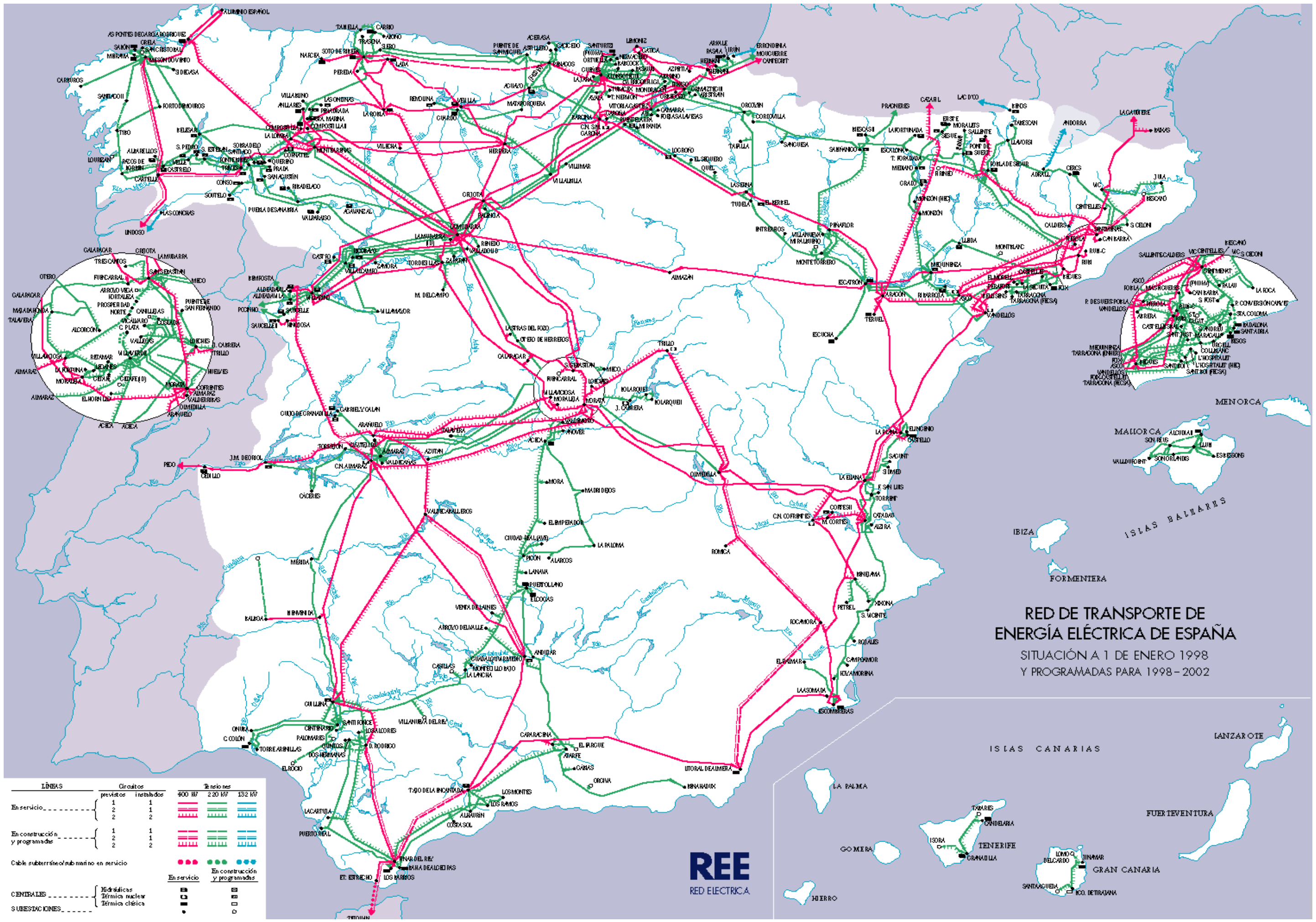


Synchronous blocks & broader perspectives (e.g. the “Mediterranean Ring”)

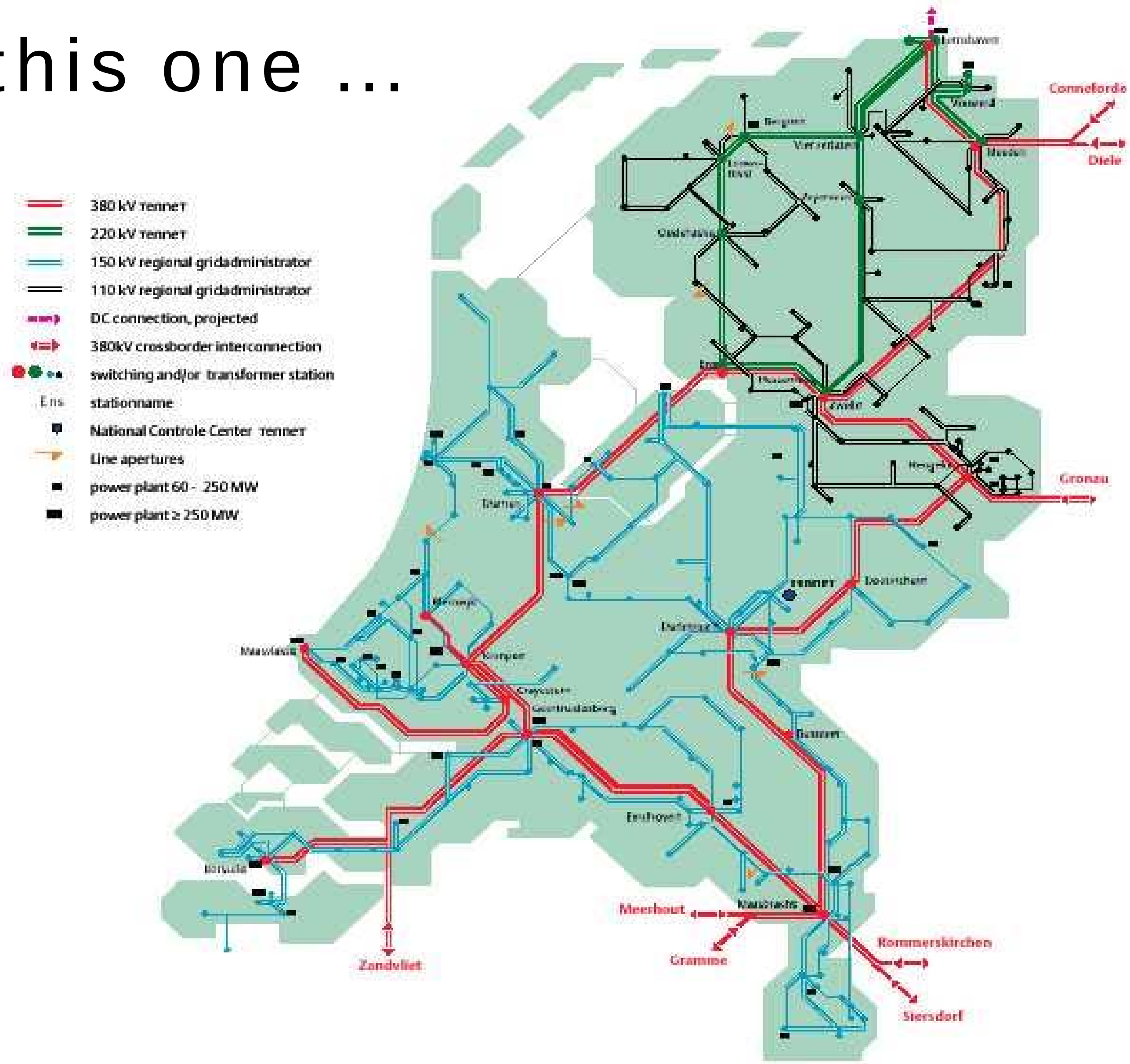
Major challenges

- Transmission complexity
  - meshed networks
  - flow patterns, commercial transactions & the laws of physics
- Lack of sufficient network infrastructure → network constraints / bottlenecks
- Lack of harmonization of transmission tariffs & regulation
- Inadequate regulatory institutions to make decisions on issues of medium size caliber

Note the complexity of just a national transmission network ...

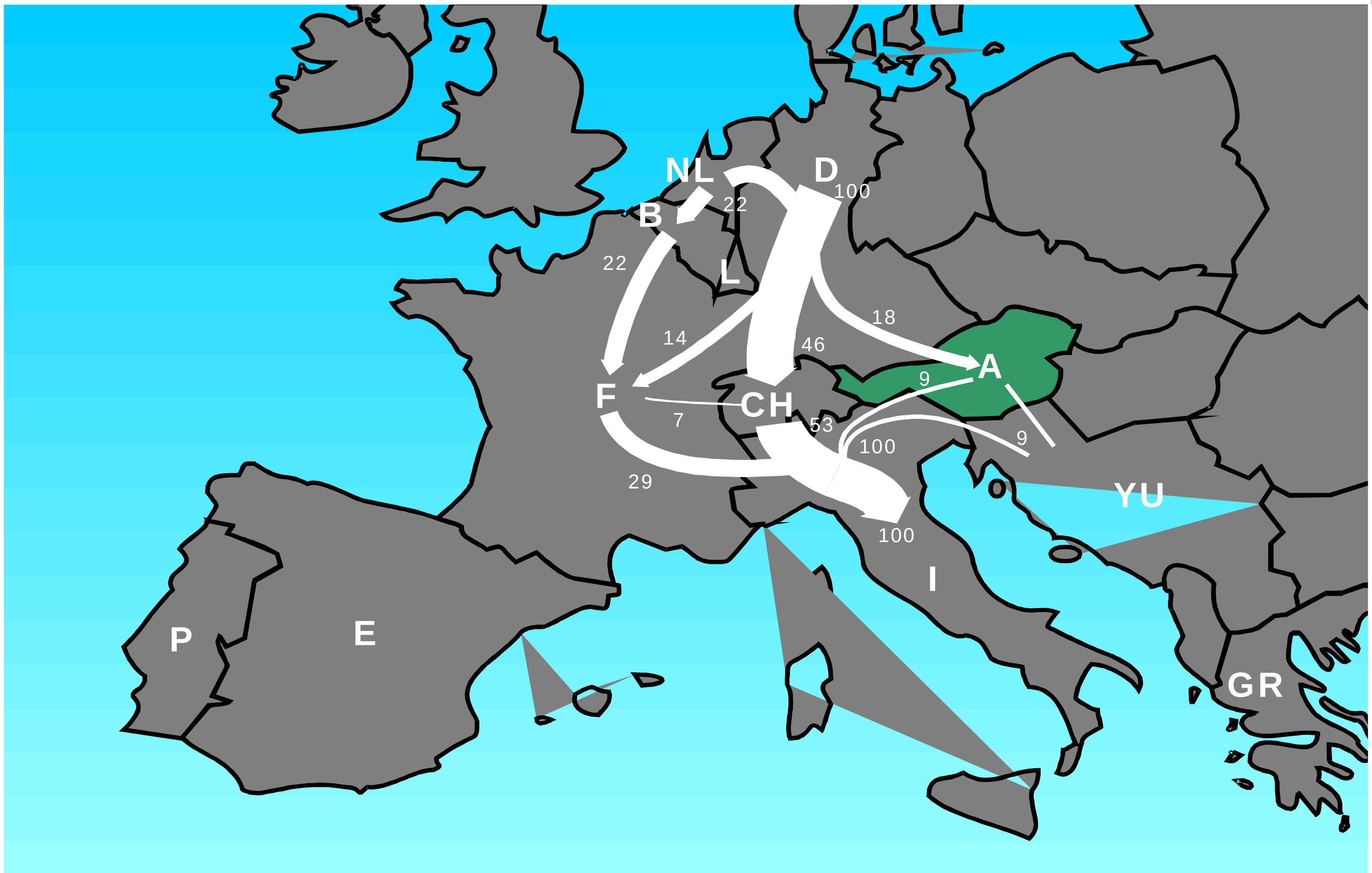


… or this one …



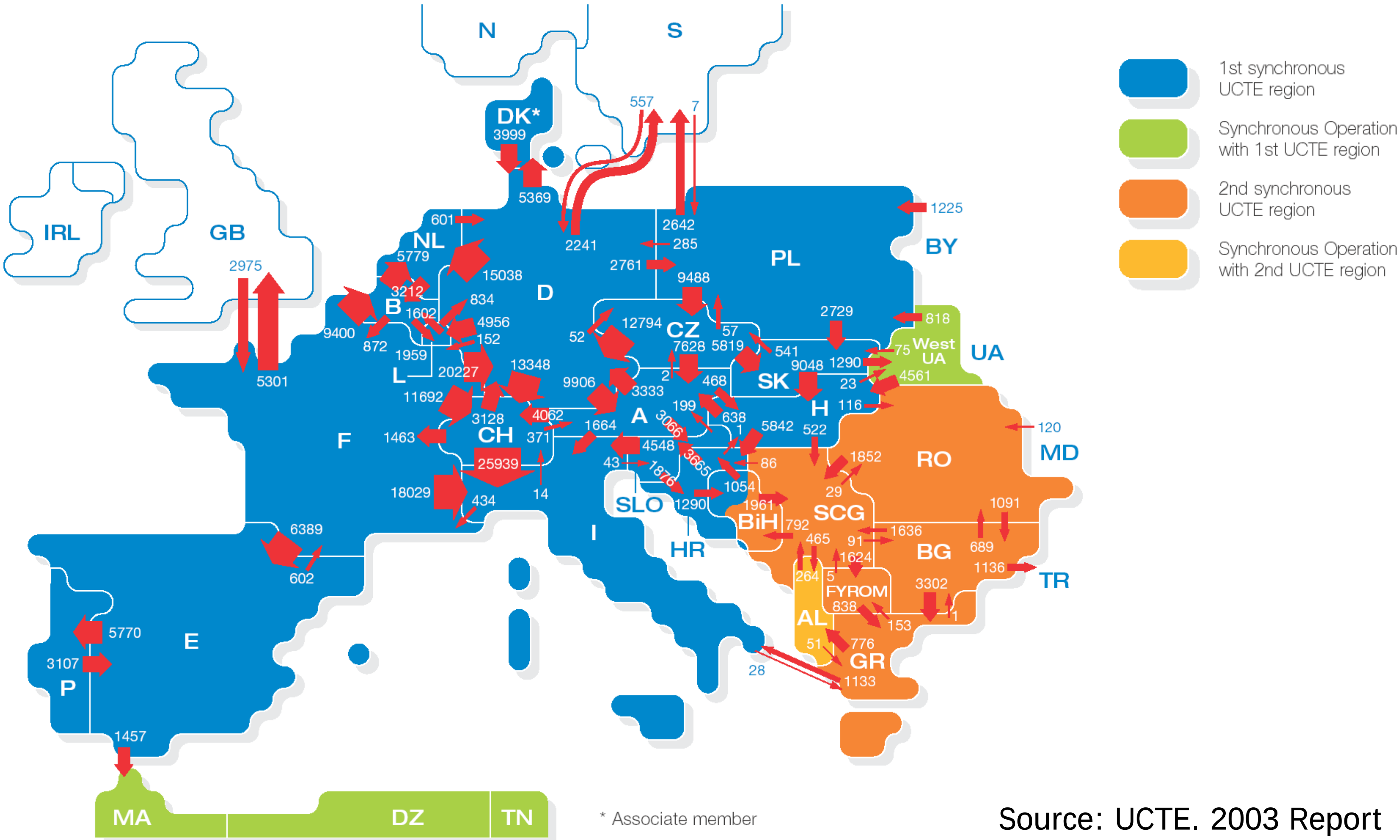
380 kV TenneT
220 kV TenneT
150 kV regional gridadministrator
110 kV regional gridadministrator
DC connection, projected
380kV crossborder interconnection
switching and/or transformer station
Ens
stationname
National Controle Center TenneT
Line apertures
power plant 60 - 250 MW
power plant ≥ 250 MW
Conneforde
Diele
Gronau
Meerhout
Gramme
Zandvliet
Rommerskirchen
Siersdorf
Eindhoven
Krimpen
Maasvlakte
Borssele
Geertruidenberg

... and the flow pattern for a single transaction ...



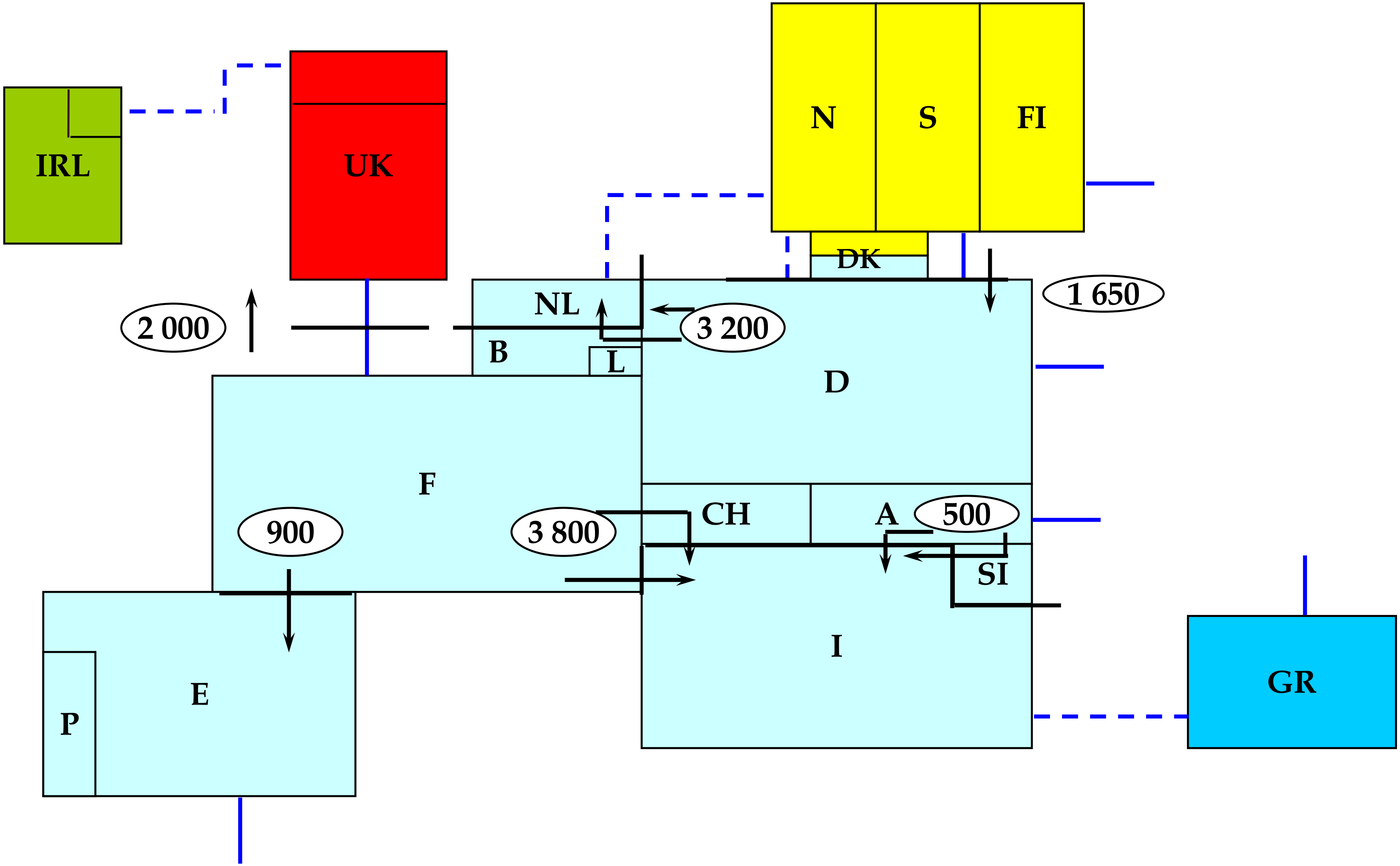
... but, do flow patterns depend on commercial transactions?

