Cross-Border Redispatch Cost-Sharing

Summary of ENTSO-E Work

for Joint ACER/ENTSO-E TF,

12/2012 – Q4/2013

27 March 2014

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Disclaimer

- The list of high-level cost-sharing principles analysed in these slides is the result of conceptual considerations. It does not constitute as such any obligation for later implementation by TSOs and numeric examples given are for illustration purposes only;
- The list of described principles may give guidance for implementation of projects, being understood that CACM NC constitutes the binding framework, according to which the final decision is up to the TSOs and NRAs of each single capacity calculation region;
- Cost-sharing principles will be assessed against criteria on the Regional level;
- Developed high-level cost-sharing principles rely on different assumptions which need to be analysed in terms of accurateness;
- Share of the costs per zone is calculated without giving priority to certain type of flows (e.g. loop flows, transit flows…);
- Described principles could not be applied in case of unplanned outages and non-implementation of agreed TSO-TSO remedial action in the prior stages of operational planning; In those cases, some other cost-sharing method would be needed;
- The list of described principles is not an exhaustive one (e.g. some simpler principles as “requester-pays“ and socialisation keys are not described).

Scope of the work and applicability of results

- CACM NC (Art. 83):
  - “No later than eighteen months after the entry into force of this Network Code, all System Operators of each Capacity Calculation Region shall develop and propose a common methodology for Cross Border Redispatching or Countertrading cost-sharing for regulatory approval“
- ToR of the Joint Redispatch TF ENTSO-E/ACER defines the work:
  - “To further detail a framework for the cost-sharing arrangements according to the process defined in the NC”
- The joint ENTSO/ACER TF will make the results of analysis transparent which can be used to create momentum for implementation steps
- A specific application of cost-sharing principles and contractual arrangements will be decided on at least capacity calculation region level in accordance with the NC.

Guidance for the work on redispatch cost-sharing principles

- Definitions agreed on ENTSO-E level
- Types of costs to be shared agreed:
  - Remedial actions activated due to uncertainties on capacity calculation OR due the Market Design
  - Remedial actions identified during operational planning phase and activated in operational planning phase and/or real-time (costly actions used during the capacity calculation phase are out of the scope of work)
  - National/internal measures, if cross-border relevance can be identified
- The costs sharing keys should be consistent with capacity calculation and allocation processes

(Rewarding of relieving unplanned flows to be potentially analysed later)

Progress on work: timeline

- **December 2012:** Start of work
- **[Q1 2013]:** The list of criteria which could be eventually used for the assessment of the different costs-sharing principles has been prepared (**Annex 1**)
- Identification of the high-level concepts and definitions (**slides 7-11**)
- [**Q2-Q3 2013]:** Creation of the possible cost-sharing principles (**slides 12-24**):
  - Requester principles
  - Decomposition/deviation principles*
    - Power Flow Decomposition Principle (PFDM)
    - Not-allocated XB-Flow Principle (NAF)
    - Planned vs. Measured (PvM) principle
  - Socialisation principles
- **[Q4 2013]:** Explanation of calculation concept over small 3-zones example (**slides 12-24**)

* try to identify cause of activation (“polluter”)

The ‘Polluter Principle’ - considerations

Remedial actions as part of the bigger picture

Grid Infrastructure

A perfect grid infrastructure development would maximise social welfare in the long run by allowing an economically efficient confrontation of supply and demand, taking into account the costs for the infrastructure.

Market Design

The perfect market design would lead to an optimal use of the existing infrastructure, both under market and secure system operations aspects.

Real Time Operation

Remedial actions in or close to real time heal shortcomings of grid infrastructure and market design (‘the pollution‘) that threaten secure operation.

In a perfect world where the market design ensures optimal use of the grid respecting all security requirements, remedial actions would only be needed to heal situations (‘pollution‘) caused by unforeseeable events that cannot be avoided, e.g. outages or forecast errors.

In reality, neither infrastructure nor market design (incl. operational planning) are perfect, leading to shortcomings that cause ‘pollution‘ in the grid.

Definitions used for the cost-sharing of cross-border relevant remedial actions (1/2)

- **Internal relevant remedial action:** a remedial action which is performed with the goal to relive a constraint(s) without XB-relevance;
- **Cross-border relevant remedial action:** a remedial action which is performed with the goal to relive a constraint(s) with XB-relevance.

Definitions used for the cost-sharing of cross-border relevant remedial actions (2/2)

– **Multilateral remedial actions:** actions which are taken among different TSOs (at least three) and used to solve XB-relevant security violations;

– **Economically efficient multilateral remedial actions (*):** actions which are taken among different TSOs (at least three) with a goal to relieve the critical situation while minimising the activation costs (in the moment of activation) and taking into account the influence of measure on the critical network element(s).

→ Those actions include topology changes, countertrade and redispatch measures.

***** Distinction is necessary as in some regions MRAs (multilateral remedial actions) are considered to be a “last-resort“ measure used to solve XB-relevant security violation.

Need for remedial actions in the transmission network: cause and solution possibilities

Cause of need	Source of this cause	Possibility for a TSO to remedy	To be solved with…
"Long-term" (structural)	▪ Location of Generation & Load within the network	Non-managable by TSO	Network investment
	▪ Insufficient transmission investments.	Managable by TSOs with sufficient public and regulatory support	Market design change
"Short-term" (operational)	▪ Difficulties in scoping the coordination of the capacity calculation and allocation (outside flows) ▪ Forecast/modelling difficulties (CGM uncertainties, data quality, inadequate forecast, unforeseen events)	Partly managable by TSO	Capacity calculation and allocation Remedial actions

Long-term vs. short-term causes: which cause to consider?

