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PRACTICES RELATED TO INTERNAL AND CROSS-BORDER CONGESTION MANAGEMENT

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Summary :

This paper is based on the survey conducted by the Working Group C5-4 on Congestion Management. First it describes various market conditions and institutional arrangements in the 18 countries participating in the survey. Then, internal and cross-border congestion management in these countries are presented. The interaction with the electricity market is discussed, considering allocation of transmission capacity, market schedule, congestion management tools and payment for the costs incurred.

The survey shows that there is a tendency towards the use of market-based methods. Coordinated market-based measures seem to be the most effective. For the time being however, few systems have experiences with it.

Key-words : Congestion management – Market

1. General conditions of data collection

This report is based on data collected at the beginning of 2004 from C5 members, using questionnaires answered by 18 participants : Belgium (BE), Czech Republic (CZ), France (FR), Norway (NO), Romania (RO), Slovakia (SLK), Slovenia (SLO), Spain (SP), United Kingdom (UK), Finland (FIN), United States – PJM, Canada – Ontario, Brazil (BR), Japan – Kepco (JP), South Korea (KR), India (In), Australia (AUS), South Africa (SA).

2. Market conditions and institutional arrangements

Participating countries have various experiences concerning the **market organization**, **system operator** and **number of interconnections with other systems**, as shown in Table 1. The only AC **merchant lines** are in South Africa and India and are operated by another entity than the System Operator (SO).

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Table 1 : Summary of market conditions and institutional arrangements

	Market organization	Futures trade	System operator *	neighboring countries / SOs	Interconnection capacity/ peak load
Belgium	Bilateral (PX in 2005)		TSO	2 / 2	40 %
Czech Rep	-		TSO	4 / 5	35 %
France	Bilateral+PX Powernnext		TSO	6 / 9	12 %
Norway	Bilateral+PX NORD POOL	X	TSO	4 / 4	16 %
Romania	Bilateral contracts		TSO	5 / 5	12 %
Slovakia	-		TSO	-	50 %
Slovenia	Organized market (Borzen)		TSO	3 / 3	30 %
Spain	Organized market OMEL		TSO	4 / 4	7 %
UK	Bilateral NETA + PXs		TSO	2 / 3	8 %
Finland	Bilateral+PX NORD POOL	X	TSO	3 / 3	-
PJM	Organized LMP	X	ISO	1 / 5	-
Ontario	Organized LMP		ISO	2 / 5	16 %
Japan	Bilateral (PX in 2005)		VIU	4 (Kepco)	23 %
India	Organized market		TSO	~20	-
S. Africa	Organized market		VIU	-	-

* TSO : own + operation – ISO : operation – VIU : Vertically Integrated Utility

3. Internal congestion management

Internal congestion is defined as congestion within a control area of a single System Operator's area.

3.1. Condition of internal congestion

BE, SP, AUS, SLO, KR and JP either seldom or never experience internal congestion. For other countries, see Table 2.

Table 2 : Frequency, duration of congestion within countries with frequent congestion

	Frequency	Typical duration
France	Almost everyday (some part of network)	12 hours in the day during peak hours
Norway	Almost everyday, especially often in Summer	Approximately 8 - 10 hours a time
United Kingdom	Around 300 balancing actions a year	From transitory in nature to longer periods
PJM	Almost every day. Use of reliability "backstop" ("TLR") several times a week	Typical 1 - 2 hours per incident. Duration for reliability "backstop" would be in the 2 - 3 hours range.
IMO (Ontario)	One particular interface often congested, however the amount of congested capacity is insignificant	
Romania	50 times a year	8 hours (Values estimated for 2003)

3.2. Allocation of transmission capacity – Market schedule

In many participating countries there is no capacity allocation in the market area. At the time of the survey, in PJM, the transmission capacity was allocated to participants that served native load and to those who obtained financial transmission rights through a yearly auction. In 2005 PJM has initiated an annual auction (conducted in three phases) of financial rights that is opened to all participants.

In some countries, market participants must submit their schedule according to specific gate closures. Schedule change are sometimes possible and can lead to penalties, see Table 3 :

Table 3 : Gate closure, schedule and penalties

	Gate closure	Schedule change	Penalty
United Kingdom	Several a day	-	Imbalance charge
France		Possible	No
Norway	Once a day		
Romania			
Japan			
IMO (Ontario)		Impossible	Imbalance charge
Slovenia			Yes
Finland		-	Imbalance charge
Belgium		-	

3.3. Methods used for internal congestion management

The methods are categorized mainly into 5 measures: "**System reconfiguration** (Topological optimization)", "**Transaction curtailments**", "**Generation re-dispatch**", "**Counter trade**", and "**Market Splitting** (with market mechanism or merit order)". See Table 4.