… see the physical flows of electricity (GWh)…

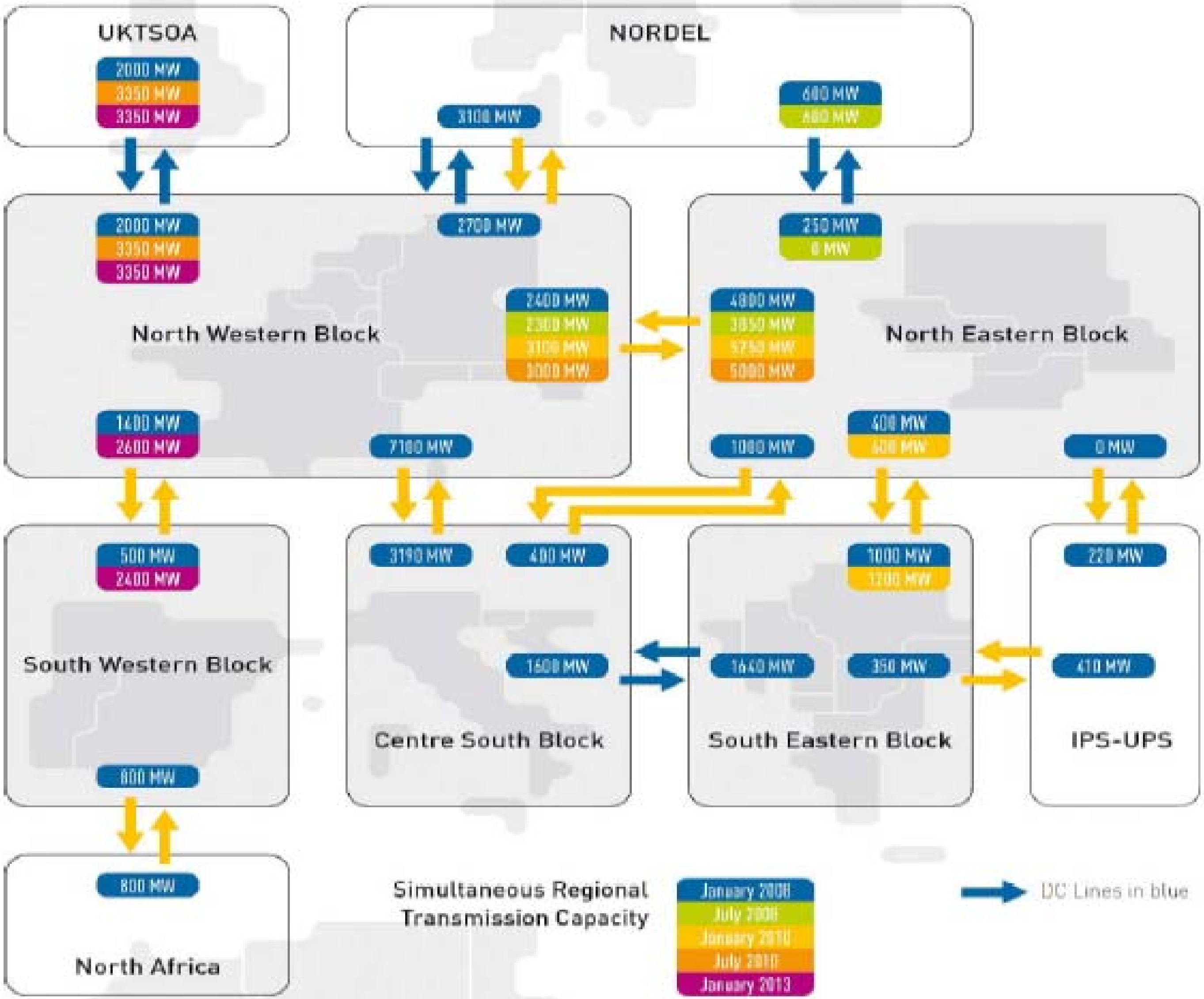


Source: UCTE. 2003 Report

... in the presence of network capacity limits ...



Present & forecast commercial interconnection capacities *(current values, 2008)*



Present & forecast commercial interconnection capacities

The assessment has primarily been carried out by region, supplemented by national comments where available. The regions considered are as follows:

BALTSO (Baltic States):	Estonia, Latvia, Lithuania
UKTSOA & ATSOI:	Great Britain, Northern Ireland, Republic of Ireland
Nordel:	Denmark, Finland, Iceland (not included in this report), Norway, Sweden
North Western UCTE:	Austria, Belgium, France, Germany, Luxembourg, the Netherlands, Switzerland
North Eastern UCTE:	Czech Republic, Hungary, Poland, Slovak Republic, Ukraine-West
South Eastern UCTE:	Bosnia-Herzegovina, Bulgaria, Former Yugoslav Republic of Macedonia (FYROM), Greece, Montenegro, Romania, Republic of Serbia
Centre South UCTE:	Croatia, Italy, Slovenia
South Western UCTE:	Portugal, Spain

Indicative values for Net Transfer Capacities (NTC) in Europe

Summer 2008, working day, peak hours (non-binding values)

REMARK:

These indicative values have been computed by extrapolation from standard situations, in order to evaluate the transfer capacity through a single interface for a typical exchange situation (European Reference Case Map also available on ETSO Website). Thus these figures are only indicative and they are not cumulative (they cannot be summed up). Maximum export and import values per country also intend to clarify this.

Legend :

- 2400 — NTC in MW : Value agreed by both countries
- 500 / 800 HU — NTC in MW : Different values are estimated between the two countries involved. The lower value is shown on top and the country providing the higher value is specified.
- 800 / MA — NTC in MW : Value provided by only one country. The country providing no value is specified.
- NRL — no realistic limit (6)
- ETSO Member country
- ETSO Associate Member country
- [illegible] TSO country
- Other country

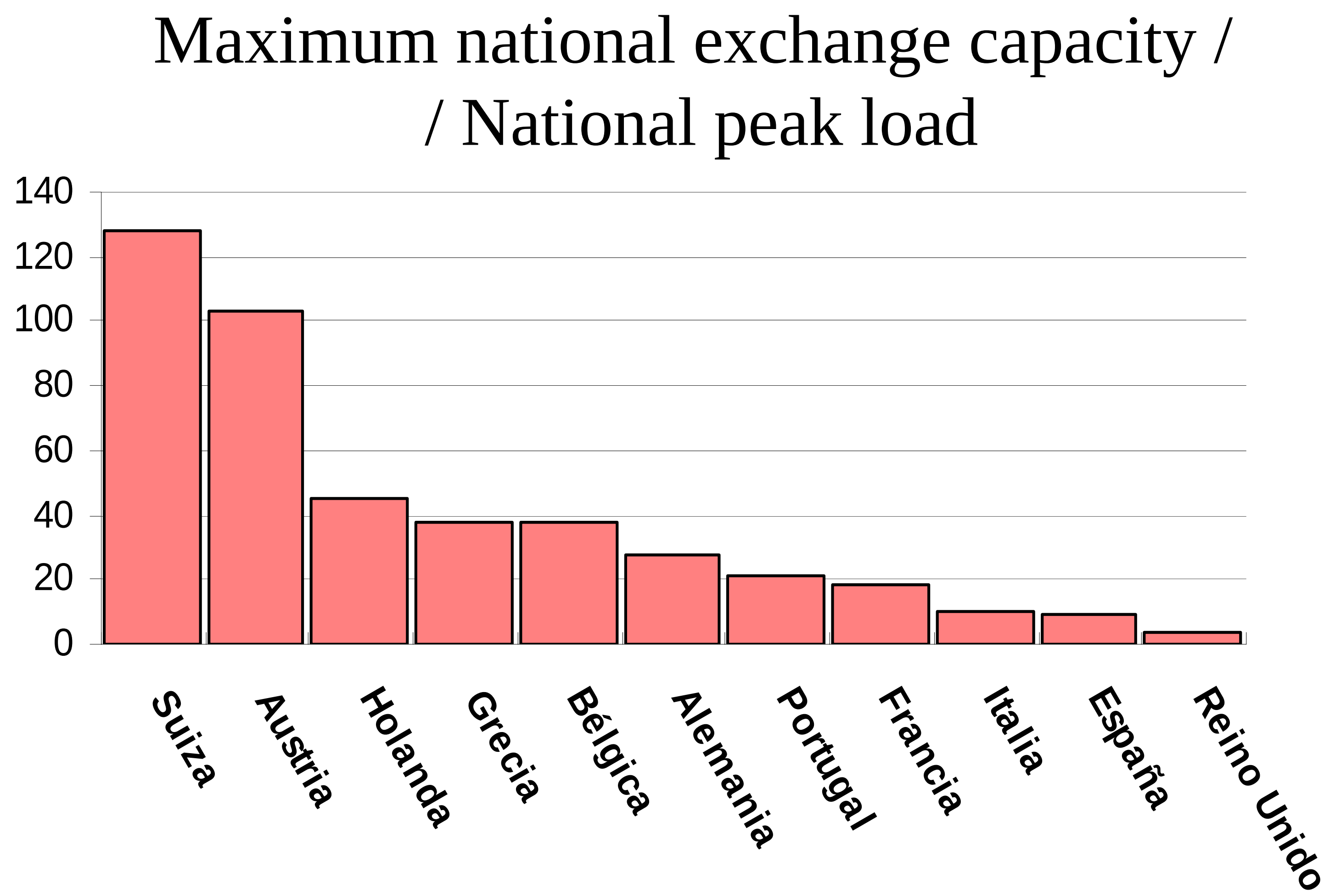
Version
15th July 2008

To ↓ / From →	IE/NI (7)	GB	MA	PT	ES	FR	BE	NL	DE (4)(5)	DKw (1)(4)	DKe (2)	NO	SE	FI	CH	IT (11)	AT	SI	PL (12)	CZ	SK	HU	GR	RO	HR	BA	RS	ME	MK	AL	BG	UA	LV	LT	EE	BY	RU	Maximum import in MW
IE/NI (7)		410																																				
GB	80					2000 GB																																
MA					800 MA																																	
PT					1100																																	
ES			600 MA	1200		1200																																
FR		2000 GB			600		1100		2400						1400 NRL CH	870																						
BE						2700		1900																														
NL							2000		4000			700 NL																										4700 (4)
DE (4)(5)						2600		3900		1500 (4)	650		600		4400		1400 1850 AT		1200 (4) PL	2250 (4)																		
DKw (1)(4)									950 (4)			1000	680																									
DKe (2)									600				1300																									
NO								700 NL		950			1700																									
SE									600	740	1700	2200		1600					100 600 SE																			
FI													2000																						350		1300	
CH						3000			1700							1140	800 1000 AT																					
IT (11)						2400									3160		200	330					500 (14) IT															
AT									1600 1000 AT						1000	70		650 1300 AT		250 1250 CZ		100 600 HU																
SI																120	360 450 SI								800 900 SI													
PL (12)									800 (4) PL				600							800 PL	600 PL																	0 (16)
CZ									800 (4)								400 600 CZ		1600 PL		1100 1350 CZ																	
SK																			400 PL	1000 2250 CZ		400										400 UA						
HU																	500 500 HU				700 1000 HU			800 1000 HU	400		800					800 UA						
GR																500 (14) IT													100	0	600							
RO																						600					460 400 RO				500 600 RO	700 UA						1850
HR																		800				1000				650	400											
BA																									600		400	460										
RS																						600		460 500 RO	450	450		360	480	125 NRL RS	450 300 BG							
ME																										523	360			125 300 ME								
MK																							200				360											
AL																							200				260	160 200 AL										
BG																							100 400 BG	600			400											
UA																					400 UA	NRL UA		200 UA														
LV																																		1100	760		400	
LT																																	800			1400	680	
EE														350																			760				1000	
BY																																		2200				
RU														0																			650	650	1000			
Maximum Export in MW								4000 (4)	7000 (4)(5)										600 (16)					1550														

Footnotes :

(1) : Denmark West
(2) : Denmark East
(3) : Maximal cumulated value from GB to NL, FR and CH
(4) : Depending on wind situation in Germany
(5) : [illegible] "no realistic limit".
(6) : [illegible]
(7) : [illegible]
(8) : [illegible]
(9) : [illegible] TSO (AT) [illegible]
(10) : [illegible]
(11) : [illegible]
(12) : [illegible] NTC Matrix
(13) : [illegible]
(16) : [illegible] DE, CZ and SK

… & note the levels of electrical insularity for some representative countries…



... resulting in numerous bottlenecks...

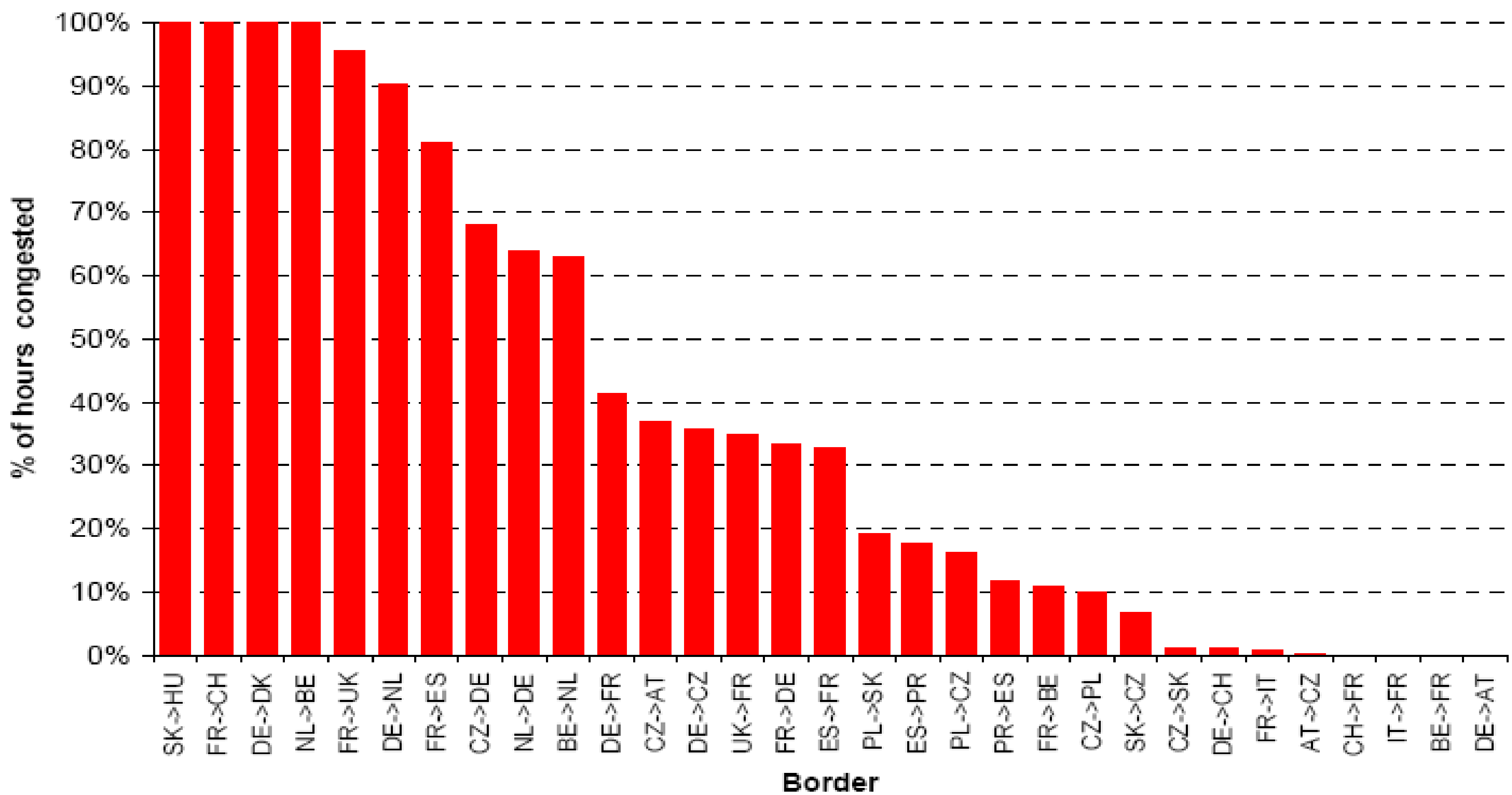
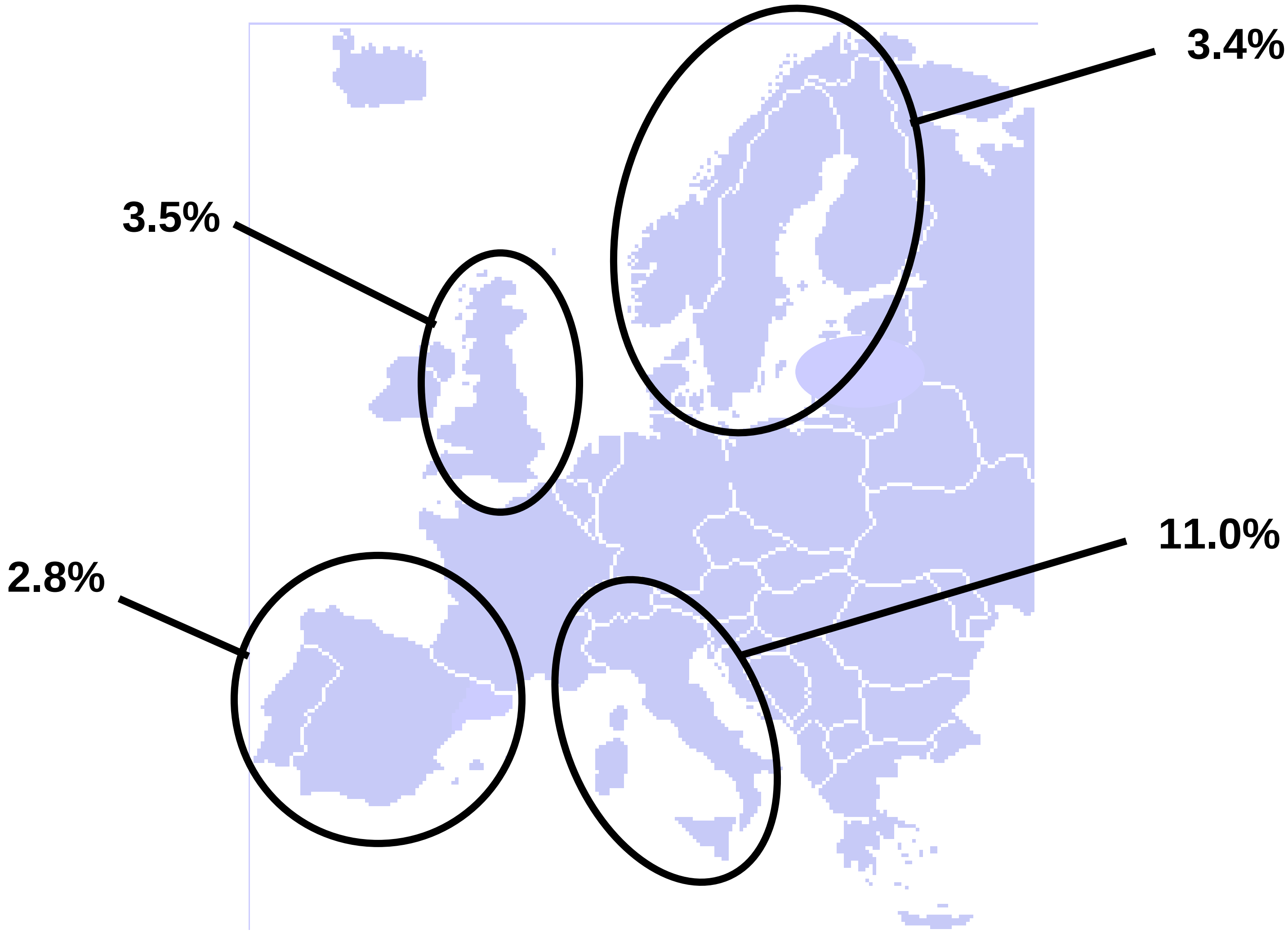


Figure 2: Current congestion on selected European borders

Source: EC Sector Inquiry

… & in poorly connected regions…



Ratios between interconnection capacity and peak load

Sources: DGTREN, ETSO, Nordel y REE

The lack of sufficient interconnection capacity

- In the past cross-border exchanges of electricity between EU Member States were of limited importance, mainly
  - for the commercial advantage of vertically integrated utilities (most often in neighboring countries)
  - for system security & mutual support