- **Long-term causes** are not completely controllable by TSOs and have to be addressed by specific measures (e.g. network investments, optimal bidding zones);
- **Short-term causes** can be solved by coordinated capacity calculation and allocation or by remedial actions.

→ The focus was on the cost-sharing principles for Remedial Actions necessary to deal with the second category of causes (operational). However, the long-term causes could be taken into account in the list of criteria which could be considered for the assessment of cost-sharing methodologies.

COST-SHARING PRINCIPLES

EXPLANATION OF CALCULATION CONCEPT OVER SMALL 3-ZONES EXAMPLE

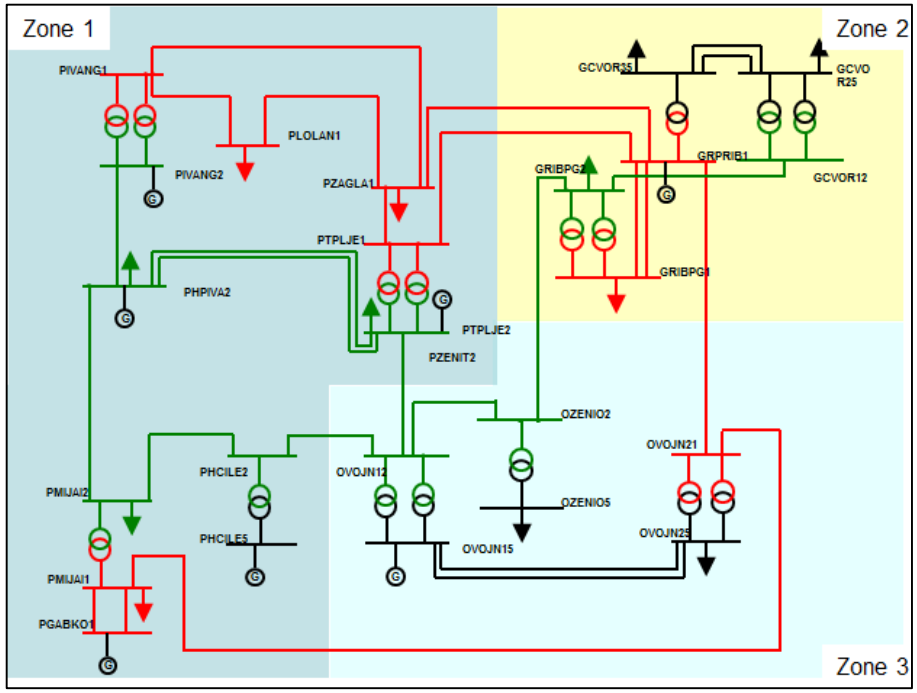
High-level cost-sharing principles: data used for calculation

* used for pre-congested cases

	Power Flow Decomposition Principle (PFDM)	Not-allocated XB-Flow Principle (NAF)	Planned vs. Measured Principle (PvM)
Forecast (IDCF)	One of the models	One of the models	YES
Snapshot (SN)			YES
GSKs	NO	YES	NO (YES*)
PTDF node-to-node	NO	NO	YES
Overloaded line	YES	YES	YES
Main characteristics	Decomposition of physical flows	Distinction between allocated and not allocated XB-flows	Development of unscheduled & unexpected flows over time

- PFDM and NAF: Either IDCF or SN → depending on which grid model has been used to decide the remedial action
- PVM: the last model (based on which the decision for remedial action activation has been made) is used as a starting point

High-level cost-sharing principles: model used for calculation



Zone	Net Position SN	Net Position IDCF	Net Position DACF
Zone 1	-55.00	-50.00	150.00
Zone 2	52.50	50.00	-50.00
Zone 3	2.50	0.00	-100.00

- Network model:
  - Small-test system with the 3 zones (380, 220 and 110 kV);
- Overload in n-0 case **in IDCF** (in Z3):

→ From 90% in base case to 170% in (n-1) contingency case

  - critical outage:
    OVOJN25 - OVOJN15 (110 kV) CKT 1
  - critical branch:
    OVOJN25 - OVOJN15 (110 kV) CKT 2