Table 4 : Methods for Congestion management in each area.

	System reconfiguration	Transaction curtailments	Re-dispatch	Counter trade	Market Splitting
PJM	X	X	X		
Belgium	X		X		
Japan	X		X		
Australia			X		
Brazil			X		
IMO (Ontario)			X		
Spain			X		
United Kingdom				X	
France			X		
Finland			X		
Romania				X	
Norway			X		X
Spain			X		

Note that "market splitting" can also be considered as a method for handling of cross-border congestion as is the case in Nord Pool. Moreover, though the method used to handle internal congestion in Nord Pool (NO, FIN) is called "Counter trading", it is actually a coordinated "re-dispatching" used to handle intra-zonal or cross-border congestion (see § 4.4).

In North America, TLR (Transaction Loading Relief, developed by NERC) is used. The principle is to curtail transactions from external areas that have a greater than 5% effect on the constraint.

3.4. Payment of congestion costs - Interaction between market and internal congestion

There are **two approaches to the** allocation of congestion cost. One is to socialize these costs (UK, FR, BE NO, FI, IMO, KR and JP). The other is that the cost is borne by the responsible (PJM), or predetermined parties, as is the case in Spain where the cost incurred are paid by the scheduled demand.

From the perspective of the System Operator and incentives for new transmission facilities, the interaction between the electricity market and internal congestion can be divided into 4 categories:

- Congestion management at planning and scheduling phase :
  - U.K.: In the long-term, generators requiring capacity compete in a national market for TEC (Transmission Entry Capacity)
  - PJM : The LMP System provides participants with the correct incentives through transparent price signals. The costs re-dispatch are covered by the load and those who do not protect themselves from congestion by acquiring Financial Transmission Rights (FTRs).
- Congestion management in Day Ahead Market or Real time Market :
  - Norway : Market splitting (Structural) & Counter trade (Temporal) by the SO. Market splitting gives incentives for construction of new generating units in higher price area. In Norway and Finland, incentives for new transmission line building are provided by the TSO's expenses on managing internal congestion.
  - Japan: Market splitting after establishment of electric power exchange in April 2005.
  - U.K and France : TSO manages congestion by using Balancing mechanism.
  - Spain : once the power transactions are adjusted in order to solve the congestion, the market operator readjusts the schedule taking into account the limitations established by the TSO, so that the production – demand balance is verified in each of the hours affected by the congestion.
- The Market is used as the way for cost allocation :
  - IMO: Real time market prices are calculated assuming no internal congestion. The congestion cost is borne by all loads via uplift charge.
  - South Korea : due to internal congestions, generation cost will increase market price, which will affect end users' charge. But the price system is regulated by government.
- No relation :
  - Belgium : none, the grid is a "virtual copper-plate".
  - Brazil : additional cost are owed only by the distribution utilities.
  - Romania : internal congestions are solved without supplementary market costs (except the payments for ancillary services). In real time internal congestion are solved through Ancillary services.

4. Cross-border congestion management

Cross-border congestion is defined as congestion between System Operator's control areas.

4.1. Condition of cross-border congestion

Only two countries (JA, RO) explicitly stated no experiences with congestion. Several countries declared occasional congestion (In, PJM, SLO, SA, UK, Ontario). All other (BE, CZ, SP, FR, NO, SLK) declared congestion as typical for at least some of its cross-border interconectors.

4.2. Allocation of transmission capacity – Market schedule

Explicit transmission access charges for cross border trade (nominated schedules) have been removed in the European countries, India and PJM. In some countries (SP, CZ, SLK, UK) grid access tariff applied for exported generation were implemented, but had been removed in 2004. In other countries, cross border charge can be regulated like in Japan (to be abolished in 2005) and Canada, or negotiated like in South Africa.