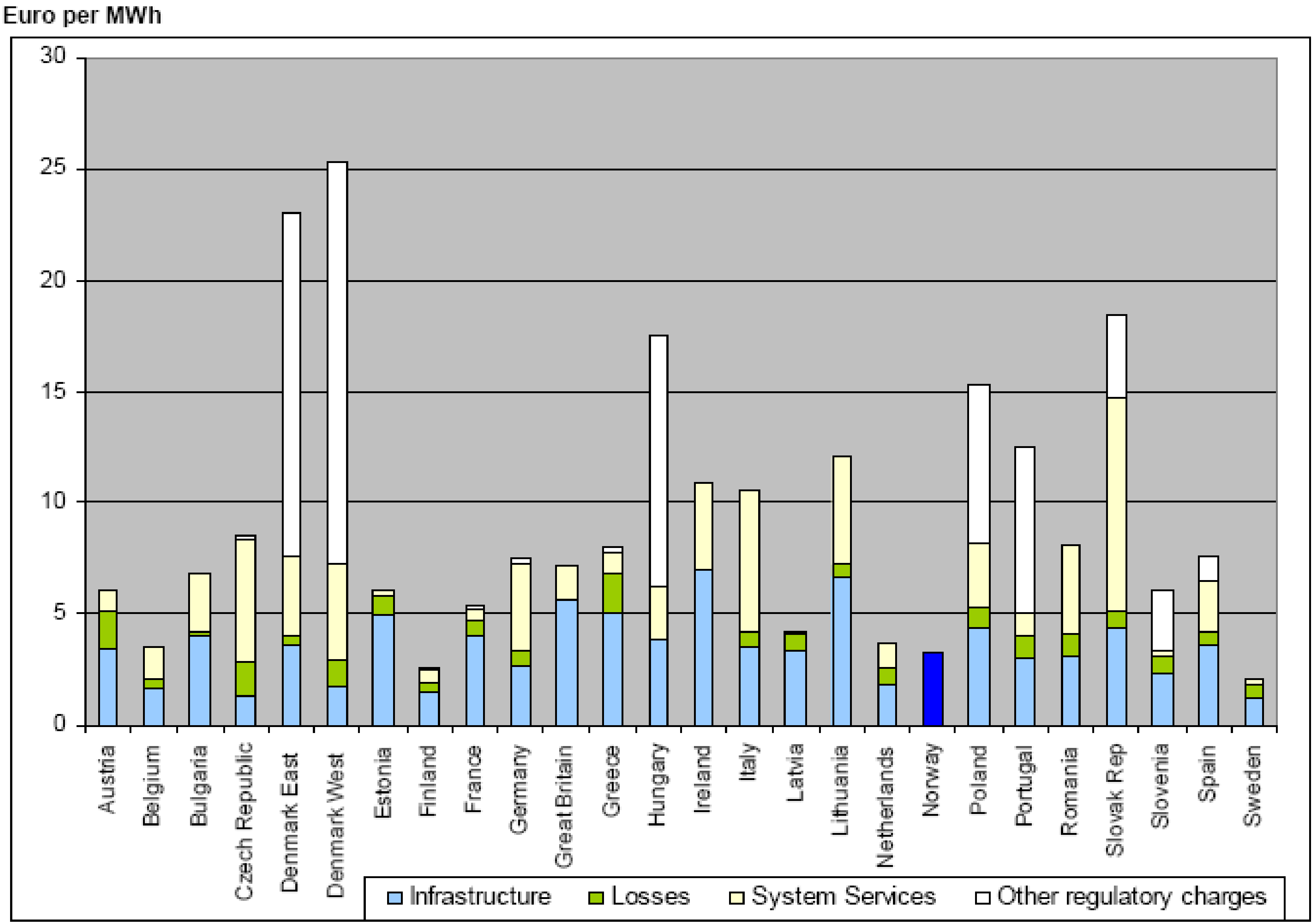
➔ Transmission networks were developed mainly to transport electricity within national borders

Moreover, the components of the cost in the transmission tariffs in EU differ widely …

Costs included in the comparison transmission tariffs

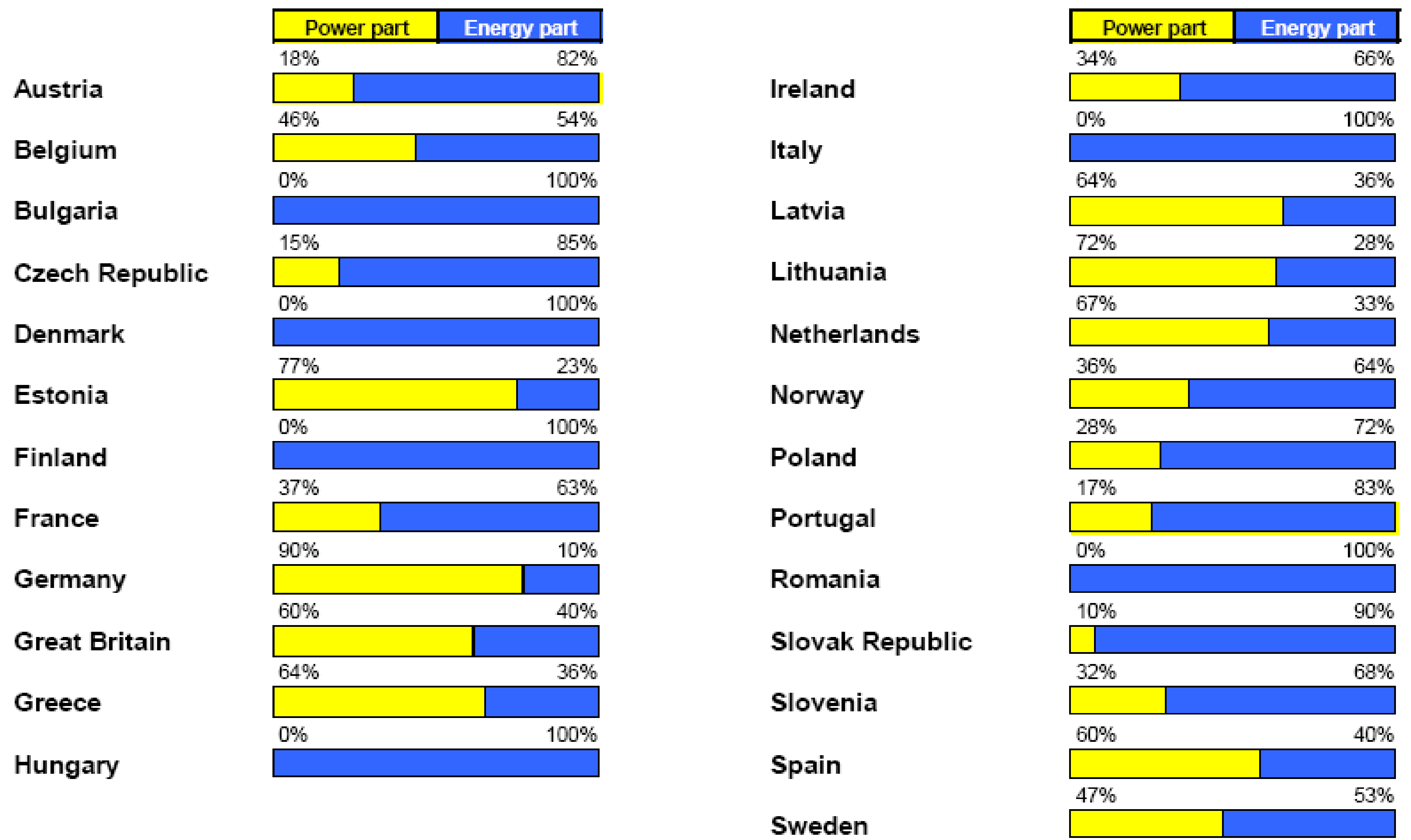
	OPEX except system-services, losses and ITC	Losses cost	ITC cost/revenue	System-services								CAPEX		Other
				Primary reserve	Secondary reserve	Tertiary reserve	Internal Congestion management	Congestion management on interconnections	Black -Start	Voltage Control Reactive Power	System Balancing	Depreciation	Return on capital invested	
Austria	C	C	C/B	N	C	N	C	C/B	C	C	N	C	C	N
Belgium	C	C	C/B	C	C/B	C/B	C	C/B	C	C	N	C	C	N
Bulgaria	C	C	C	C	C	C	N	N	C	C	C	C	C	N
Czech Rep.	C	C	C	C	C	C	N	C	C	C	C	C	C	C
Denmark E.	C/B	C	C/B	C	N	C	C/B	C/B	C	C	C/B	C	C	C/B
Denmark W.	C/B	C	C/B	C	C	C	C/B	C/B	C	C	C/B	C	C	C/B
Estonia	C	C	N	N	N	C	N	N	N	C	N	C	C	N
Finland	C	C	C	C	N	C	C	C	C	C	N	C	C	C
France	C	C	C	C	C	N	C	N	C	C	N	C	C	C
Germany	C	C	C/B	C	C Partly	C Partly	C	C/B	C	C	C	C	C	C
Great Britain	C	C	N	C	C	C	C	C	C	C	C	C	C	N
Greece	C	C	N	C	C	N	N	C	N	N	N	C	C	C
Hungary	C	C	C/B	C	C	C	C	N	C	C	C/B	C	C	C
Ireland	C/B	N	N	C	C	C	C	C	C	C	C	C	C	N
Italy	C	C	N	C	C	C	C	N	C	C	C	C	C	N
Latvia	C	C	N	N	C					C	C	C	C	N
Lithuania	C	C	C	N	C	C	N	N	C	C	N	C	C	N
Netherlands	C	C	C	N	C	C	C	N	C	C	C	C	C	N
Norway	C	C	C/B	C	N	C	C/B	C/B	N	C	N	C	C	N
Poland	C	C	C	C	C	C	C	N	C	C	C	C	C	C
Portugal	C	C	C	N	N/C**	N/C**	N	N	N	N	N/C**	C	C	C
Romania	C	C	C/B	N	C	C	C	C/B	C	C	N	C	C	C
Slovak Rep	C	C	C/B	C	C	C	N	N	C	C	N	C	C	C
Slovenia	C/B	C/B	C	N	C	C	N	N	C	C	C	C/B	C/B	C
Spain	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Sweden	C	C	C/B	N	N	C (1/3)	C	C/B	C	C	N	C	C	N

Components of transmission tariffs

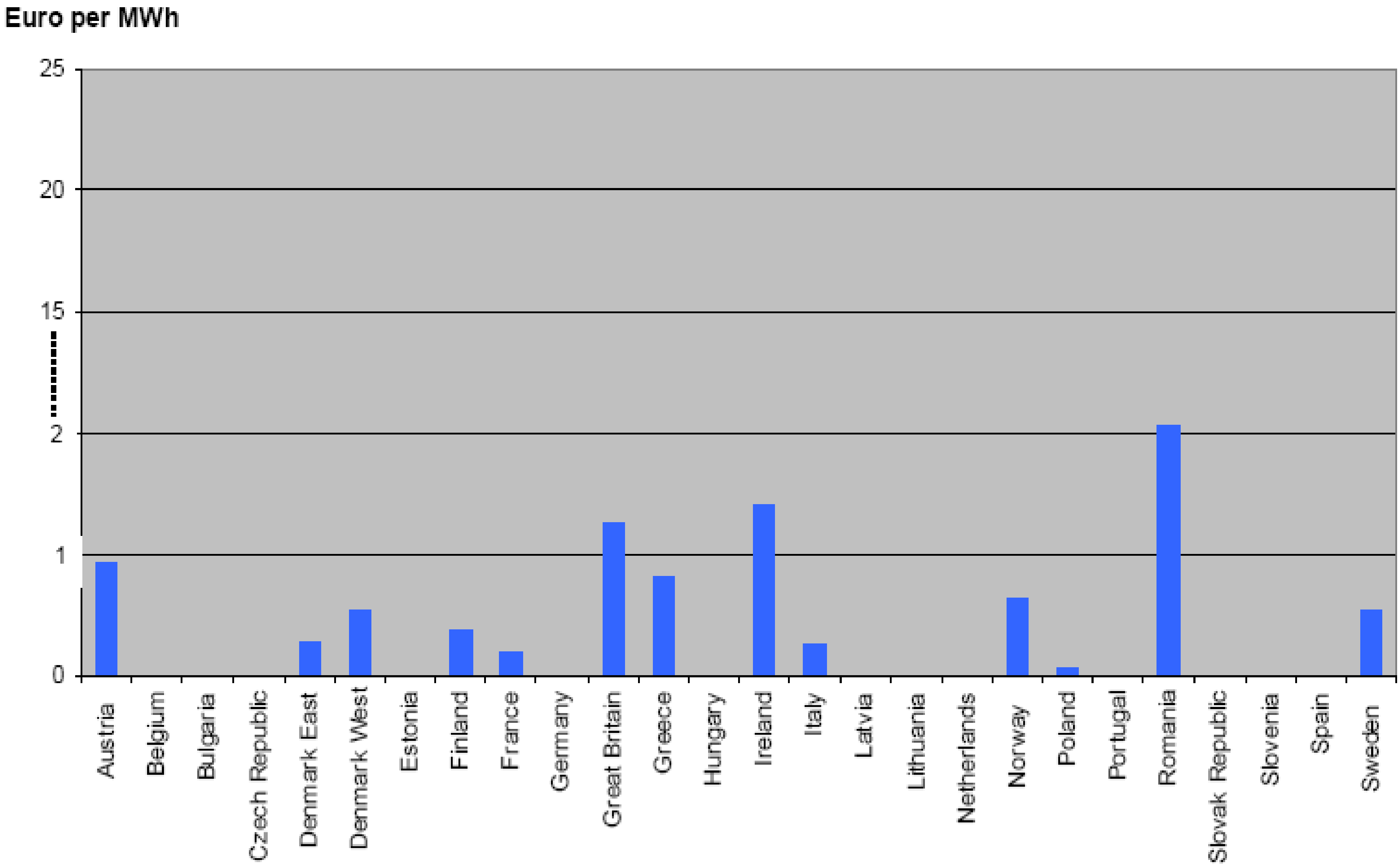


... as well as the structure of the tariffs themselves...

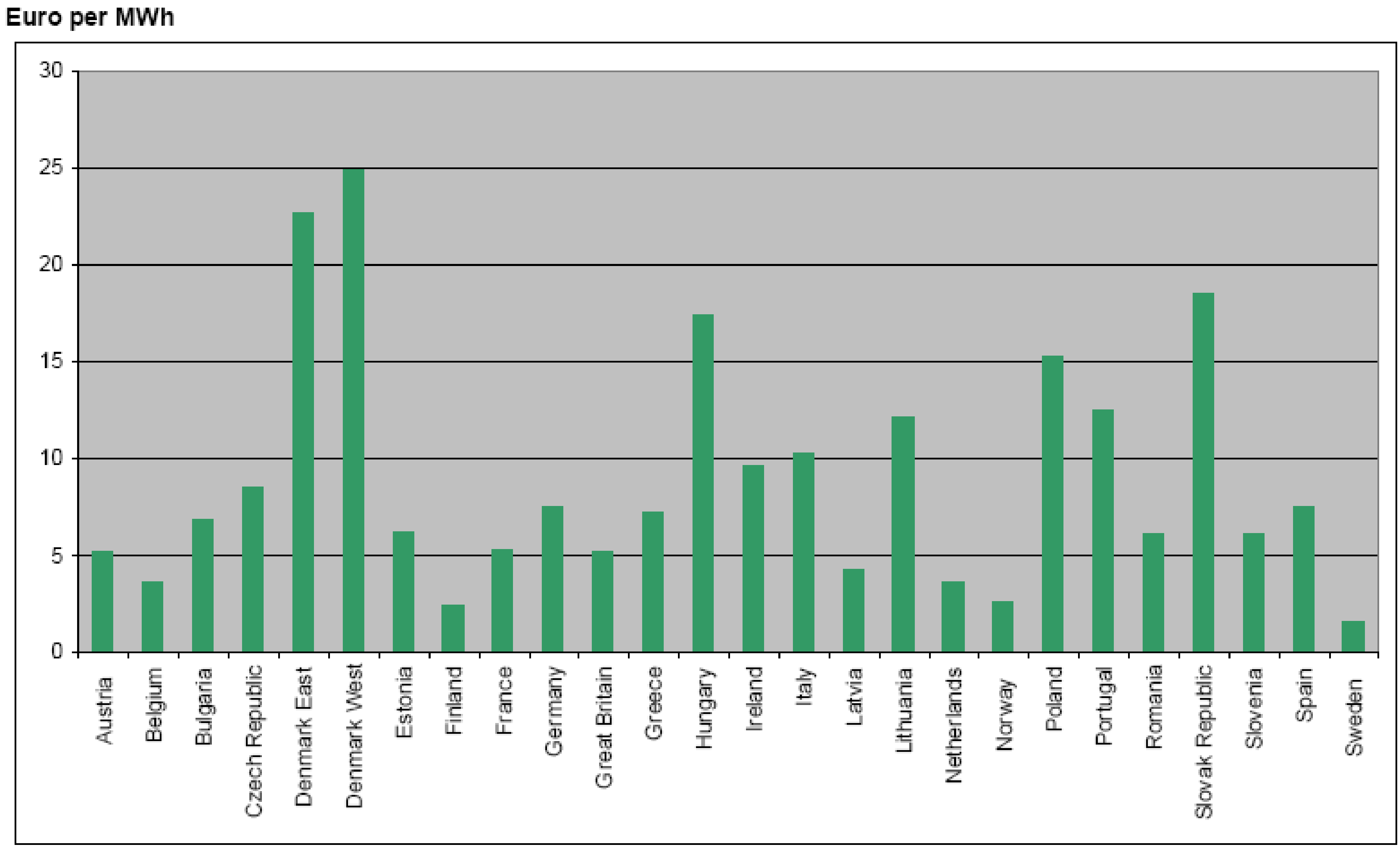
Energy-related components and power-related components in the transmission tariff