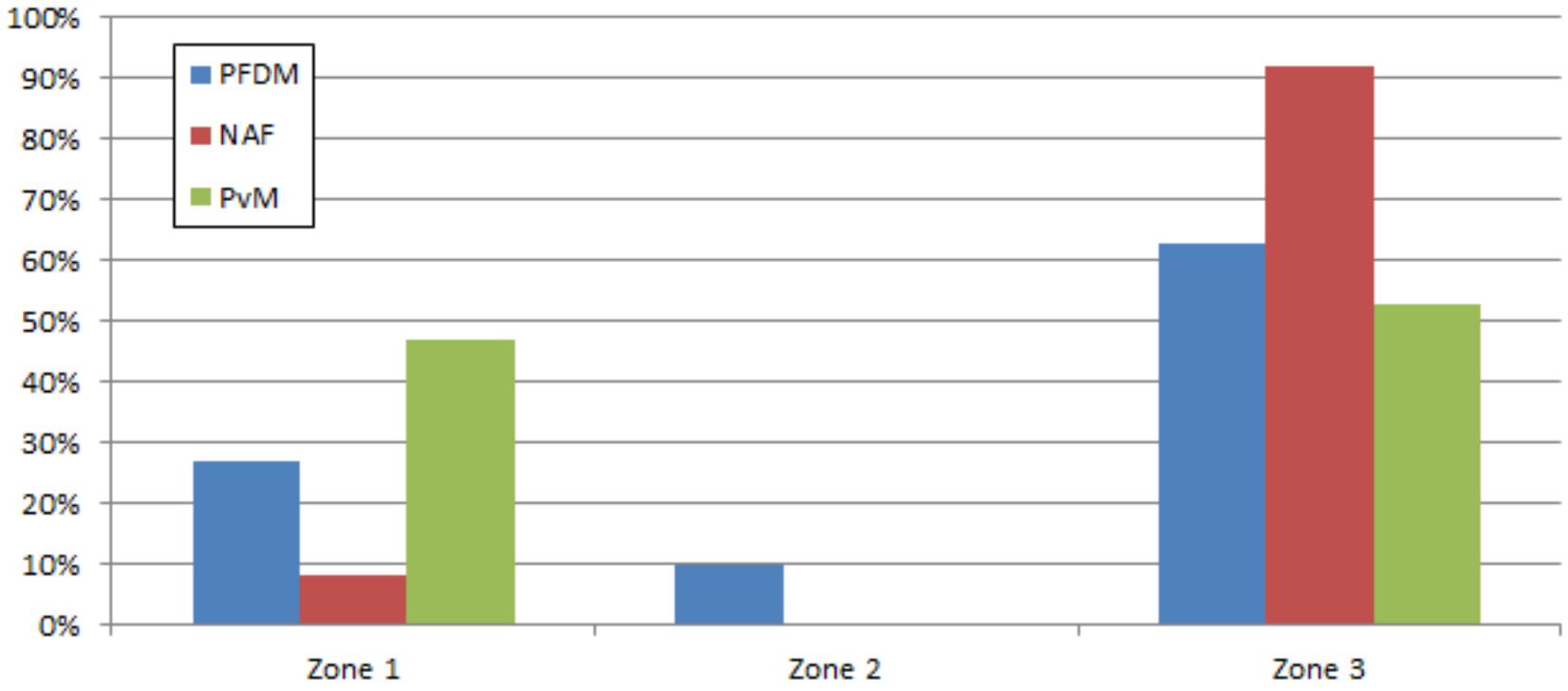
Line (n-0 case)	Flow DACF	Flow IDCF	Flow SN	PATL
OVOJN15 - OVOJN25	186	214.71	225.06	210

The high-level cost-sharing principles only demonstrate the mathematical viability of each model. The chosen use case (i.e. congestion of an internal line, line of 110KV) does not represent a standard scenario for activation of cross-border relevant redispatch.

High-level cost-sharing principles: results of calculation

critical branch: OVOJN25 - OVOJN15 (110 kV) CKT 2
critical outage: OVOJN25 - OVOJN15 (110 kV) CKT 1

} Overload in IDCF model on the internal line in Zone 3 in the base case (n-0)



COST-SHARING PRINCIPLES

POWER FLOW DECOMPOSITION PRINCIPLE

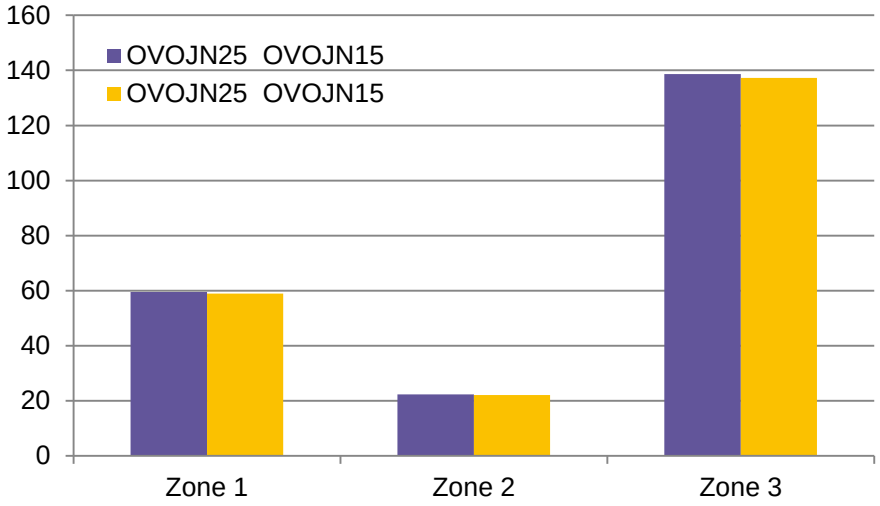
Power flow decomposition principle: concept note

Calculation Step	Description
Main characteristics	Decomposition of physical flows
Total power flow calculation	Based on *.uct file the overall physical power flow is calculated based on a grid model taking into account all relevant technical parameter of the grid elements
Power flow decomposition	• Node to node calculation of power flows between each generator and load (based on Kirchhoff's laws) • Summing up of partial flows on each line/grid element to calculate total power flow
Impact assessment	Only burdening contributions to a specific grid element/line are taken into account
Cost-sharing	• in proportion to burdening contribution the flows are allocated to the zones the nodes are belonging to • the costs are shared based on the contribution of the zones • cost-sharing based on *partial flows* is also possible