Congestion is a common problem in most of the countries. There are typically two ways to solve this – *ex ante* (**capacity allocation mechanisms**) and *real-time* (**de-congestioning mechanisms** – see § 4.4). Main capacity allocation mechanisms are shown in Table 5 :

Table 5 : Capacity allocation mechanisms

	Priority rules of a kind set by SO	First come first served	Pro-rata curtail-ment	Expli-cit auction	Impli-cit auction	Combined explicit-implicit mechanism	Coordi-nation with neighbo-ring SO
Belgium	X		X	X			X
Czech Rep			X	X			X
France	X	X	X	X			X
Norway					X		X
Romania		X					
Slovakia			X	X			X
Slovenia			X	X			
Spain						X	
UK			X	X			X
Finland					X		X
PJM		X					X
Ontario					X		X
Japan		X					
India			X				
S. Africa	X		X				X

Coordination with neighboring SOs seems to be a necessary prerequisite for efficient congestion management. Countries that do not coordinate the management of their congestion management with the neighbors are considering adoptions of the procedures (SP, RO).

On the other hand, there is little standardization and cooperation in **scheduling procedures and gate closure times**. Each SO has its own mechanisms and timing for accepting cross-border schedule notifications from interconnection users, as shown in Table 6 :

Table 6 : Gate closure for cross-border trade

Gate closure	Close to real time or continuously accepted	One for all sche-dules	Separate for long term and daily schedules	Week - ahead	Intra-day allowed	Coordina-tion of CM and market
Belgium			X		X	
Czech Rep			X			
France		X			X	
Norway		X				Mkt splitting
Romania		X				
Slovakia			X			
Slovenia		X				
Spain		X			X	
UK		X			X	X
Finland		X				Mkt splitting
PJM	Non-firm schedules *				X	LMP
Ontario	X				X	X
Japan		X			X	
India	cont. Accepted					
S. Africa				X		

* In PJM, gate closure is D-1 with no further changes for firm contracts.

For cross border congestion management it is essential to know whether the nominated schedules can be changed after nomination. If schedules can be changed by market participants in - or close to real time, **netting of firm schedules** (also named "netting of counter flows") is very difficult to be taken into account at any stage of Transfer Capacity definition, as the latter is by definition based on assumption of existing (nominated) flows.
Three categories of systems can be identified :

- Systems with firm schedules and no curtailment option for the SO – only market based methods can be used (CZ, NO, SA, UK, FIN)
- Systems with firm schedules and curtailment option for the SO (RO, SLO, BE-NL, SLK)
- Systems with flexible schedules and curtailment option for the SO (FR, BE-FR, PJM, JP, SP, In, Ontario)

Generally speaking**, congestion is typical for open market** arrangements. Unfortunately in most systems and especially in those being in the early stages of market opening, system operations (provided by TSO/ISO) are not much coordinated with electricity market.

Administration of cross border schedules in the majority of system operators takes place on a 7 days-a-week basis. In some systems (JP, SA, UK) Saturday, Sunday and Monday schedules are required to be nominated on Friday.
Another important factor in market operations and CM mechanisms is **information distributed among market participants** with respect to available capacities. This information includes yearly Cross-border Transfer Capacity forecasts available as monthly fixed values, monthly ATC forecasts as well as daily ATCs. In UK this information is detailed up to half hourly values.

Table 7 : Netting, administration, information

	Netting of firm schedules	Administration of schedules	Information exchange
Belgium		week + weekend	web page
Czech Rep		week + weekend	web page
France	X	week + weekend	web page
Norway	X	week + weekend	web page
Romania		week	web page
Slovakia		week + weekend	web page
Slovenia		week + weekend	web page
Spain	X	week + weekend	web page
UK	X	week	web page
Finland	X	week + weekend	web page
PJM	X	week + weekend	web page
Ontario	X	week + weekend	web page
Japan	X	week	Individually upon request
India	X	week + weekend	web page
S. Africa		Week	Individually upon request

4.3. Physical flows and congestion on cross-border interconnectors

Commercial transmission capacities **NTC and ATC** are determined in all systems by entity responsible for system operations (ISO, TSO, VIU). Significant factor that should be taken into account while discussing these capacities and congestion management in general, is the estimation of the difference between physical and commercial flows, so called **parallel flows** (loop flows) on the interconnectors. Significant parallel flows on cross-border interconnections can sometimes be higher than 50% of the commercial interconnection capacity. Therefore the unpredictable parallel flows substantially affect the calculation of

ATC values by introducing the uncertainty over the real physical flows on the interconnection.
For systems with high interconnection capacity (sum of cross-border capacity is higher than 20 % compared to the system peak demand – see Table 1), cross-border congestion is not only a cross border trade issue, but can address system balance and its stability, since countries with high interconnection capacity tend to rely on more import.