Range of G components paid in 2007 by producers across Europe

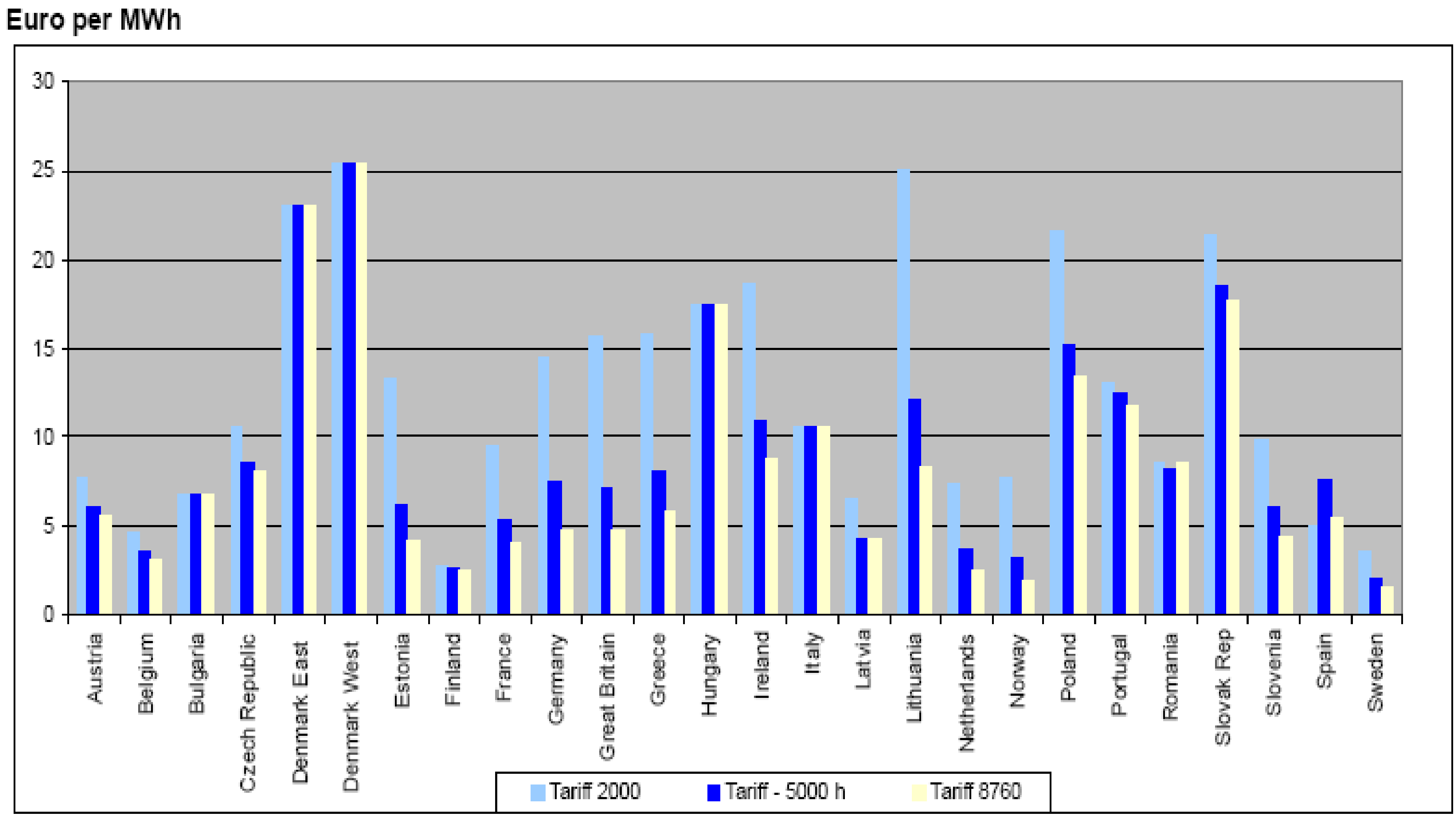


Range of L components paid in 2007 by load across Europe



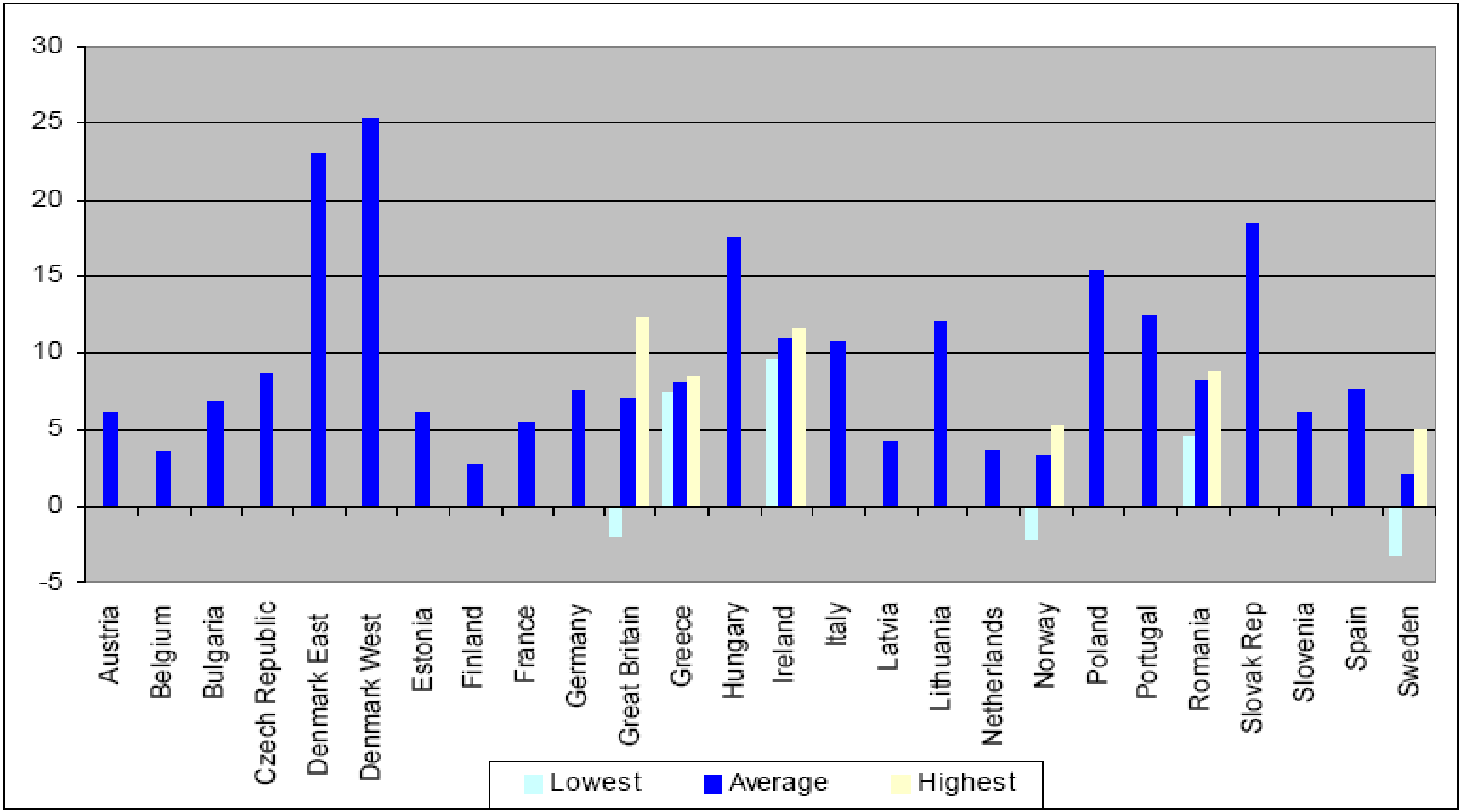
... and the final numerical values of the tariffs, without a convincing explanation

Comparison of transmission tariffs G+ L: impact of utilisation time



Comparison of transmission tariffs G+ L: impact of location

Euro per MWh



Inter-TSO payments: What's the solution?

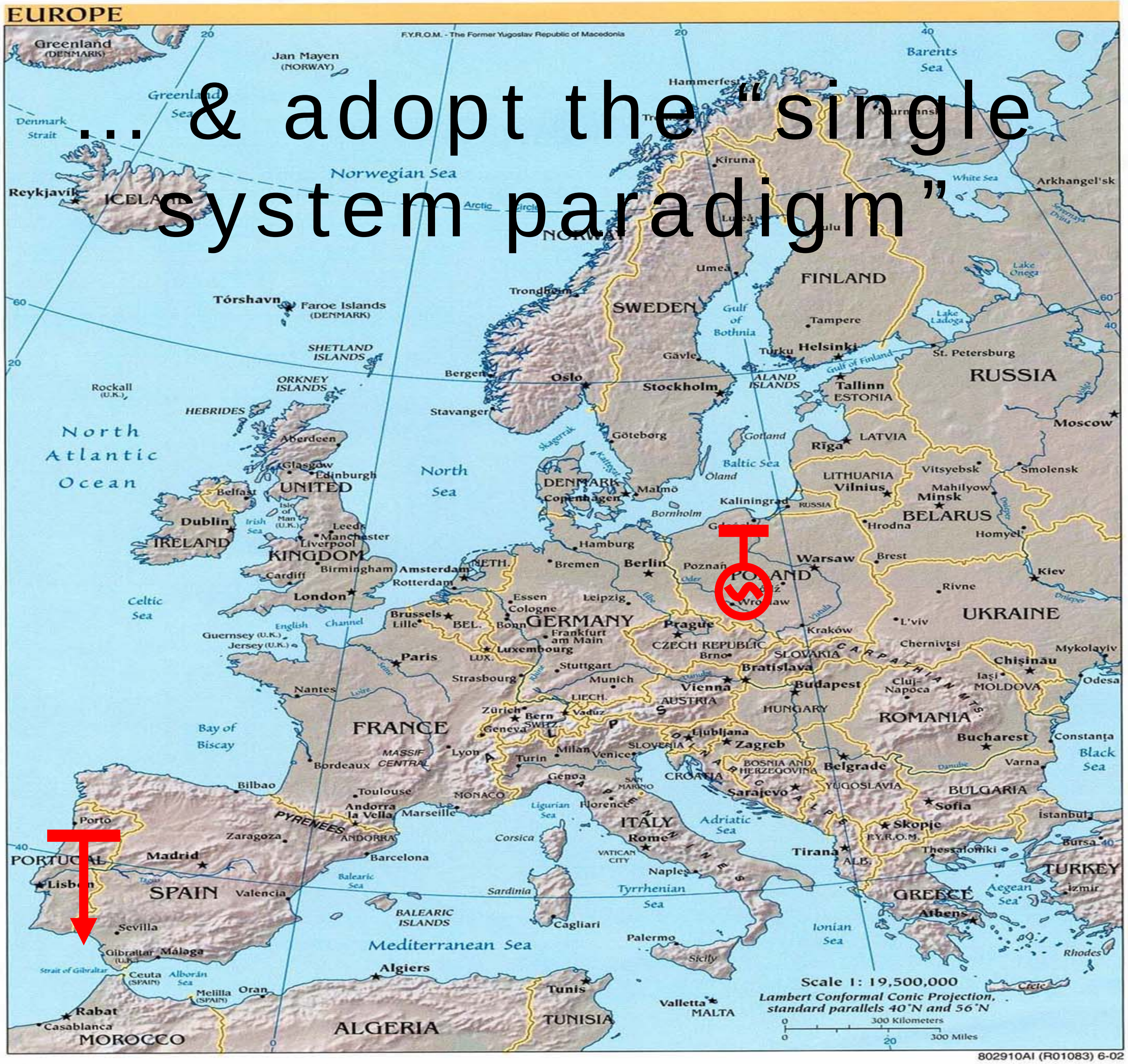
What is an acceptable cross-border trading scheme?

- The "obvious" approach is wrong:
  - Treat each cross-border transaction CBT as a local generator or demand that is placed at the corresponding border node ➔ this leads to tariff pancaking & lack of coordination in transaction management
    - economically inefficient
    - an obstacle to international trade

➔ back to the basics

Abandon this mental model ...

… & adopt the “single system paradigm”



Cross-border tarification

"Single system paradigm" for transmission network pricing ➔

- Local connection charge (G, L) provides access to entire EU network
  - charges are independent on the commercial transactions
  - some transmission tariff harmonization should be achieved

Cross-border tarification

Implementation

- Pan-European access with local G & L charges
  - Implemented since March 2001
    - Also an initial export fee was applied, but eliminated two years later
- Inter-TSO payments to compensate for external network use
  - The temporary scheme adopted in 2001 was very crude. The initial disagreement on the appropriate method to measure external network use, how to determine its cost & how to allocate the charges still persists

Cross-border tarification

- **Implementation** *(cont.)*
  - no cross-border tariffs, but inter-TSO payments
  - with the net balance of inter-TSO payments each country modifies its internal G & L tariffs
  - Note that the final G & L tariffs are not transaction-based *(& this is how it should be)*

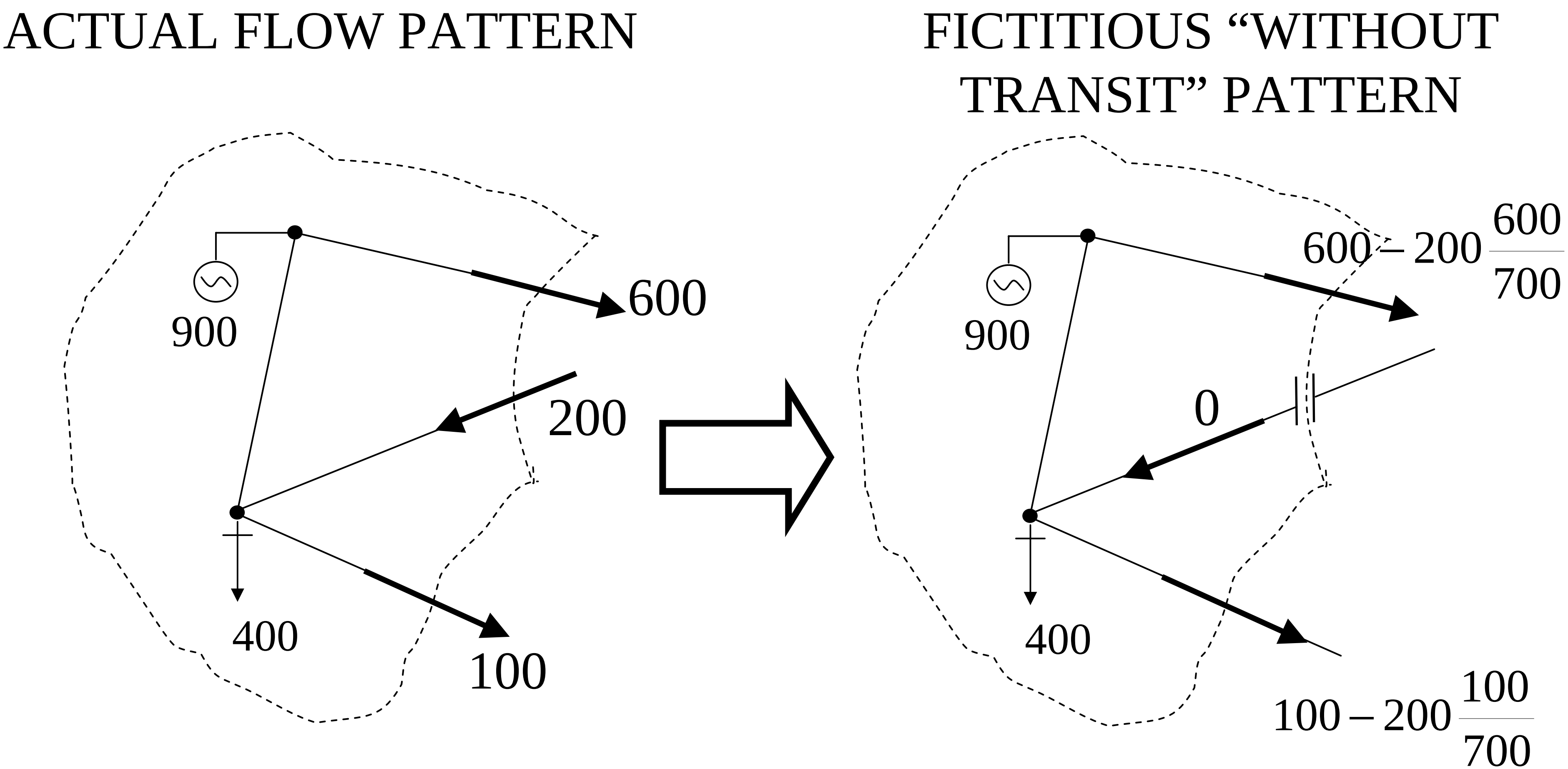
Inter-TSO payments
Computation

- **Step 1.** Determine the **compensation** that is due to each country/TSO on the basis of the external use of its network & standard network & energy costs
- **Step 2.** Determine the **charges** to be applied to each country/TSO because of its responsibility in the extra costs of other countries
- **Step 3.** Application of the **net balance** of compensation & charges of a country/TSO to its internal network users

Computation
Two basic approaches

1. Difference in network costs with & without transits
   - several possible algorithms
2. Allocation of the use (standard cost) of each one of the lines to individual nodes → How much each country (TSO) must pay of each line
   - Inter-TSO compensations & charges are obtained by aggregation for all lines
   - several possible algorithms

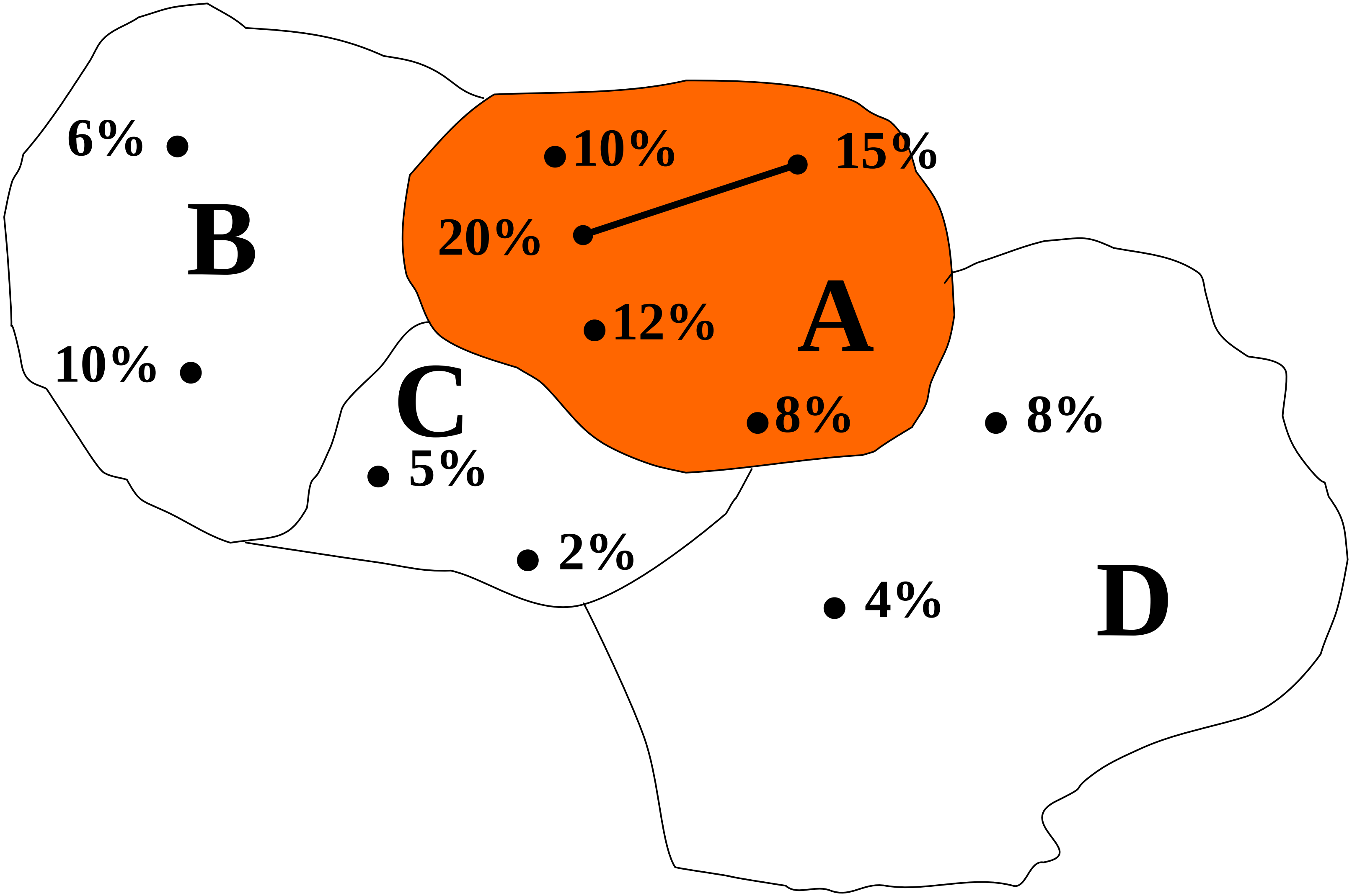
Methods that are based on the comparison between with & without transit situations



T=min(200,600+100)=200

(Each country or TSO is treated separately)

Methods *(such as AP)* that are based on the allocation of the use of each individual line



The institutions

The EU institutional framework

- **General:** Parliament, Council, Commission
  - Capacity to establish EU norms *(propose & approve Directives)*
- **Specific:** General Direction for Energy & Transport (DG TREN) in the EU Commission
- **Institutions**
  - Council of European Energy Regulators, CEER→ ERGEG
  - European Transmission System Operators, ETSO
  - Other: Market Operators (Europex), Consumers, Traders (EFET), Power Companies (Eurelectric)

→ **The Florence Forum brought all of them together**

Inter-TSO payments
The technical debate

Approach 1:
Identify the fraction of a network that is used by "transit"

The WWT method (1)

- A temporary approach developed by ETSO, evaluated by CEER and approved by EU Commission
  - First version implemented by 1st March-01 & accepted until Dec-2001
  - Several temporary modifications have been approved & applied since, while searching for a satisfactory permanent method
- The longer-term (permanent?) approach is still under discussion

Allocation using the "with & without transits WWT" approach *(as of 2008-09)*

- A definition of transit across a country or TSO is needed
  - Current version: the sum of all inflows into or of all outflows from a country, whatever is smaller
- Compensation to a TSO (step 1) is determined by comparison of the with & without transit situations
  - Note that the definition of "without transit" situation needs additional assumptions

The temporary mechanism
(it has gone through several versions)

- **Step 1. Compensations:**
  - The horizontal network HN *(the network of a country that is used by transits)* is determined first
    - Only lines “significantly” affected by transits are included
  - The comparison with / without transit for each country determines
    - The fraction of the country’s network that is used by transits and whose regulated cost must be compensated
    - The losses to be included in the cost claim

The temporary mechanism

- **Step 2. Charges:**
  - The cost of the horizontal networks that is determined to be subject to external utilization is allocated to countries in proportion to the total amount of net physical exports or imports of each country (or TSO): “net flows” *(computed for each scenario & aggregated for the entire year)*
  - A 1.4 €/MWh fee is applied on imports/exports from perimeter countries

The temporary mechanism

- **Step 3. Application of net result of compensations & charges to the final end network users at each Member State**
  - In the G & L national tariffs, with the allocation being left to subsidiarity

Ex ante financial outcome of the ITC agreement 2008/2009

The 1st column shows the estimated ex ante total net result for each country.

The 3rd & 4th columns show the compensations (i.e. before charges are accounted for) due to losses & infrastructure use.

The allocation % of any deviation in estimated exports or imports to perimeter countries (2nd column) is made pro rata of total net results (1st column)

Ídem for deviations in losses, which are allocated pro rata of the values in 4th column.