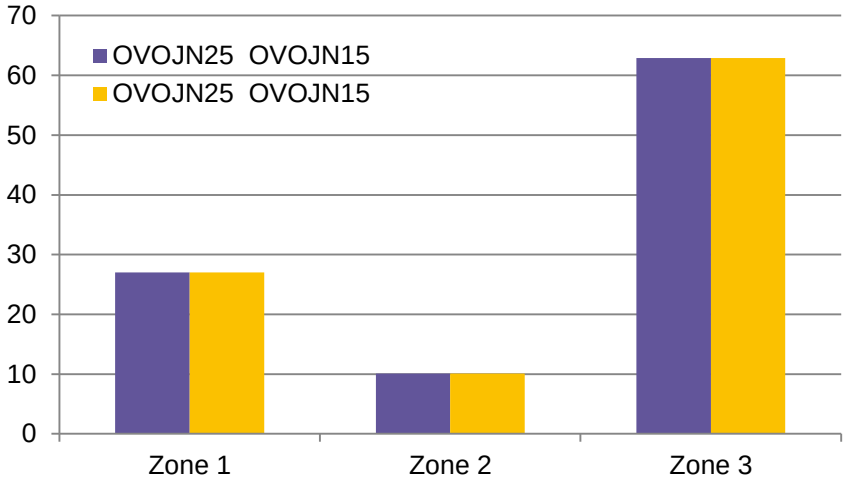
Power flow decomposition principle: calculation results

IDCF Model
SN Model

load contribution to line per zone [MW]



cost-sharing per zone [%]



Contribution to	Load [MW]*	Costs [%]*
Zone 1	60	27
Zone 2	22	10
Zone 3	138	63

* per line

COST-SHARING PRINCIPLES

NOT-XB-ALLOCATED FLOW PRINCIPLE

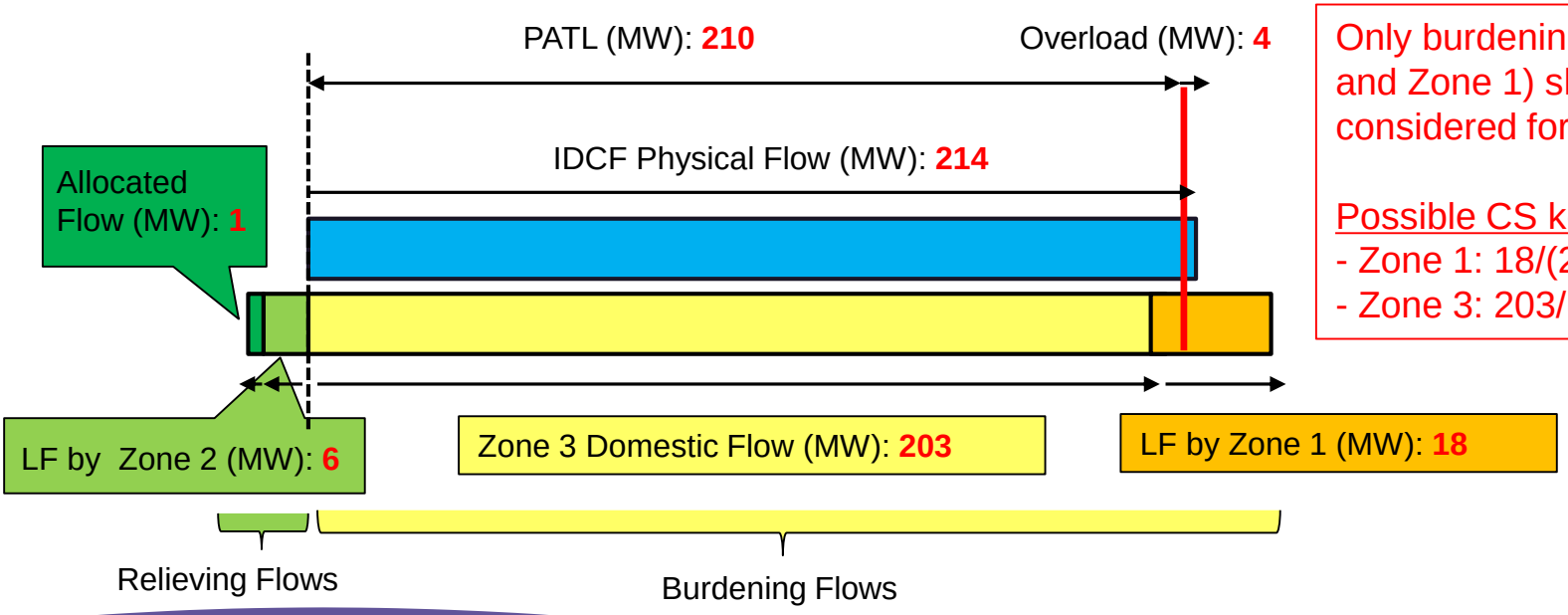
Not XB allocated flow principle: concept note