4.4. Congestion management tools and arrangements used

In a market environment, regional energy price differences allow arbitrage, and players look for the cheapest source of electricity. Zonal network model, assumed everywhere in Europe and in many countries around the world, entails working **with aggregated index ATC values** instead of individual line capacities. Calculation of ATC, being a result of aggregation of individual tie lines into an index value, is based on assumptions, such as the base case scenario constituting of load flow patterns within each control area.
However, even taking all these precautions into account, **congestion can occur during real time** operation, be that a result of incorrect *base case scenario* assumptions or cumulative outage of generation units and network elements. This congestion is often invisible to market players, as the allocated commercial capacity has not been exceeded. When some cross-border lines become overloaded it is up to the SO to solve the problem. There are number of different mechanisms that are able to handle such situations : see Table 8.

Table 8 : congestions management tools

	Pro-rata curtail-ment	Priority curtail-ment	Negotiated curtailment	Optimal line swit-ching	Internal re-dispatch	Coordi-nated CB re-dispatch	Counter-trading
Belgium		X		X			
Czech Rep							X
France	X			X	X		
Norway						X	
Romania	X						
Slovakia	X						
Slovenia	X						
Spain	X						
UK							X
Finland						X	
PJM		X			X	X	
Ontario	X						
Japan		X					
India						X	
S. Africa			X				

- Pro-rata curtailment – all exchange schedules are curtailed proportionally
- priority curtailment or TLR – exchanges curtailed based on written rules and priorities
- negotiated curtailment – individually negotiated curtailment conditions
- optimal line switching – change in internal network topology so as to eliminate overflows
- internal re-dispatch – change of generation/load pattern in the affected system, more useful in larger systems with geographically spread generation and/or interruptible loads
- coordinated cross-border re-dispatch – coordinated change of generation/load pattern on both sides of congested interconnector (NO, FIN under the name *counter-trading*)

- counter-trading – trade between two affected systems in opposite direction to congested flows, organized by system operators. Less efficient as often large volumes of counter-trade have to be used to alleviate a given congestion (CZ). Works well for DC links (UK).

4.5. Payment of congestion costs

Each cross border congestion management measure always entails a cost, as it affects the optimal solution (from market point of view) and leads to a sub-optimal one, creating thus less market value. Therefore there is a need for a mechanism to allocate these costs to end-users. There are typically 4 schemes used:

- Costs not settled and constitute operational costs of the SO (JA, RO, SA, SK)
- Costs became a part of total costs of system services, allocated to system users through network tariffs, usually averaged over a year or a tariff period (SP, FIN, NO, PJM, BE)
- Costs are allocated to system users through additional balance and settlement mechanism, usually on an hourly basis (Ontario, CZ, UK)
- Costs are allocated to cross border interconnection users by additional charges (FR, SLO, In)

If **curtailment** is used, it is usually considered as *force majeure* and there is no remuneration/compensation for affected market participants. There are two exceptions:

- Spain - compensation is based on a market price, remunerated to affected users and allocated to all users through settlement procedures
- UK - compensation is determined by a contract with TSO and allocated to balance providers

5. Conclusion

The task of the working group C 5-4 during 2004-2005 was to make an inventory of various practices of Transmission System Operator related to the management of congestion in a market environment. The objective of the working group was to achieve a more general view of the practices around the world and to present them in a way that would favor benchmarks.

The survey showed that it is essential to establish a common terminology, definitions and understanding of terms related to congestion management. The questionnaire's respondents may have taken the same terms in various different meanings, making comparisons sometimes difficult.

There are very many approaches to congestion management as each power grid has its own typical features such as a high number of cross-border tie-lines, long distance between load and generation, geographical location (i.e. in the meshed interconnected system). This makes the existence of one universal solution for congestion management unlikely.

Currently, the existing real time congestion management measures are mostly non-market based, but there is a tendency towards the use of market-based methods. Coordinated market based measures seem to be the most effective. There are however few systems that have experiences with it (PJM, Ontario, FIN, NO). For further market integration, especially in meshed and highly interconnected systems with many system operators present, it is essential to establish a well-functioning and efficient real time congestion management tools. Otherwise, with increasing cross border trade and uncertainties related with it, security margins would have to be significant, decreasing the amount of transmission capacity available for market purposes.