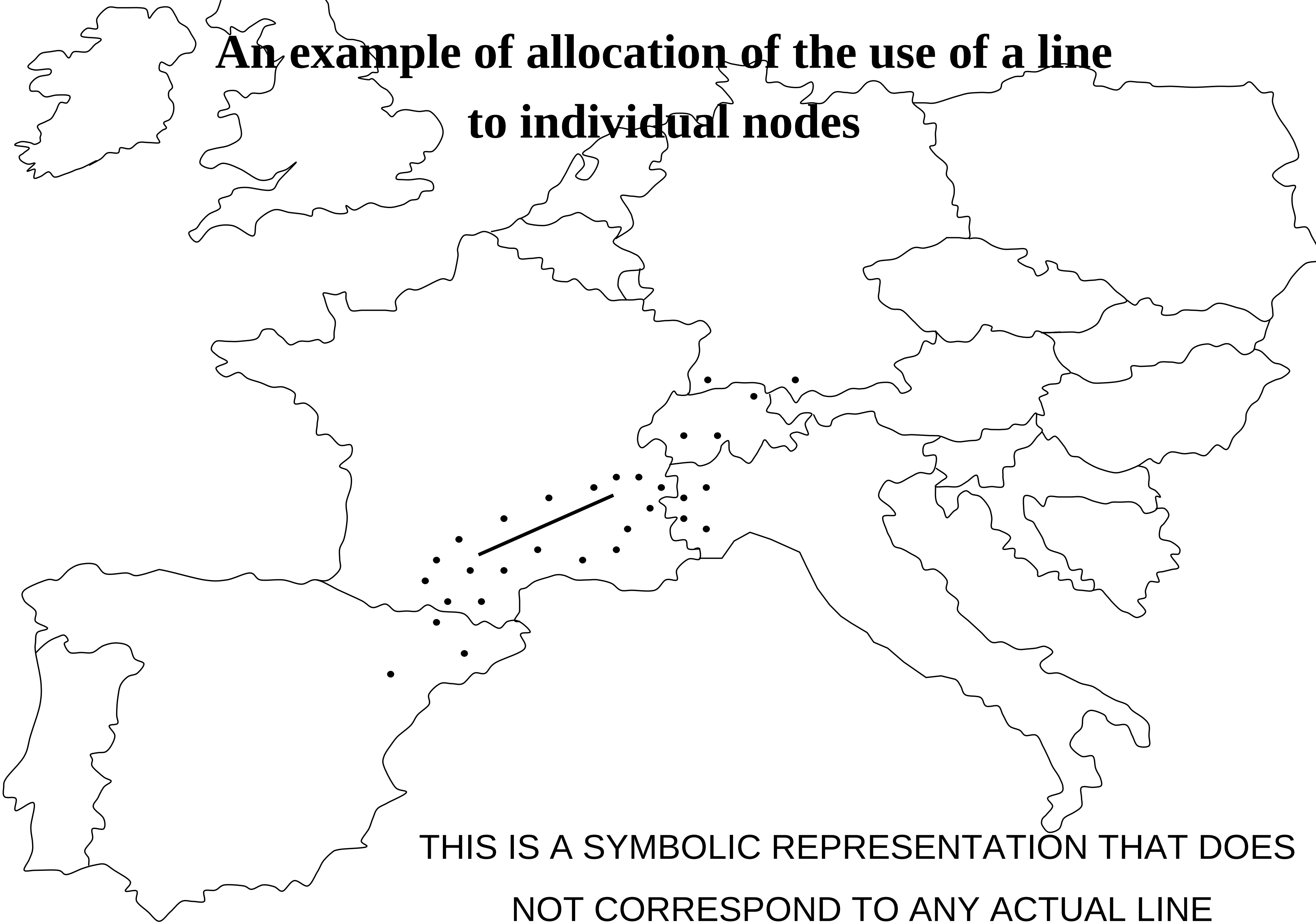
Country	Ex Ante Total Net Result [M€]	Shares due to Volatility of Scheduled Flows with Perimeter Countries	Ex Ante Losses Costs - Claim [M€]	Ex Ante Infrastructure Cost-Claim [M€]	Shares due to Volatility of Losses Costs
	$NR_{se}(k)$	$Share^{PC}(k)$	$CC_{se}L(k)$	-	$ShareL(k)$
Albania	-1,290	0,327%	-0,173	0,371	0,053%
Austria	24,476	6,199%	7,767	72,584	10,395%
Belgium	-1,271	0,322%	1,522	13,599	1,948%
Bosnia	2,943	0,745%	0,524	11,886	1,703%
Bulgaria	-5,673	1,437%	0,475	2,803	0,402%
Croatia	7,751	1,963%	4,301	35,392	5,070%
Czech Rep.	1,624	0,411%	3,819	25,006	3,582%
Denmark (NORDEL)	4,597	1,164%	0,440	19,486	2,759%
Denmark (UCTE)	7,651	1,938%	2,942	25,388	3,637%
Finland	-12,086	3,066%	2,415	8,181	1,172%
France	-57,046	14,448%	2,437	23,962	3,433%
Germany	51,336	13,002%	25,138	169,518	24,286%
Great Britain	-9,357	2,370%	-1,088	0,000	0,000%
Greece	-0,948	0,239%	0,942	4,611	0,661%
Hungary	10,002	2,533%	5,563	41,726	5,978%
Ireland	-1,628	0,412%	0,027	0,000	0,000%
Italy	-48,824	12,366%	0,905	1,849	0,265%
Estonia Latvia Lithuania	-2,200	0,000%	-	-	0,000%
FYROM	-1,222	0,309%	0,187	0,718	0,103%
Montenegro	-0,620	0,157%	-0,076	3,571	0,512%
Netherlands	-20,773	5,261%	1,808	8,305	1,190%
Northern Ireland	-0,483	0,122%	0,812	1,542	0,221%
Norway	-17,311	4,384%	0,828	3,870	0,554%
Poland	-6,986	1,769%	-0,968	5,800	0,831%
Portugal	-5,269	1,335%	1,029	0,619	0,089%
Romania	-5,556	1,407%	-0,505	0,000	0,000%
Serbia	4,211	1,067%	3,719	15,834	2,268%
Slovakia	2,273	0,576%	1,569	9,680	1,384%
Slovenia	7,844	1,987%	2,164	24,214	3,469%
Spain	2,770	0,702%	-0,804	11,147	1,597%
Sweden	1,428	0,361%	8,798	23,599	3,381%
Switzerland	69,610	17,630%	15,527	132,840	19,030%
Total	0,000	100,000%	91,939	698,040	100,000%

Perimer Country	Edge Country	Nominated Import from Edge country [GWh]	Nominated Export to Perimeter Country [GWh]	Total [GWh]
Bekrussia (UCTE)	Poland	865,8	0,0	865,8
Morocco	Spain	110,3	898,2	1008,5
Russia (Nordel)	Finland	11312,4	0,0	11312,4
Russia (Nordel)	Norway	215,6	0,0	215,6
Ukraine	Hungary	3304,7	0,0	3304,7
Ukraine	Poland	985,2	0,0	985,2
Ukraine	Romania	667,4	60,4	727,8
Ukraine	Slovakia	290,6	0,0	290,6
Total		17751,9	958,6	18710,5

Perimeter Countries Contribution Reference Amount = 1,4x18710500 = 26194700 €

Approach 2:
Allocation of the use of each individual network facility

An example of allocation of the use of a line to individual nodes



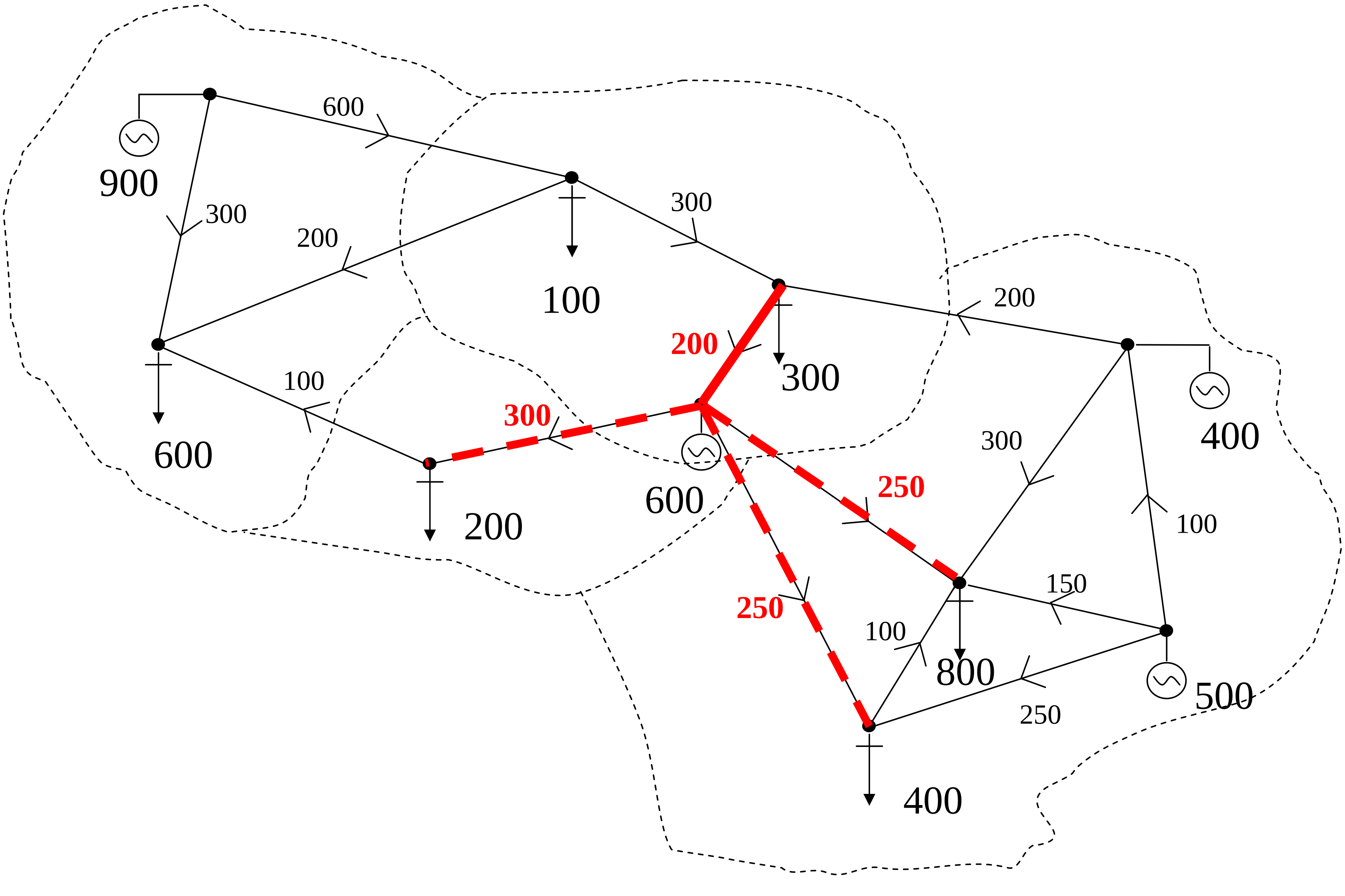
THIS IS A SYMBOLIC REPRESENTATION THAT DOES NOT CORRESPOND TO ANY ACTUAL LINE

Example: Allocation of the flow of a line to the nodes of the system

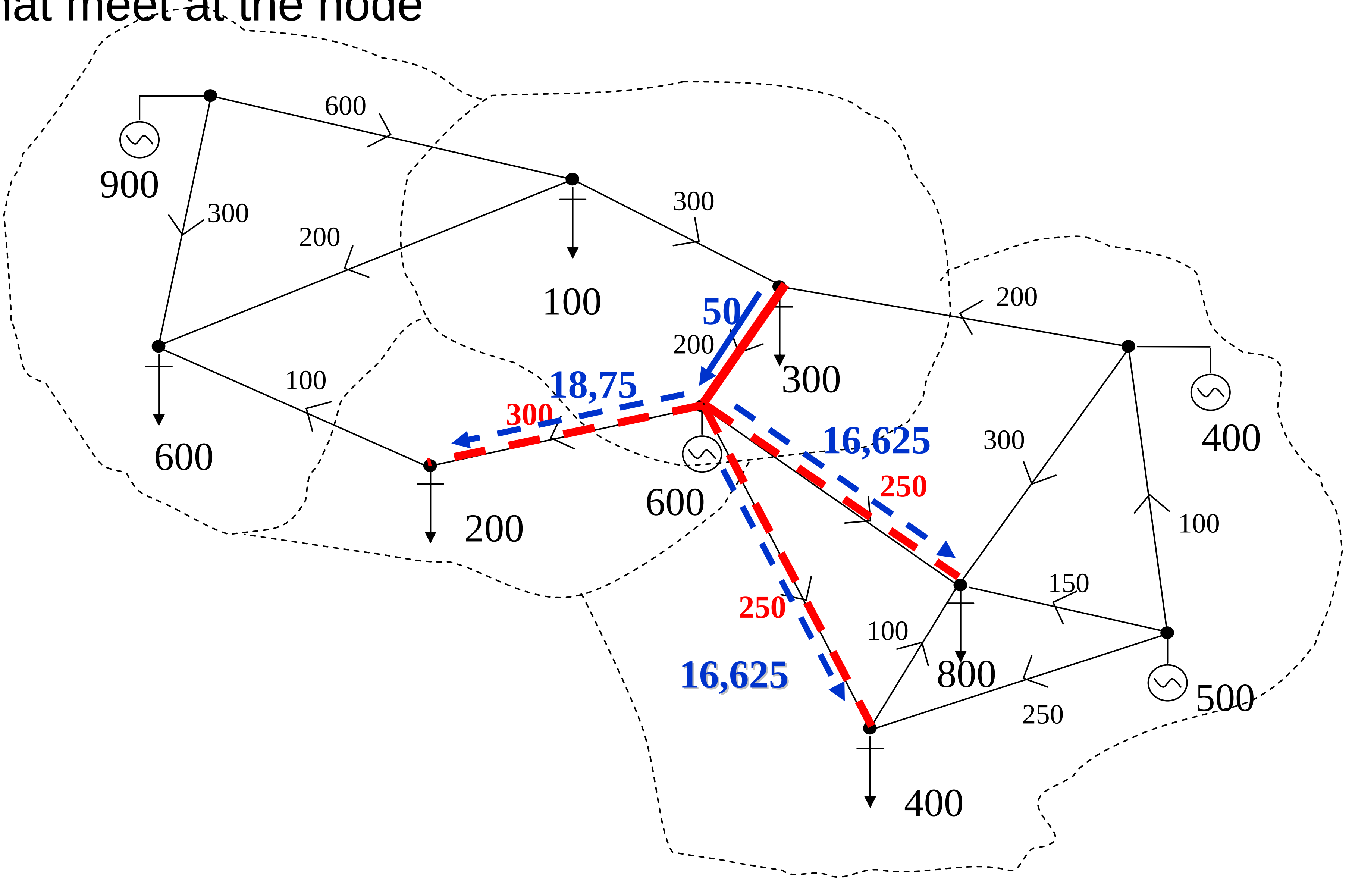
Allocation of utilization of the line between the nodes of LACHMAT and MUENCHWI, in Germany, for a given scenario

Bus Name	Relative contribution to the line flow
CHAMOSON	0.36%
LEIBSTAD	32.39%
DAXLANDE	1.75%
LACHMATT	50.86%
MITTELBE	4.60%
KK PHILI	6.11%
KUEHMOOS	3.94%

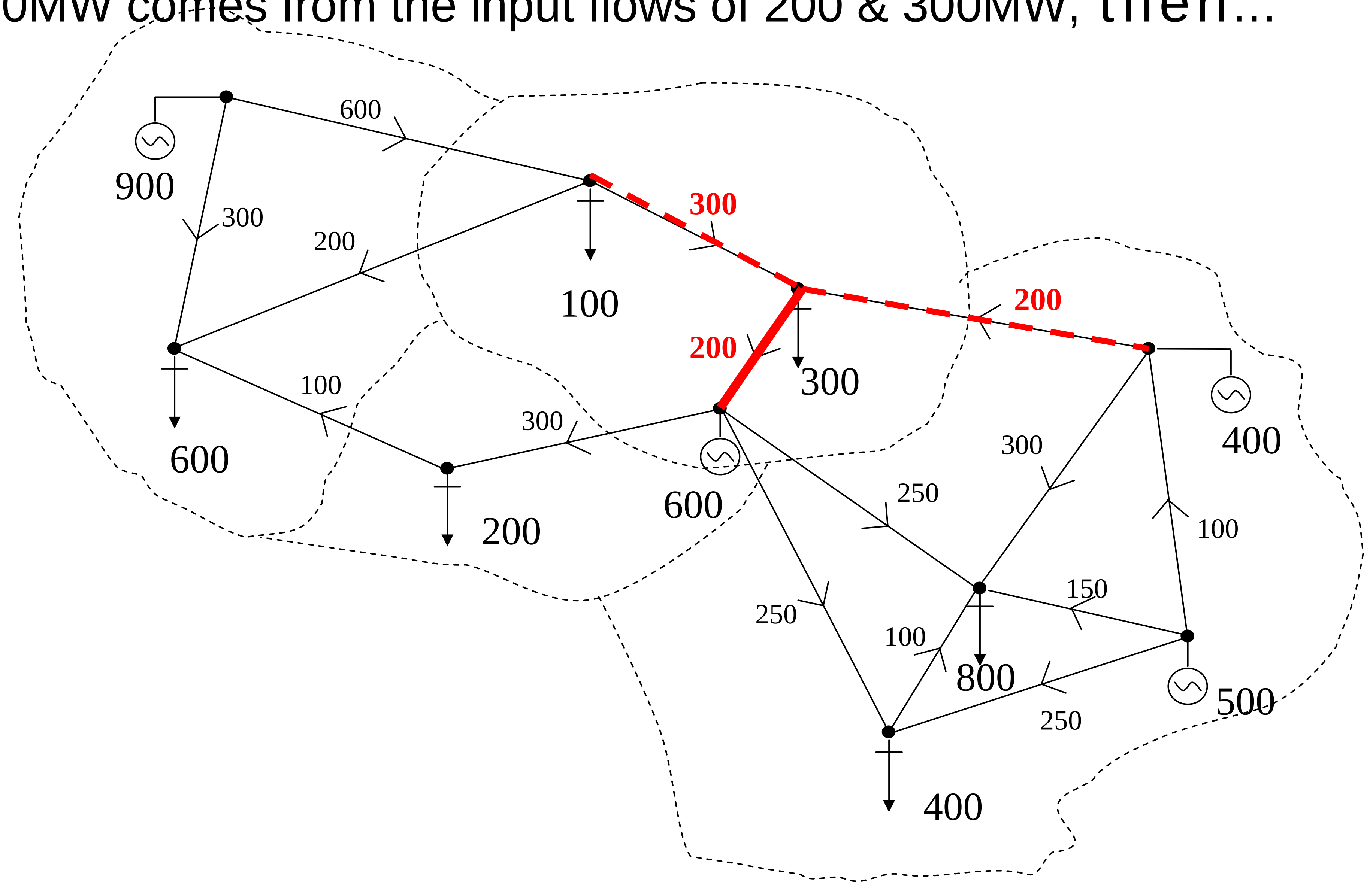
The basic assumption behind AP: If an energy flow of 200MW branches as 300, 250 & 250 MW at a node, then…



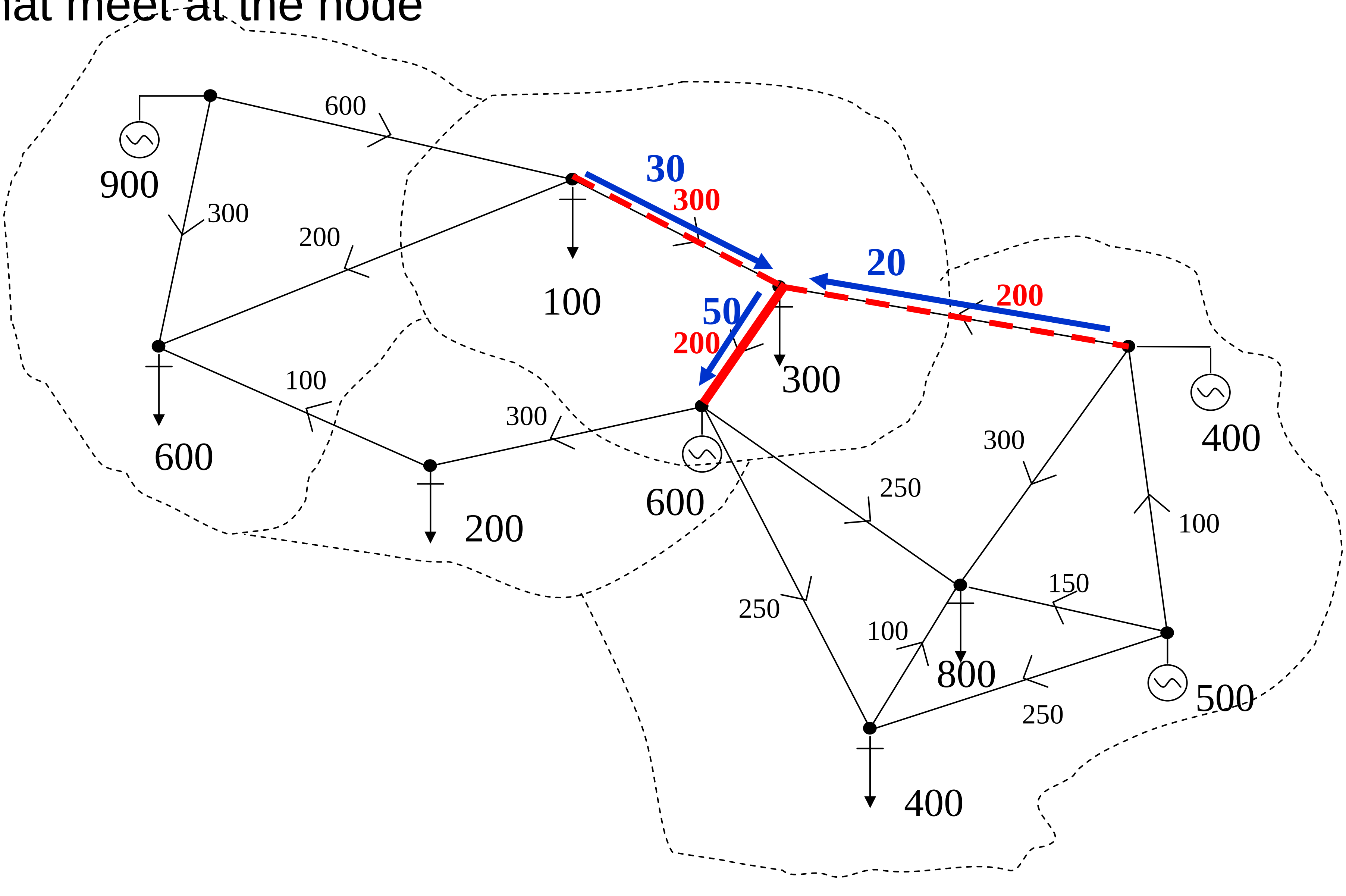
... then a flow of 50 MW in this same line, which I want to track downstream, will branch pro rata to 300, 250 & 250 in the same lines that meet at the node