Calculation Step	Description
Main characteristic	Distinction between allocated and not allocated XB-flows
NP adjustment	Starting from the base case, all Zones' Net Positions are forced to 0, using the Generation Shift Key provided by TSOs (proportional GSK used for this example).
Loads/Injections extinction	Then, for each zone "i" at a time (Z_i), loads/injections are preserved while loads/injections of all the other zones are forced to 0 ("passive network"). **=> *Loop flows*** originated by Z_i on any grid elements in any other zone ($Z_{j,\ k...}$) can be directly measured (it applies also for tie-lines of Zi). **=> *Internal flows*** originated by Z_i on any grid element of Z_i can also be measured.
Not XB Allocated flows calculation	Sum of Loop and Internal flows gives the Not XB Allocated Flows.
XB Allocated flows calculation	Difference between Physical flows from the base case and Not XB Allocated Flows gives ***XB Allocated flows*** *(equivalent to flows resulting from zonal PTDF*NP calculation).*
Cost-Sharing	Different priorities and/or weighting can eventually be applied to these 3 types of flows (Loop, Internal and XB Allocated) on the congested line and provides the cost-sharing.

Not XB allocated flow principle: calculation results

Cost-sharing is applied after activation of a costly XB remedial action. Let's consider that this kind of remedial action is implemented to solve the constraint on OVOJN25 – OVOJN15 2 in (n-0) case (IDCF physical flow = 214 MW for a PATL* of 210 MW).

The Not XB-allocated Flow decomposition gives on OVOJN25 – OVOJN15 2 in (n-0) case:



Only burdening flows (Zone 3 and Zone 1) should be considered for the cost-sharing.