The same idea applies when attributing responsibility for a flow in the **upstream** direction: since the energy flow of 200MW plus the load of 300MW comes from the input flows of 200 & 300MW, then…



… then a flow of 50 MW in this same line, which I want to track upstream, will branch pro rata to 300, 250 & 250 in the same lines that meet at the node



Results of AP for a sample case

OWNER

USER	AT	BE	CH	CZ	DE	ES	FR	GR	HU	IT	NL	PG	PL	SI	SK
AT	92.2	0.0	0.1	11.5	7.4	0.0	0.0	0.0	2.7	4.0	0.0	0.0	0.3	4.8	1.3
BE	0.0	232.3	0.0	0.0	1.0	0.0	8.7	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0
CH	1.9	0.0	147.8	0.0	25.2	0.0	19.3	0.0	0.0	22.6	0.0	0.0	0.0	0.0	0.0
CZ	21.3	0.0	0.0	181.3	21.8	0.0	0.0	0.0	2.4	0.4	0.0	0.0	7.4	0.8	4.9
DE	17.2	2.2	24.8	11.6	1555.9	0.0	6.3	0.0	0.0	4.9	32.1	0.0	8.5	0.3	0.0
ES	0.0	0.0	0.0	0.0	0.0	987.7	16.8	0.0	0.0	0.0	0.0	21.3	0.0	0.0	0.0
FR	0.0	17.1	26.3	0.0	28.8	11.1	1457.0	0.0	0.0	28.9	0.4	0.0	0.0	0.0	0.0
GR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	315.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HU	1.6	0.0	0.0	1.6	0.0	0.0	0.0	0.0	96.1	0.0	0.0	0.0	0.1	0.0	7.3
IT	11.0	0.0	46.3	0.3	9.8	0.0	36.3	0.0	0.0	649.7	0.0	0.0	0.0	7.0	0.0
NL	0.0	5.5	0.0	0.0	11.6	0.0	0.1	0.0	0.0	0.0	282.2	0.0	0.0	0.0	0.0
PG	0.0	0.0	0.0	0.0	0.0	27.5	0.0	0.0	0.0	0.0	0.0	183.7	0.0	0.0	0.0
PL	0.7	0.0	0.0	13.2	4.9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	451.5	0.0	15.6
SI	12.0	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	22.2	0.1
SK	1.9	0.0	0.0	6.5	0.0	0.0	0.0	0.0	11.7	0.0	0.0	0.0	11.5	0.1	75.2
Use by others	67.6	24.9	97.5	45.2	110.9	38.6	87.5	0.0	17.0	62.9	44.5	21.3	27.8	13.0	29.1
Use of others	32.2	21.8	69.1	59.1	107.8	38.0	112.6	0.0	10.6	110.6	17.3	27.5	34.5	15.0	31.7
Net use	35.4	3.1	28.4	-13.9	3.1	0.6	-25.1	0.0	6.4	-47.8	27.2	-6.2	-6.7	-2.0	-2.6

Numbers are expressed in Millions of Euros

Source: “Study on the inter-TSO compensation mechanism” by the Florence School of Regulation, October 2005.

More approaches are possible

Family 1:

- Simplified average participations (SAP)
  - each country/TSO is represented by a single node
- Modified average participations (MAP)
  - forced match of internal generation & demand
- Marginal participations (MP)
  - A single slack node is assumed for all perturbations

Family 2:

- Average participations applied to transits (APT)

Other methods:

- Shapley, IMICA, Central American approach

Inter-TSO net payments
Why should we care?

- Transmission tariff pancaking has been abolished already ➔ **the most critical issue is already solved**
- The net amounts of payments *(e.g. the net payment of 49 M€ for Italy means 0,16 €/MWh if charged 100% to Italian energy demand)* are typically **very small** if they are fully passed-through to the transmission tariff
- However
  - Allocations that are perceived as **unfair** may be a future source of **conflicts**
  - The ITC method will implicitly allocate the cost of any **new transmission investment** ➔ a poor allocation method may make any future line even more difficult to build

Can we tell which one is best?

I shall reproduce here a fraction of my presentation to a Working Group of regulators when they were trying to reach a decision in 2006

1) With & without transits

WWT

Comparison of ITC methods

- What should we look at first when making a comparison?
  - Do we **really understand** what each method does?
  - What are the **basic assumptions** behind each method?
  - Perhaps we can make a choice that is just based on these basic issues & **common sense**
  - Do not mix up *"how good a method is"* with *"how sophisticated is the computation method that is employed in some step of the calculation"*

Underlying assumptions behind each method

With & without transits (WWT)

- The external use of the grid of a country can be measured as the incremental impact of the **transit** through the country on the country's grid flows
  - This requires to define "transit" & to allocate the "transit" among the several cross-border lines, therefore creating a new "**without transit**" situation to be compared to the actual one
- The **responsibility of each country** k in the external use of the network of any other country m is **assigned pro rata** of the net flow into or out of the country k, regardless of geographical proximity or any other consideration

Is WWT a reasonable method? (1)

- The following criticisms apply to WWT
  - "transit" is an **ambiguous concept**
    - It may refer to flows with origin & end in external countries that actually appear to cross the country (**OK**)
    - It may refer to flows with origin & end in external countries that actually do not cross the country (**not OK**)
    - It may refer to "loop flows" that start & end in the own country (**not OK**)

  But WWT **does not distinguish** among them
    - However, "loop flows" may be as important as the flows that do cross the countries

➔ The very foundation of WWT *(the external "impact" of the transit on the country or TSO)* is **unreliable**

Is WWT a reasonable method? (2)

(continuation)

- The “**without transit**” situation is an **artificial** one: How do you subtract “transit” if it is not clear what a “transit” is? How do you subtract the loop flows that are naturally occurring among systems without net power exchanges?

  ➔ the resulting “without transits” flow pattern is an artificial construct that may not even be physically possible

  - Subtracting a flow pattern that may not make sense from the actual flow pattern may result in nonsensical results
  - For instance, some ETSO members have rejected the results of WWT concerning losses because they do not make physical sense

➔ The very foundation of WWT is **unreliable**

Is WWT a reasonable method? (3)

(continuation)

- If a country (e.g. Germany) consists of several TSOs, WWT will result in **different** net ITC payments for the country as a whole with respect to the other countries when
  - The country is treated as a single system
  - Each TSO is treated as a single system & the results are aggregated

➔The results do not have the basic additive property

➔The very foundation of WWT is **unreliable**

Is WWT a reasonable method? (4)

(continuation)

- In WWT, the rule of allocation of the compensation that is due to a country M to all other countries is too crude: pro rata of net imports & exports
  - ➔ For instance, if Portugal, Norway & The Netherlands have the same net imports or exports, they will be charged an equal share of the compensation that may be due to Belgium

➔This rule ignores the actual pattern of flows *("The compensation shall be paid by the operators of national transmission systems **from which cross-border flows originate** & the systems **where those flows end**" in the EU Regulation 1228/2003)*

➔If we want to socialize throughout the EU ➔ let us use a flat postage stamp transmission tariff & forget about ITC mechanisms

Is WWT a reasonable method? (5)

(continuation)

- Since the “without transit” system condition may not have much sense, the subtraction of the “with” & “without” conditions may lead to **bizarre results for individual lines** ➔ this may have serious implications in the allocation of the cost of new lines

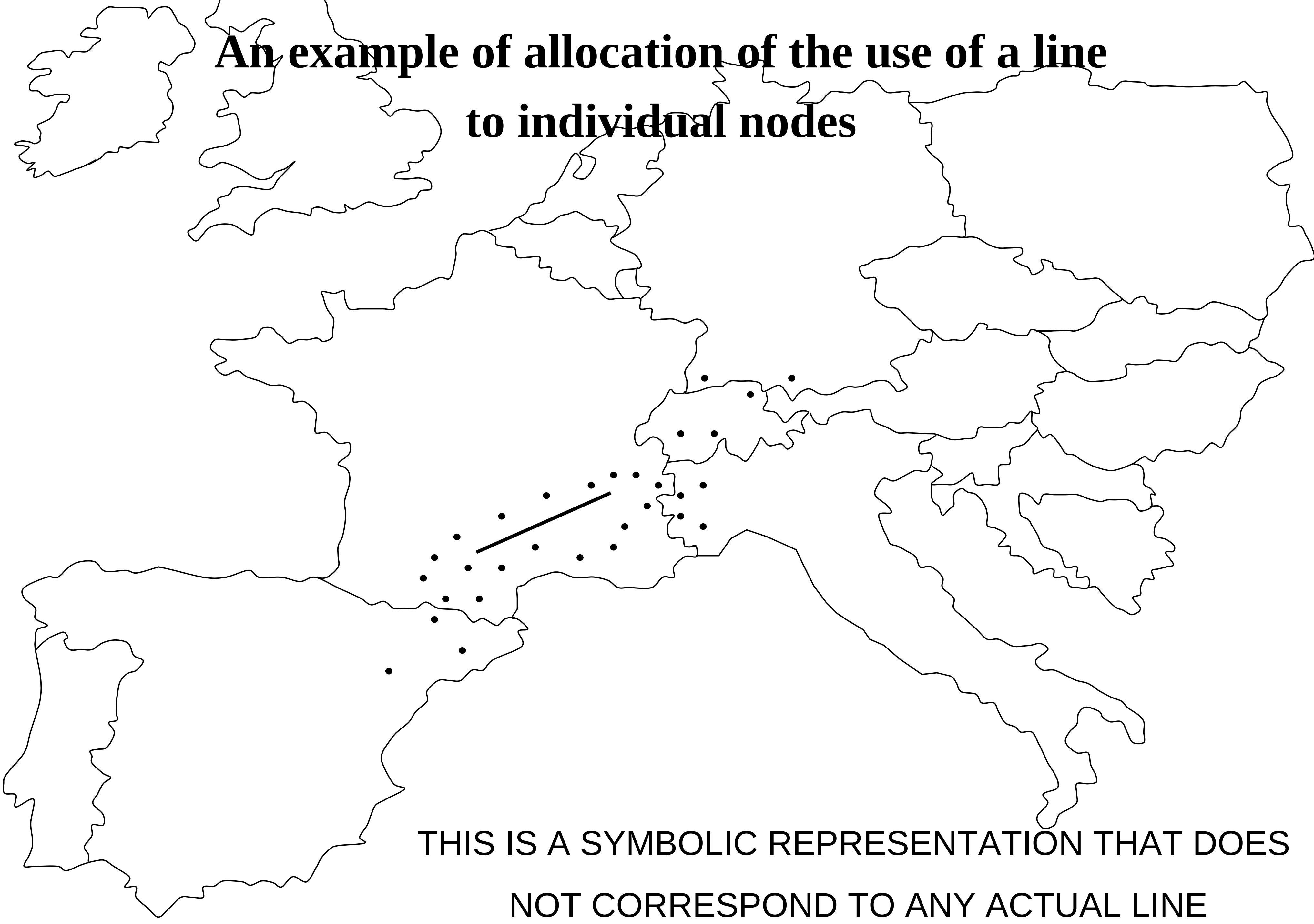
➔WWT may give conflictive results in the allocation of the cost of new lines

Is WWT a reasonable method?
Summary

- **Ambiguity** in the very definition of transit ➔ WWT mixes up the different types of flows
- "without transit" is an **artificial** system condition that may lead to nonsensical results
- WWT results do **not** have **additivity**
- The rule of allocation of charges **ignores the actual pattern of flows**
- WWT may give **bizarre results for individual lines** *(critical issue when allocating the cost of future lines)*
- WWT **only** works with transits, not with all cross-border flows: Is this an advantage?

2) Average participations AP

An example of allocation of the use of a line to individual nodes



THIS IS A SYMBOLIC REPRESENTATION THAT DOES NOT CORRESPOND TO ANY ACTUAL LINE

Underlying assumptions behind each method

Average participations (AP)

- Accepting the **technical impossibility to assign line flows unambiguously to sinks or sources**, it is assumed that this responsibility can be simply obtained by tracking each flow upstream & downstream following the same paths & branching proportions that exist in the actual flows provided by ETSO
  - By construction, the use of each line is assigned 50/50 to demand & generation, although this proportion may be easily modified afterwards if the user of the algorithm has a good reason to do so

Why is not possible to assign the flows to sources & sinks?: "true" physics!!!

- Load flows & circuit theory are just a convenient approximation to **electromagnetic field theory**, which is "as close as we can get" to explaining the flow of electromagnetic energy:
  - Energy flow is guided by lines & takes place in the broad space around them *(**outside** the lines)*
  - **Energy flow establishes at the speed of light & is the result of the joint & inseparable contribution of all sources & sinks** acting together & interacting with one another → it is not possible to attribute a piece of energy flow to a particular generator or load

  → Probably the most reasonable thing to say is that any fraction of the flow that is guided by a line, branches in the same proportion as the total flow in the line *(this is the basic assumption of AP, which I think it is superior to those of MP & WWT)*

Is AP a reasonable method?

- It **tracks the flows as they are**, with no other spurious assumptions: If the complete flow (200 MW) branches as it does, a fraction of it (50 MW) will branch in the same proportion
- Do the flows die **too soon** with AP?
  - Who has the a priori knowledge to tell how far or close the flows die? They do what they do; AP does not change reality
  - Some of the actual flows travel far
  - Some small inconsistencies may happen at micro level, which can be fixed & are irrelevant for ITC

Is AP a reasonable method?

There is also an economic justification for AP

- If we accept that power in a line only flows in the direction of the actual flows *(this is, we do not think of decomposing actual flows as superposition of many flows going in all directions)*, then the transmission charges resulting from the application of AP coincide with the Shapley value for each agent in a cooperative game with good properties in terms of fairness, efficiency & stability
  - AP & a new cost allocation method named Aumann-Shapley, with strong economic basis, have given very similar numerical results on test cases performed in the Brazilian transmission network

Who is in charge here?

Current situation is not satisfactory

- Directives, Regulations & Guidelines
- Many institutions involved & not clear sense of direction
  - EU Parliament, Council & Commission
  - Associations of electric companies & other stakeholders
  - Regulatory Fora of Florence & Madrid
  - CEER & ERGEG
  - National regulators

➔ *The overall approach works, but very slowly; progress is difficult with so many viewpoints and lack of an effective decision-making procedure*

A little history *(1 of 5)*

- First EU Electricity Directive (1996)
  - Ambiguous. Transmission charges could be negotiated or regulated. Scarce progress in market implementation
- National independent regulators take the lead. The Florence Forum is born in 1998
  - A proposal is requested from TSO. Tariff "pancaking"
- Regulators propose the "single system paradigm"
  - The concept of complete access with just local G & L charges plus inter-TSO payments is accepted. But, how to implement the 3 steps?
- Creation of ETSO, CEER, EFET, EUROPEX, etc.

A little history *(2 of 5)*

- The initial consensus → a provisional method (March 2002)
  - An endless debate to decide on the permanent method. How to reach a decision? Proposals by ETSO (WWT) & some regulators (AP). Positions aligned with national interests. The cases of Italy & Switzerland. Disagreements in ETSO because of the poor performance of the current & proposed methods. Several instances of renewal of provisional method
- 2003 Directive establishes minimum requirements on
  - Network access, creation of wholesale markets, unbundling of activities, installation of new generation, consumer eligibility, role of regulators, etc.

A little history *(3 of 5)*

- 2003 Regulation does not provide specific implementation criteria on
  - Harmonization of transmission charges, cross-border tarification, network congestion management, handling of long-term contracts, interconnection reinforcement ➔ *the possibilities of cross-border trade are not fully exploited yet*
- Creation of ERGEG & extension of UE
  - Comitology. Gridlock of regulators & TSOs with new proposal (IMICA) by ETSO. Other proposals. Current request of EU Commission to ETSO to make a new proposal by 2009 Nobody is really in charge

A little history *(4 of 5)*

- Proposal *(Sept. 2007)* by the EU Commission to Parliament & Council to establish an "Agency for the Cooperation of Energy Regulators" (ACER). Main tasks:
  - Providing a framework for national regulators to cooperate
  - Regulatory oversight of the cooperation among TSOs
  - Individual decision powers *(do not include normative decisions)*
    - Exemption requests for infrastructure assets *(direct lines)*
    - Regulatory regime concerning cross-border infrastructure
    - Specific decisions when established by any Guidelines under comitology procedure
  - General advisory role

A little history *(5 of 5)*

- A European network of TSOs (ENTSO), both for electricity (ENTSO-E) and gas (ENTSO-G), will be created to set and coordinate network access rules and grid investment plans
- Still an open issue is the scope of the responsibilities of ACER, in particular its capability to harmonise cross-border transmission regulation

Some considerations

- National regulators are closest to the actual topics, but they are also more prone to be influenced by stakeholders and by the need to give solution to pressing political issues
- A European regulatory agency would help in maintaining a distance to national specific interests & overcoming gridlock situations on issues of medium relevance & EU dimension

Other pending transmission issues in cross-border trade

(maybe another talk?)

Harmonization of network tariffs

Harmonization of transmission tariffs The present situation

- The ***level*** of the tariffs differs much among countries
  - objective factors justify that national tariffs should be different
  - regulatory factors of difficult harmonization are also very influential in the level of the tariffs
- The tariff ***structures*** also differ much
  - allocation to energy or capacity, to generators or consumers, time or geographical differentiation

The impact of lack of tariff harmonization

- The average value of the 2002 inter-TSO national compensations *(assuming a uniform charge to all consumers)* was 0.2 €/MWh *(with two outliers of 0.5 & 1.8€/MWh)*
- Typical transmission tariffs for large consumers in the IEM range between 2.5 & 25 €/MWh in 2007

➔tariff harmonization is far more important on the final value of the transmission charges than inter-TSO payments

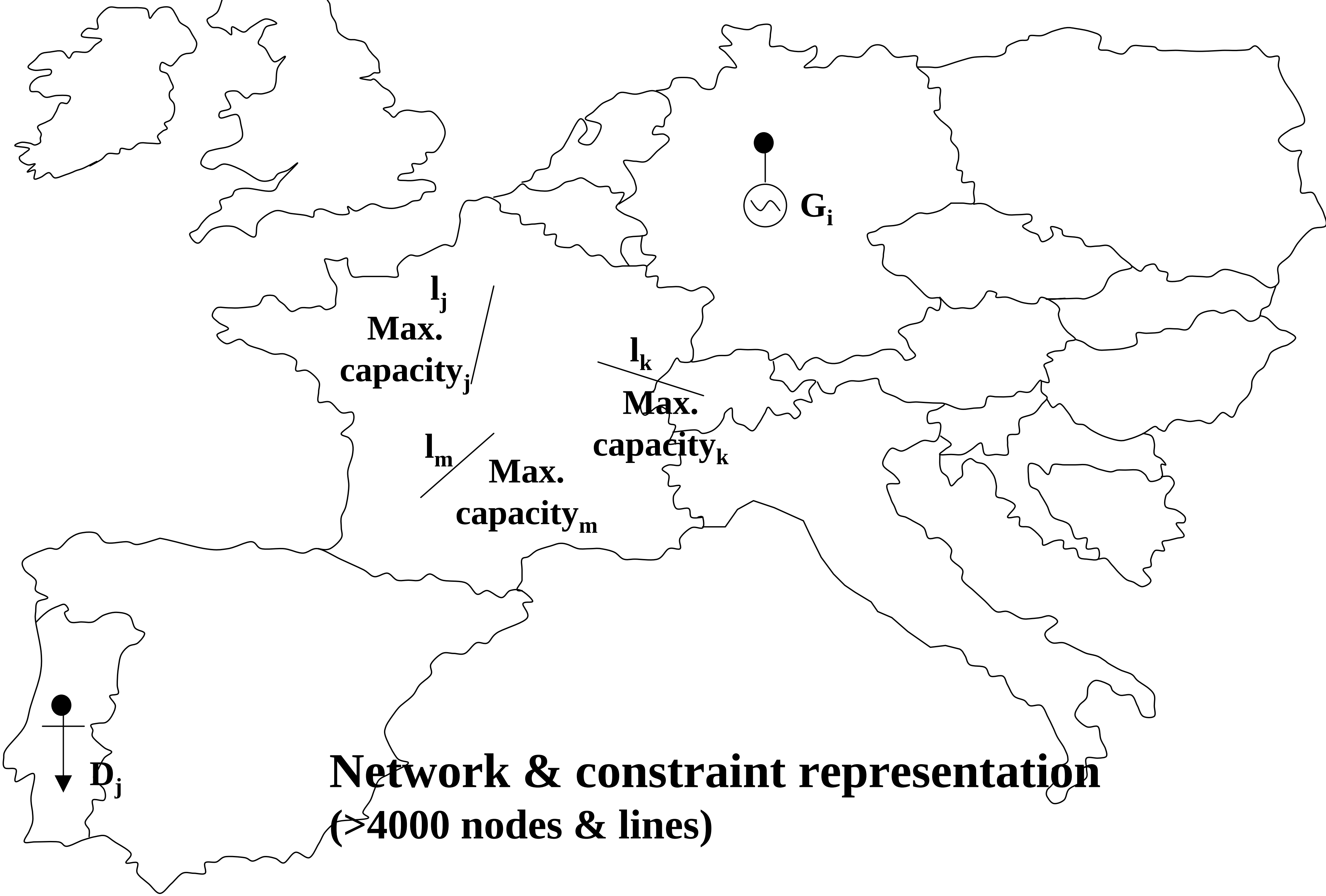
Harmonization of network tariffs
A pragmatic approach

- The global ***level*** of the tariffs may not be harmonized, since it is very difficult to do
- Harmonization of some ***structural*** aspects is very advisable & not too problematic
  - charges to generators have the highest potential to send locational signals & also to distort the market ➔ if it is not possible to harmonize & design convincing transmission charges to generators, then
    - charge mostly to consumers
    - establish a reasonable level playing field for generators
    - if charges to generators are not uniform ➔ use preferably capacity charges

Management of network constraints

Current state of debate
Congestion management

- Again a pragmatic approach
  - A EU-wide “centralized dispatch” of generation & demand is not presently viable
  - There is a basic agreement to look for a coordinated & market-based mechanism
  - Open issues
    - Start with coordinated schemes at **regional** level
    - Level of decentralization & responsible institution
    - Acceptable level of simplification (single price zones, borders vs. flowgates)



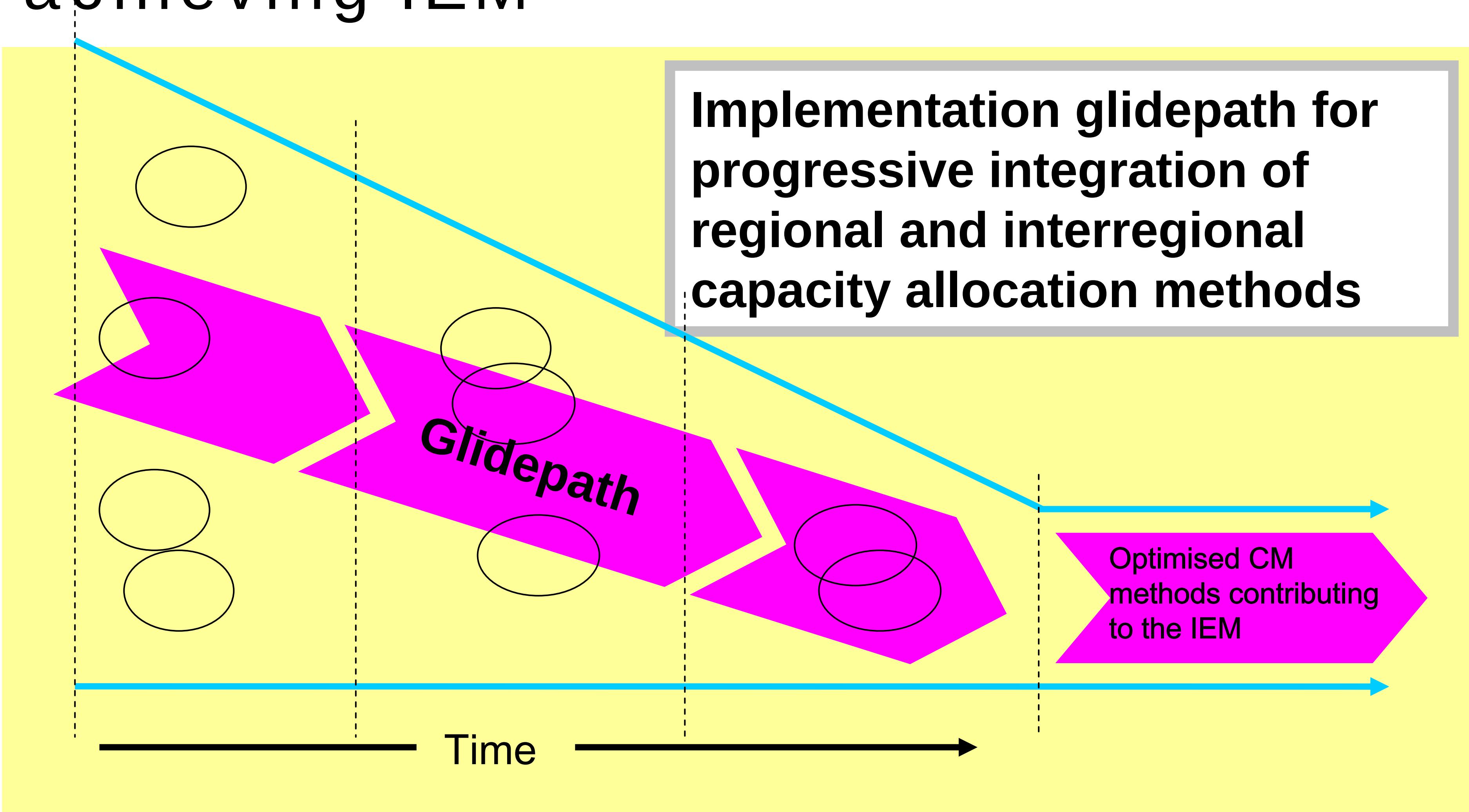
Network & constraint representation

(>4000 nodes & lines)

Current state of debate
Considered options

- A working group from ETSO & EuroPEX established in November 07
- Terms of Reference identified 5 broad areas of work
  - Long Term & Secondary Market Timeframe
  - Day Ahead Timeframe
  - Intraday Timeframe
  - Flow based capacity calculation methods
  - Legal and Regulatory Issues

Congestion Management is key for achieving IEM

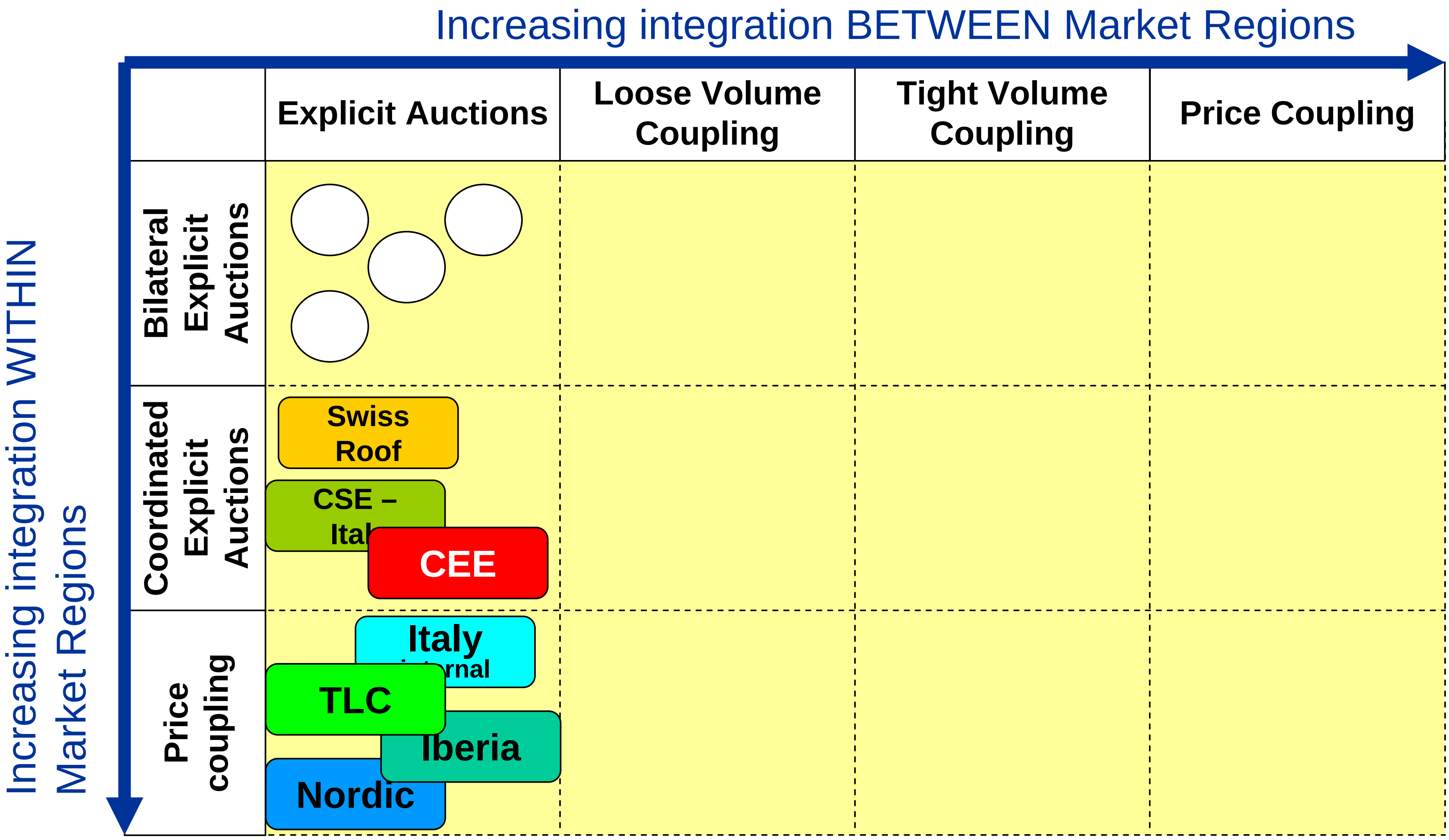


Developing a possible roadmap

Need to distinguish solutions by geographic scope:

- "Market Region" (MR) is a group of markets sharing a common congestion management approach on the borders within the MR. Only two approaches emerging:
  - price coupling
  - coordinated explicit auctions
- Interregional solutions are required to manage borders between MRs. Four basic options:
  - explicit auctions
  - loose or tight volume coupling, and
  - price coupling (horizontal integration of market regions)

Roadmap Framework



Adequacy of network infrastructures

Current state of debate

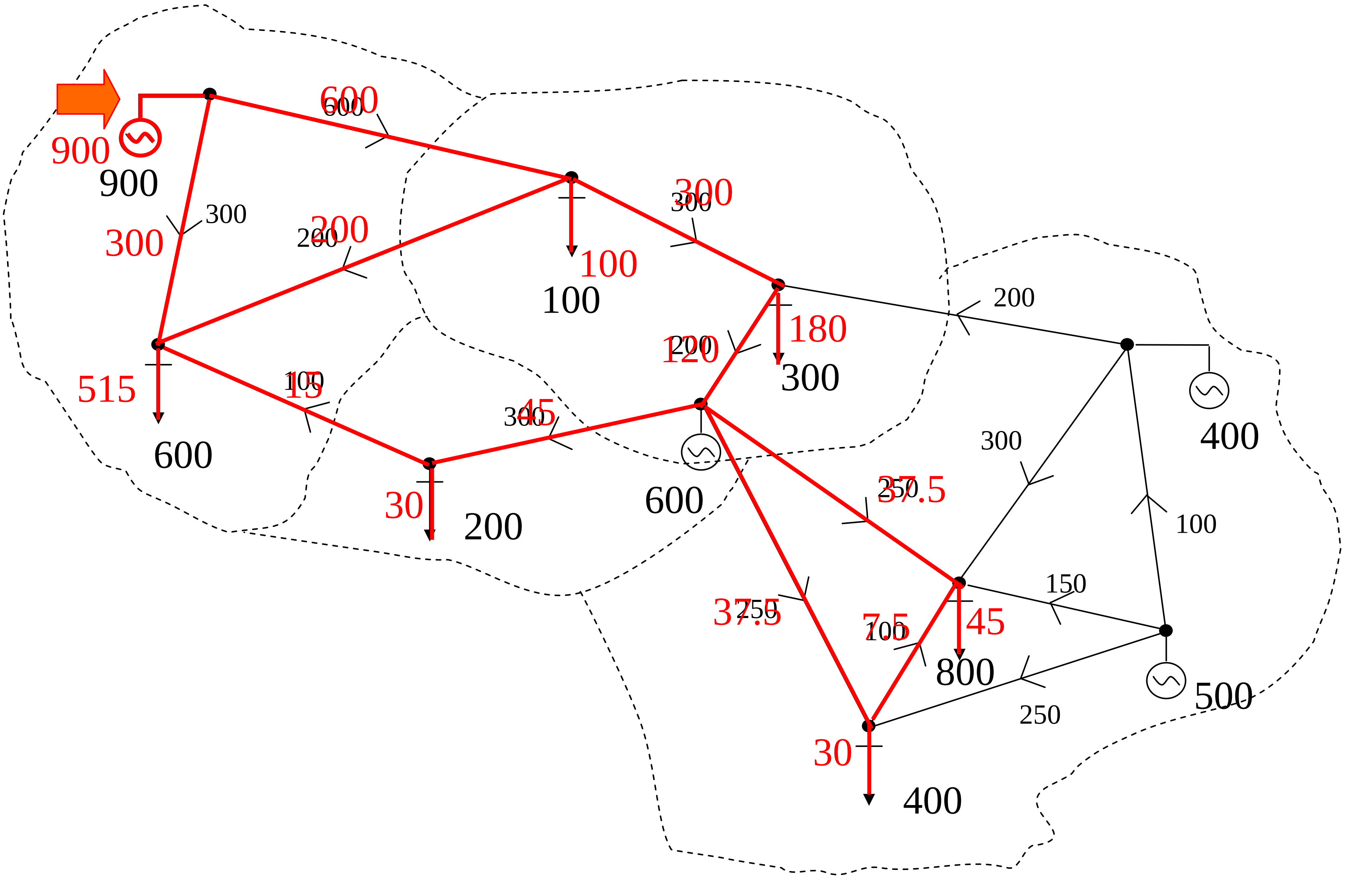
New network investments

- Need to achieve a minimum level of interconnection
- No clearly defined regulatory scheme to promote new investments or to perform regulatory test
  - Major role for **regulated / planned** investment, proposed by TSOs, authorized *(if this is the case)* by regulators & included in the inter-TSO payment scheme
  - **Merchant lines** to be authorized on an individual basis in exceptional cases & be subject to regulatory oversight, such as priority rules and open access conditions
- Cost allocation scheme is already implicit in the inter-TSO payment mechanism

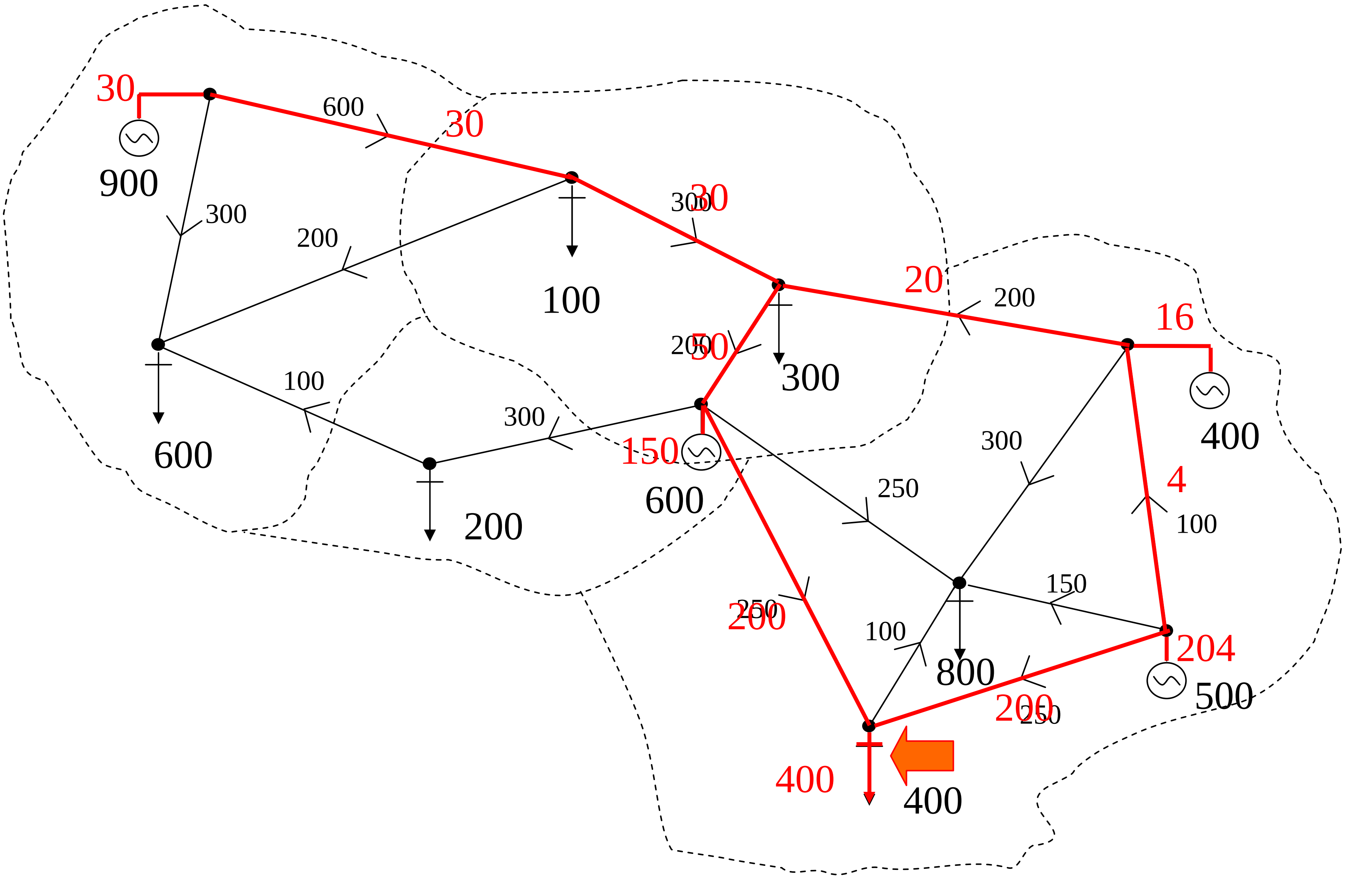
THANK YOU FOR YOUR ATTENTION

Annex 1
DETAIL ON THE METHOD OF AVERAGE PARTICIPATIONS (AP)