Possible CS key:
- Zone 1: 18/(203+18) -> 8%
- Zone 3: 203/(203+18) -> 92%

* see Annex 2

COST-SHARING PRINCIPLES

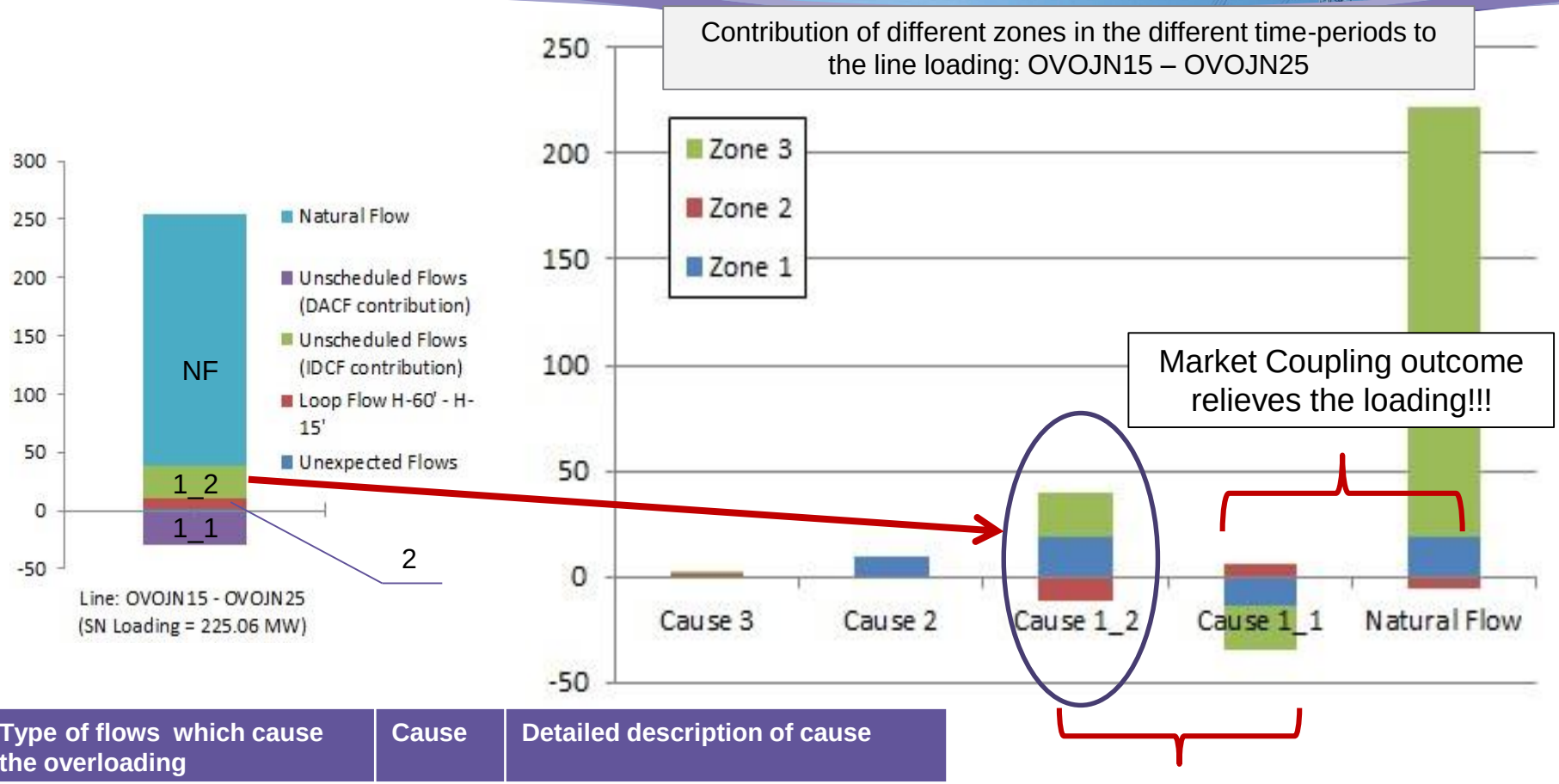
PLANNED VS. MEASURED PRINCIPLE

Planned vs. measured principle: concept note

Calculation Step	Description
Main characteristic	Development of unscheduled & unexpected flows over time
Nodal injections	Nodal injections in two models are compared (Model 1 and Model 2). Model 1 is always the model where the need for redispatch is identified (in example: IDCF). Model 2 is a “previous one” in a timeline (DACF). The NF model calculated with GSKs (proportional shift to Gen used) setting net positions to zero.
Nodal PTDFs	Calculate a nodal PTDF matrix for the overloaded element for each node total ≠ 0 (node 2 set as the reference one)
Nodal contributions to flow on the overloaded element	Multiply nodal totals with Nodal PTDFs
Calculate zonal contribution to critical line	Sum up nodal contributions per zone; only positive (burdening) contribution considered for the cost-sharing
Scaling (to correct the influence of “reliving” flows)	Once (line_loading Model A < PATL < line_loading Model A+1), scale all zonal contributions (Model 1-Model 2 vs. Model 2-Model 3 …) such that the sum equals **marginal contribution:** the difference between the loading of a line in Model 1 and PATL*
cost-sharing among zones	Costs are shared among zones **proportionally** to their scaled contributions.

* see Annex 2

Planned vs. measured principle: calculation results (1/2)

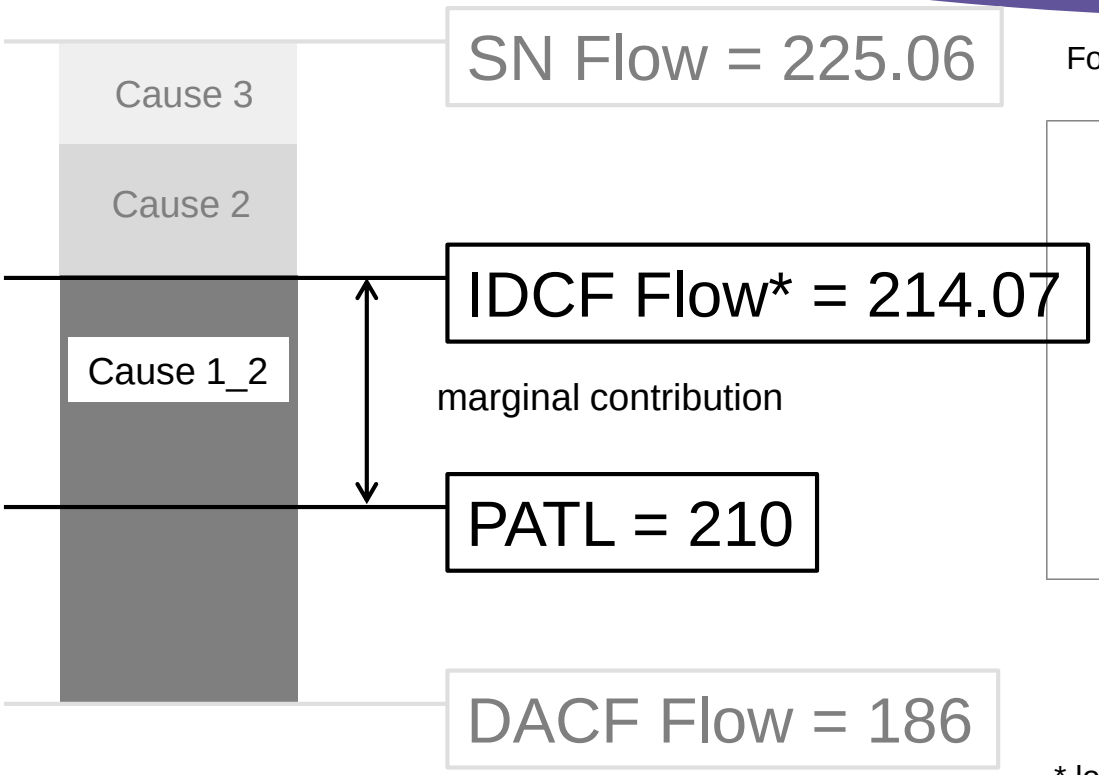


Type of flows which cause the overloading	Cause	Detailed description of cause
Unexpected Flows (incl. Loop Flows from GCT 1* to GCT 2**)	#3 & #2	Change of zonal model IDCF→ SN
Transit Flow, Loop Flow and Direct Flow	#1_2	Change of zonal model and/or net position DACF→ IDCF (Intraday market)
Transit Flow, Loop Flow and Direct Flow	#1_1	Change of zonal model and/or net position NF→ DACF

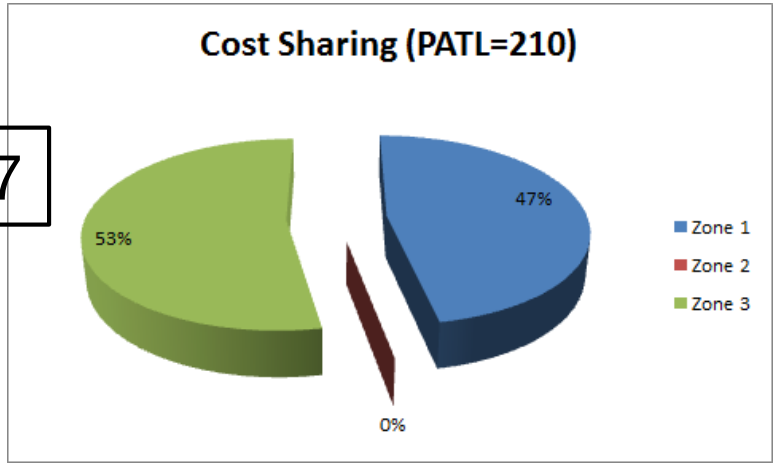
Net Position change of different countries lead to the change of contribution to the line

* GCT 1 = Gate Closure Time for Intraday XB-trade
** GCT 2 = Gate Closure Time for inner-zonal Intraday trade

Planned vs. measured principle: calculation results (2/2)



For activation close to real-time (SN) see Annex 3



→ sharing proportional to marginal contribution of Cause #1_2

* loading before the activation of XB-relevant redispatch

Type of flows which cause the overloading	Cause	Zone which cause activation	Detailed description of cause	Marginal contribution to OVOJN15 - OVOJN25
Transit Flow, Loop Flow and Direct Flow	#1_2	ALL (positive contribution of ZONE 1 and ZONE 3)	Change of zonal net positions due to model changes between DACF and IDCF (Intraday market)	28.10 MW (DACF→IDCF)

Annexes

Annex 1: Criteria for the assessment of the cost-sharing principles

Annex 2: Definitions used for the explanation of cost-sharing concepts

Annex 3: Planned vs. measured principle: calculation results (SN used as a starting point of calculation)

Annex 1: Criteria for the assessment of the cost-sharing principles

List of the possible criteria for the assessment

1. Transparency
2. Predictability
3. Incentive for TSOs to ensure the overall efficiency of the applied measures from the short-term to the long-term level
4. Speed of implementation
5. Incentive to increase the accuracy of network models, capacity calculation and planning process
6. Possibility for free-riding and gaming
7. Reflective to physical grid situation

* Disclaimer: The list of the criteria is used for the assessment of the different cost-sharing principles and should not be considered as the final one;

Criteria 1: Transparency

The applied cost-sharing principle has to be transparent to all participating TSOs in such a way that there is:

– **Sub 1.1:** No possibility for the misinterpretation (different ways of the implementation); PRECONDITION

– **Sub 1.2:** Possibility to replicate it with reasonable effort independently by each TSO; PRECONDITION

– **Sub 1.3:** All data necessary for calculation is available to all TSOs involved. PRECONDITION

The applied cost-sharing principle* has to:

– **<u>Sub 2.1</u>:** Enable reasonable financial planning. The applied cost-sharing principle must allow to reasonable asses the approximate shares of the total costs that have to be remunerated by involved TSOs.

(*) The costs are as such not predictable as they depend on the total number of activations.

Criteria 3: Incentive for TSOs to ensure the overall efficiency of the applied measures from the short-term to the long-term level

The cost-sharing principle has to give the proper incentives to TSOs:

– **Sub 3.1:** In short-term: increase the efficiency of redispatch and strive for optimal balance between redispatch costs and the level of cross-zonal capacities, while maintaining network security as primary objective;

– **Sub 3.2:** In mid-term: Improve the market design when efficient (bidding zones & capacity calculation);

– **Sub 3.3:** In long term: Invest in the transmission network to relieve congestions when efficient.

Criteria 4: Speed of implementation

- **The applied cost-sharing principle has to be assessed according to the time and effort which is necessary for the implementation:**

– **Sub 4.1:** Multilateral contractual framework;

– **Sub 4.2:** Additional business processes which need to be agreed on and to be implemented (time frame);

– **Sub 4.3:** Compatibility of the solution over the different regions and inter-regional coordination.

Criteria 5: Incentive to increase the data accuracy of network models, capacity calculation and planning process

The applied cost-sharing principle has to give the proper incentives to TSOs to reduce the total redispatching costs by:

– **Sub 5.1:** Increasing the data quality for modeling the transmission network

– **Sub 5.2:** Increasing the data quality for capacity calculation and allocation process (margins; GSK);

– **Sub 5.3**: Increasing the data quality for operational planning.

The applied cost-sharing principle should not provide incentives for:

– **Sub 6.1:** Free-riding (e.g. country causing the problem is benefiting from the solution without paying for it);

– **Sub 6.2:** Gaming (no possibility to abuse of the cost-sharing principle to acquire extra benefit).

The applied cost-sharing principle should:

– **Sub 7.1:** Clearly indicate the relationship between the physical grid situation leading to the need for redispatch and the associated financial impact for TSOs;

– **Sub 7.2:** Cost burden should be based on cost causality, i.e. by identification of cost causers and cost bearers;

– **Sub 7.3:** Consistency with capacity allocation and congestion management (CACM) framework. PRECONDITION

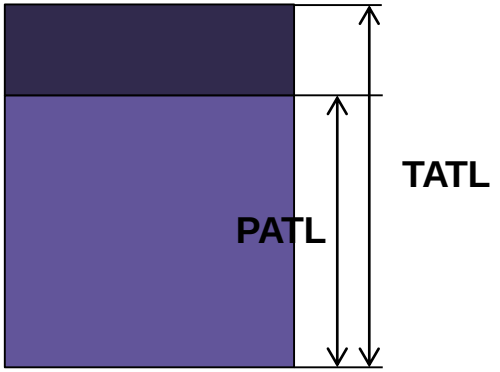
Annex 2: Definitions used for the explanation of cost-sharing concepts