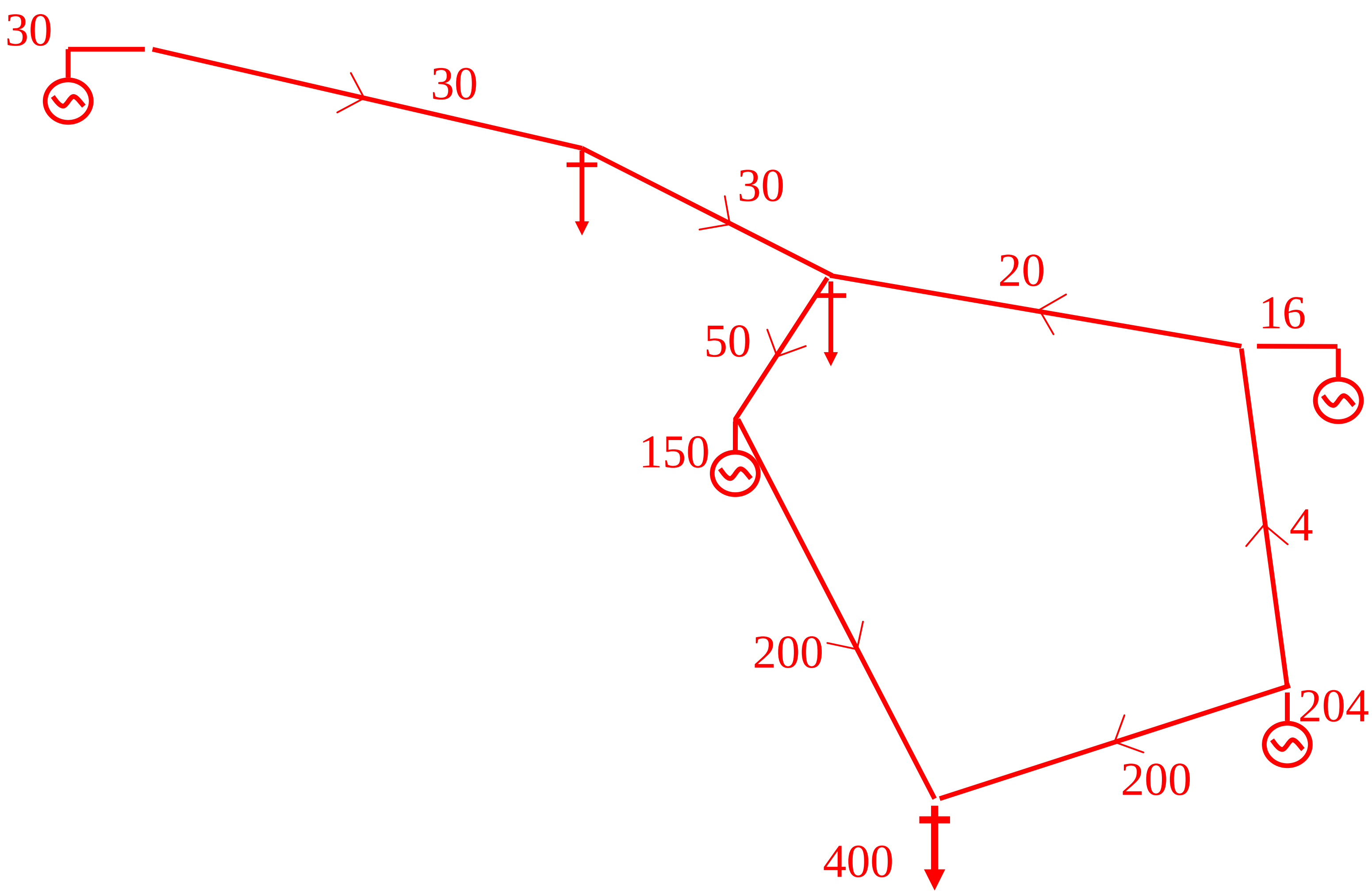
This is how the "average participations" algorithm works (I)



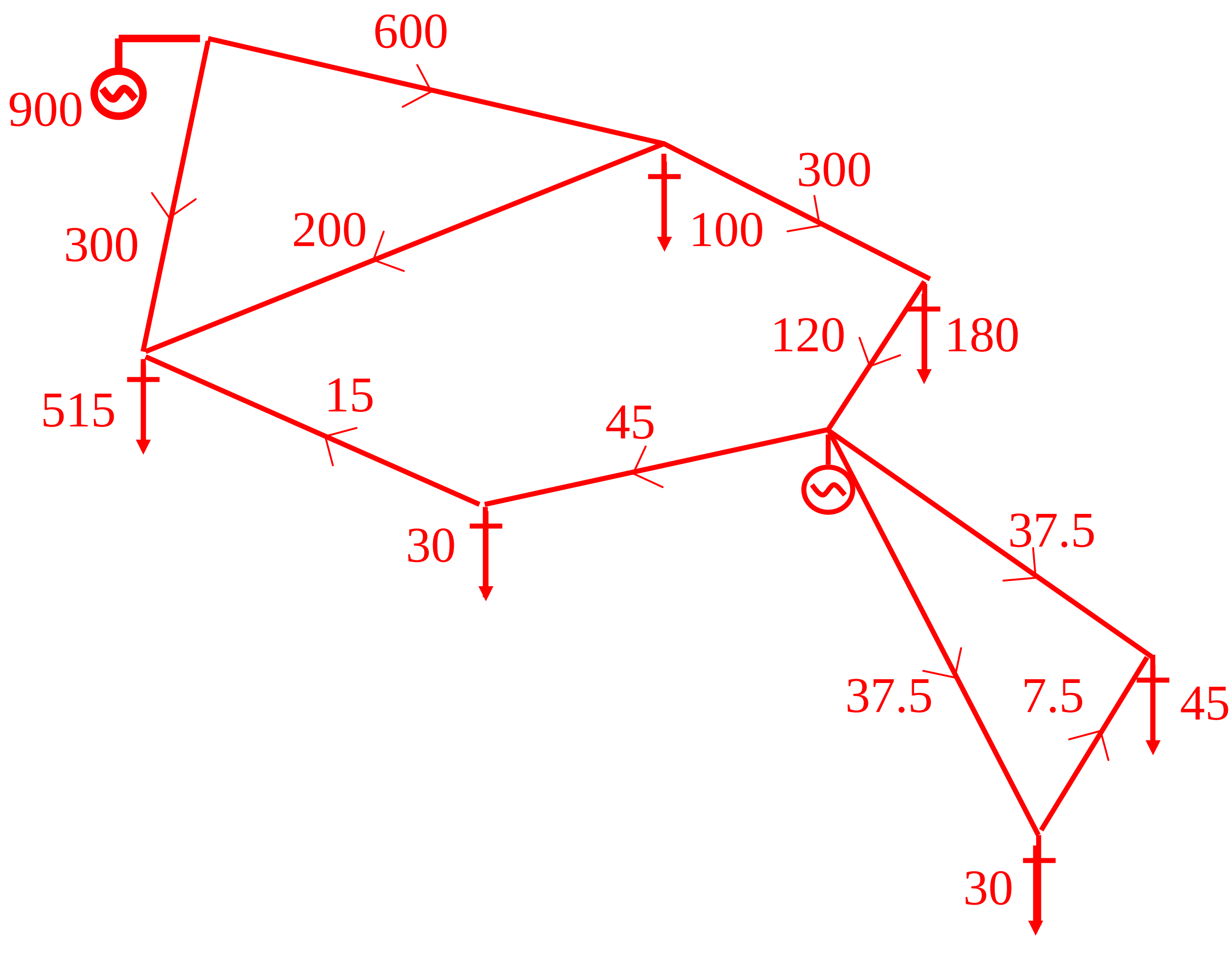
This is how the “average participations” algorithm works (II)



Flow pattern that feeds a load node

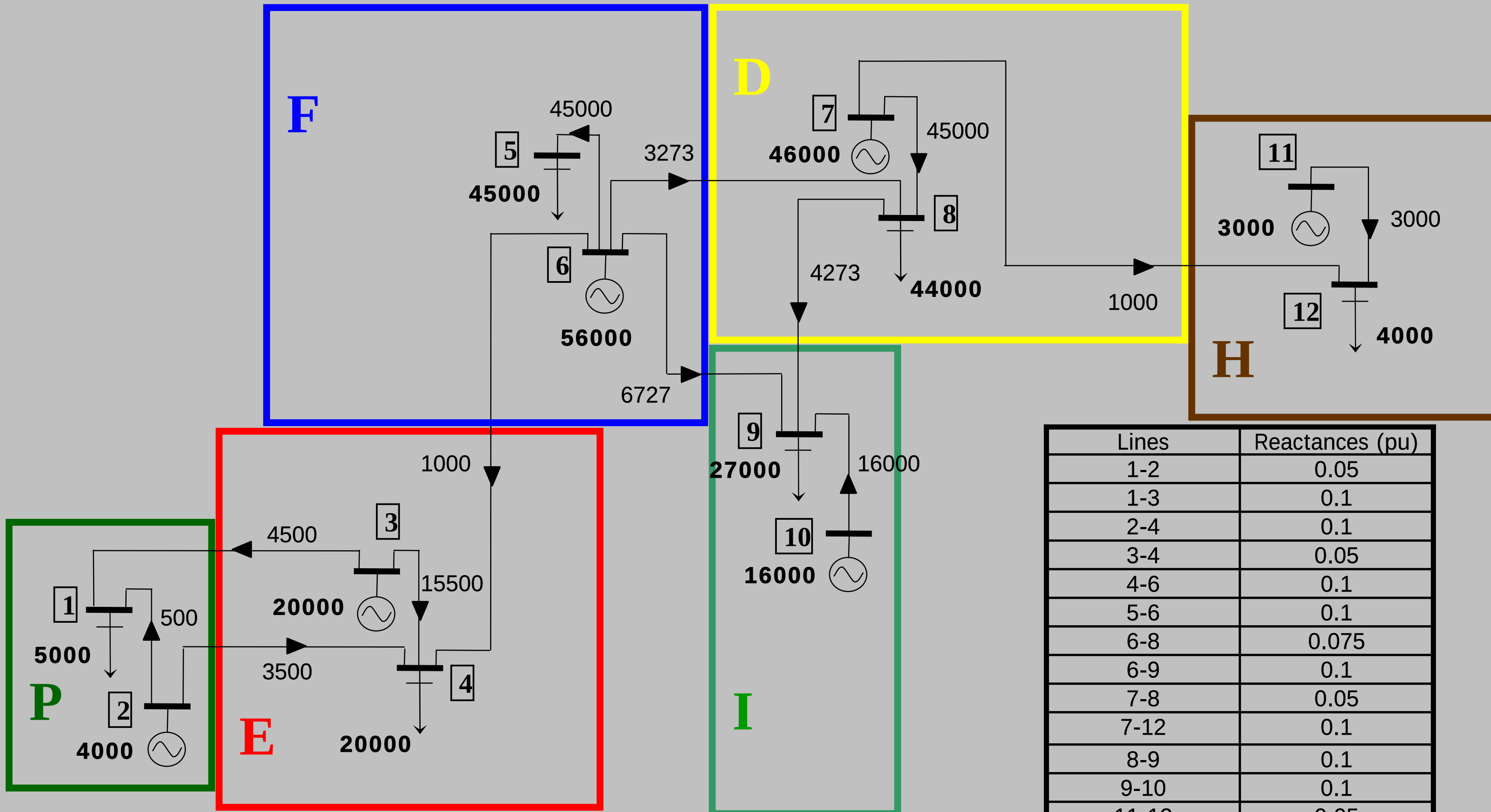


Flow pattern fed by a generation node



ANNEX 2
Some quantitative comparisons on a simple case example

A representative case example



Lines	Reactances (pu)
1-2	0.05
1-3	0.1
2-4	0.1
3-4	0.05
4-6	0.1
5-6	0.1
6-8	0.075
6-9	0.1
7-8	0.05
7-12	0.1
8-9	0.1
9-10	0.1
11-12	0.05

WWT (1)

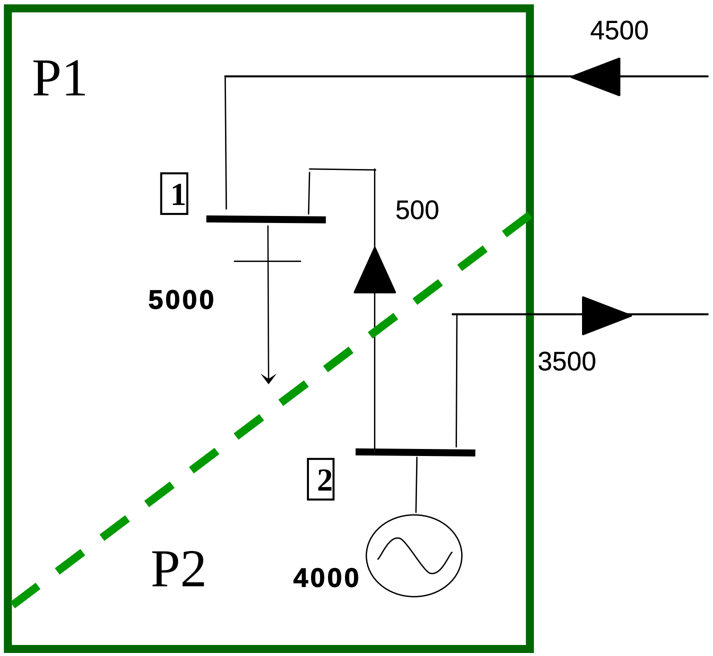
Compensations & charges among countries considering the original political borders are:

	P	*E*	*F*	*D*	*I*	*H*
P	1285	45	0	51	0	0
E	0	5000	0	0	0	0
F	368	473	23364	536	0	0
D	70	90	0	12007	0	0
I	368	473	0	536	10750	0
H	35	45	0	51	0	1000
Use by others	840	1125	0	1175	0	0
Use of others	96	0	1376	160	1376	131
Net use	744	1125	-1376	1015	-1376	-131

Each row in the table shows the use that the corresponding country makes of all the countries in the system. **Use by others**: use of the grid of the corresponding country by others; **Use of others**: use that the country makes of others' grids; **Net use**: difference between the two previous results. Numbers are expressed in '000 MWkm

WWT (2)

If country P is split into two new systems P1 and P2:



Transit through new systems P1 and P2 is zero ➔ they are not entitled to any compensation

Total net flow produced by P1 and P2 is much higher than that produced by P ➔ contribution factors change as well

Numbers are expressed in MW

WWT (3)

Compensations & charges among countries splitting P into 2 countries are:

	P1	P2	E	F	D	I	H
P1	1188	0	169	0	192	0	0
P2	0	938	135	0	153	0	0
E	0	0	5000	0	0	0	0
F	0	0	360	23364	409	0	0
D	0	0	68	0	11982	0	0
I	0	0	360	0	409	10750	0
H	0	0	34	0	38	0	1000
Use by others	0	0	1125	0	1200	0	0
Use of others	360	288	0	769	68	769	72
Net use	-360	-288	1125	-769	1133	-769	-72

Each row in the table shows the use that the corresponding country makes of all the countries in the system. **Use by others**: use of the grid of the corresponding country by others; **Use of others**: use that the country makes of others' grids; **Net use**: difference between the two previous results. Numbers are expressed in '000 MWkm

WWT: Comparison of the two cases

Net inter-TSO payments, for both cases, are:

TSOs	P	D	F	E	I	H
P is 1 TSO	**744**	**1125**	**-1376**	**1015**	**-1376**	**-131**
P is 2 TSOs	**-360 &-288**	**1125**	**-769**	**1133**	**-769**	**-72**

Use by others: use of the grid of the corresponding country by others; **Use of others**: use that the country makes of others' grids; **Net use**: difference between the two previous results. Numbers are expressed in '000 MW x km

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

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

The line is located in Spain, not particularly close to any border.
Its flow decreases when the transit through the Spanish grid is removed.
Results correspond to just a single scenario (scenario number 1).

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

Curious implication:

With WWT the Spanish network users will have to pay 100% of the cost of the line & also 30,7% of the cost of the line to other countries

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

The line is located in the north-central part of Spain between the nodes of 'Garoña' and 'Herrera'. Computation is also only for scenario number 1. The removal of the transit causes the flow over the line to increase

Allocation of the cost of a line in Switzerland

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

The line is located in Switzerland between 'Innertk' and 'Robiei' and the considered flows are from snapshot number 5.

Allocation of the cost of a Belgian line on the border with France

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

The line located near the border with France, between the nodes of 'Achen1' and 'Ac Lo11'.

Average Participations (1)

Participations by agents in the usage made of electrical lines

	L1-2	L1-3	L2-4	L3-4	L4-6	L5-6	L6-8	L6-9	L7-8	L7-12	L8-9	L9-10	L11-12
N1	250	2250	0	0	0	0	0	0	0	0	0	0	0
N2	250	0	1750	0	0	0	0	0	0	0	0	0	0
N3	0	2250	0	7750	0	0	0	0	0	0	0	0	0
N4	0	0	1750	7750	500	0	0	0	0	0	0	0	0
N5	0	0	0	0	0	22500	0	0	0	0	0	0	0
N6	0	0	0	0	500	22500	1637	3364	0	0	145	0	0
N7	0	0	0	0	0	0	0	0	22500	500	1992	0	0
N8	0	0	0	0	0	0	1492	0	20508	0	0	0	0
N9	0	0	0	0	0	0	145	3364	1992	0	2137	8000	0
N10	0	0	0	0	0	0	0	0	0	0	0	8000	0
N11	0	0	0	0	0	0	0	0	0	0	0	0	1500
N12	0	0	0	0	0	0	0	0	0	500	0	0	1500

Numbers are expressed in MW

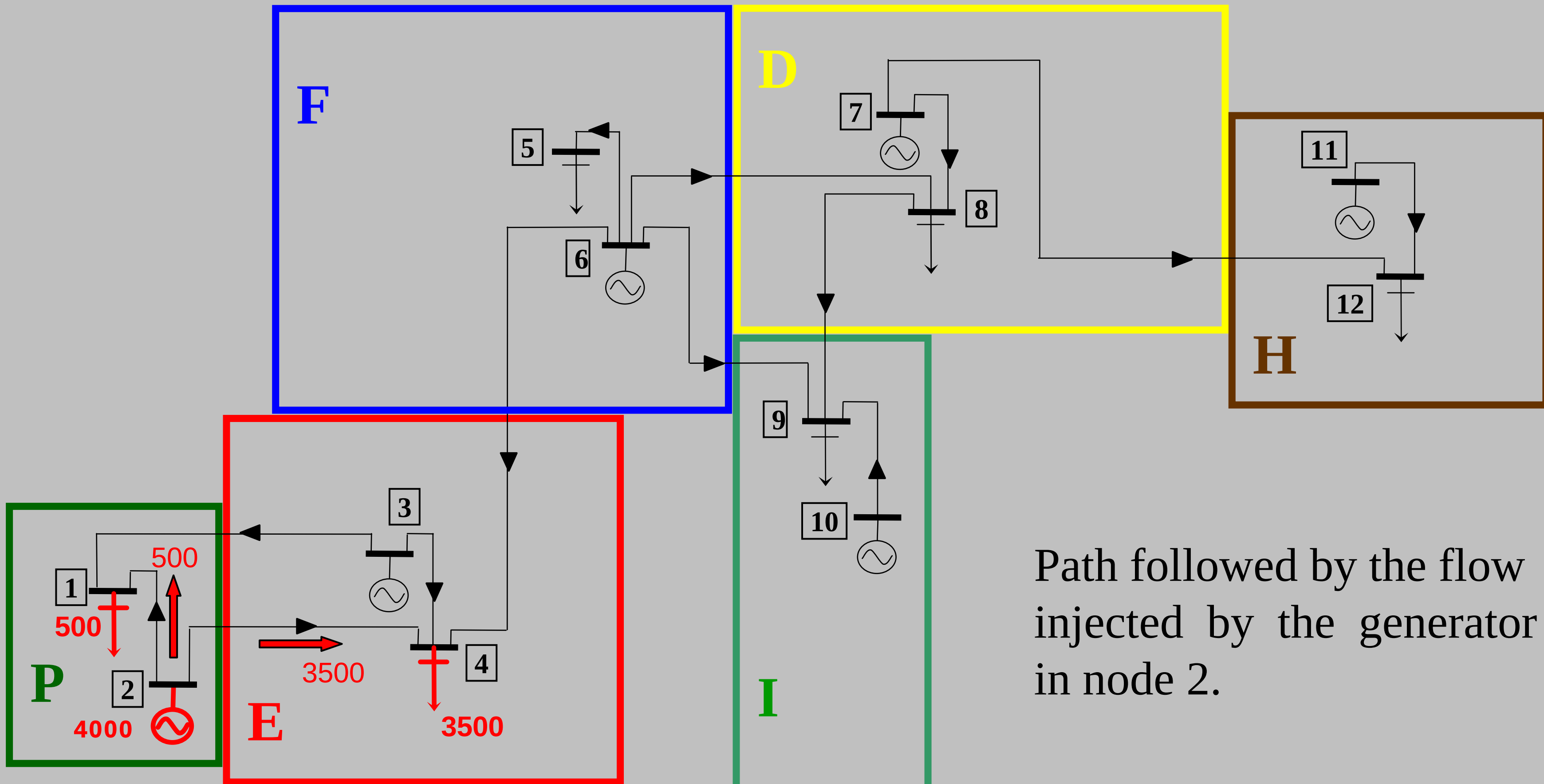
Average Participations (2)

Compensations among countries are:

	P	E	F	D	I	H
P	1125	1000	0	0	0	0
E	1000	5000	125	0	0	0
F	0	125	23773	343	877	0
D	0	0	280	11655	498	125
I	0	0	868	1059	9375	0
H	0	0	0	125	0	875
Use by others	1000	1125	1273	1527	1375	125
Use of others	1000	1125	1345	903	1927	125
Net use	0	0	-72	625	-552	0

Each row in the table shows the use that the corresponding country makes of all the countries in the system. **Use by others**: use of the grid of the corresponding country by others; **Use of others**: use that the country makes of others' grids; **Net use**: difference between the two previous results. Numbers are expressed in '000 MWkm

Average Participations (3)



Path followed by the flow injected by the generator in node 2.