Policy 3 - Operational Security

– **Permanent Admissible Transmission Loading (PATL):** is the loading in Amps, MVA or MW that can be accepted by a network branch (XB-relevant constraint) for an unlimited duration without any risk for the material;

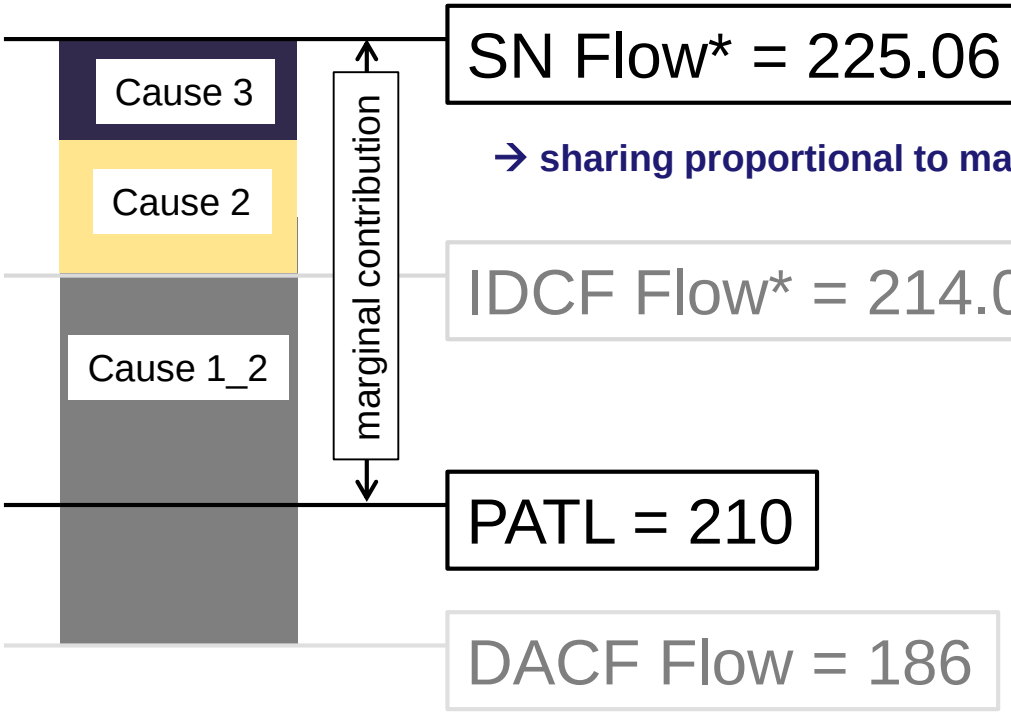
– **Temporary Admissible Transmission Loading (TATL):** is the loading in Amps, MVA or MW that can be accepted by a branch for a certain limited duration.

The TATL can be defined in different ways – as a fixed percentage of the PATL for a given time (for example, 115% of the PATL can be accepted during 15 minutes);

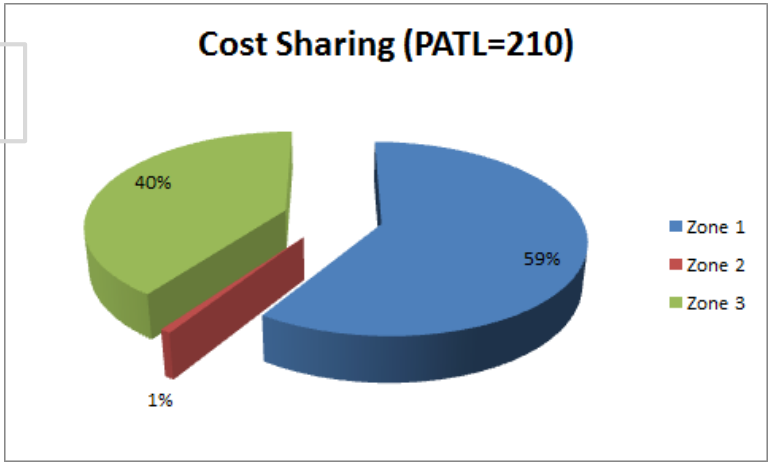


Annex 3: Planned vs. measured principle: calculation results

→ Case of redispatch activation close to real-time (SN used as a starting point of calculation)



→ **sharing proportional to marginal contribution of Causes #2, #3 and #1_2**



* loading before the activation of XB-relevant redispatch

Type of flows which cause the overloading	Cause	Zone which cause activation	Detailed description of cause	Marginal contribution to OVOJN15 - OVOJN25
Unexpected Flow	#3	ALL	Consumption pattern in Zones deviate from the one assumed in IDCF and secondary energy is activated	1.31 MW
Loop Flows	#2	ZONE 1	Internal transaction PHCILE 5 > PHPIVA 2: 100 MW	9.02 MW
Transit Flow, Loop Flow and Direct Flow	#1_2	ALL (positive contribution of ZONE 1 and ZONE 3)	Change of zonal net positions due to model changes between DACF and IDCF (Intraday market)	28.10 MW (DACF→IDCF)