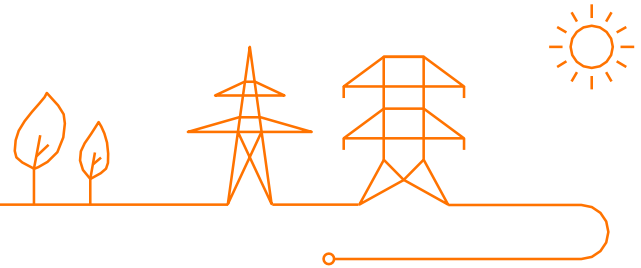
ICAROS - Congestion Risk Indicator (CRI)

ICAROS stakeholders brainstorming session

23/10/2019 – Martin FUNCK

Agenda

1. Red Zones (AS IS)
2. Objectives of **C**ongestion **R**isk **I**ndicator (TO BE - ICAROS)
3. Presentation of the processes:
   - CRI zone determination
   - CRI level determination



Red zones 2018

Situation AS IS

Red Zone mechanism, counting and graphical representation

- **A Red Zone (RZ)** is the status of an electrical zone, for a defined direction (I/D) and for a defined period during the day, in which **a constraint in MW** has been set with regards **to production program adaptation on CIPU PU** situated in this electrical zone.

- **As from Q2 2017**, three adaptations have been brought to the concept of RZ:
  1. From Peak-Off Peak periods to hourly defined periods allowing a better time granularity
  2. Splitting of the zones of Langerbrugge and Hainaut allowing a better geographical granularity
  3. Intraday update of the status of the RZ in function of the last intraday forecast

- One (I/D) RZ is counted for each day where a (I/D) RZ has been applied. This means that different (I/D) RZ in the same electrical zone covering different periods within the same day count as one.

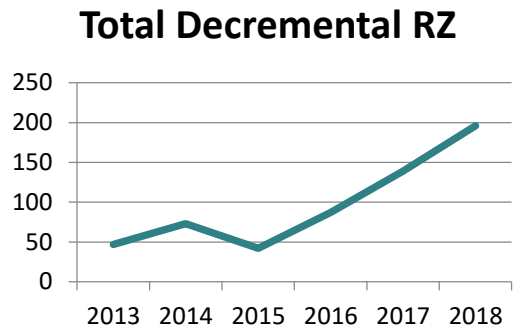
- **Because of the split of Langerbrugge and Hainaut in Q2 2017,**
  - Dotted lines represent the number of RZ applied on the new electrical zones (LAE,LAW, HTE and HTW) as the beginning of their existence

Electrical Zone	Short name
Hainaut	HT
Hainaut East	HTE
Hainaut West	HTW
Langerbrugge	LA
Langerbrugge East	LAE
Langerbrugge West	LAW
Liège	LG
Schaerbeek	SC
Stalen	ST
Ruien	RU
Merksem	MK
380 kV connected PU	380

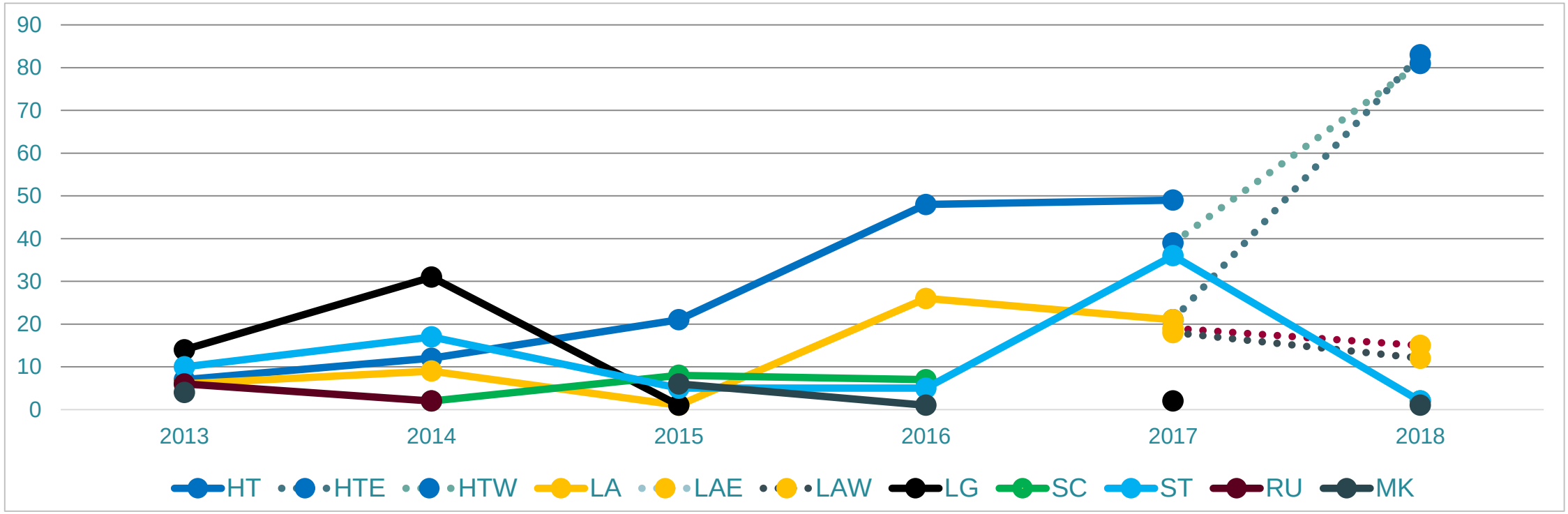
Number of activations of decremental Red Zones

2013-2018

Increase of activations of decremental red zones, mainly due to high flux in the 380kV.



#'s days

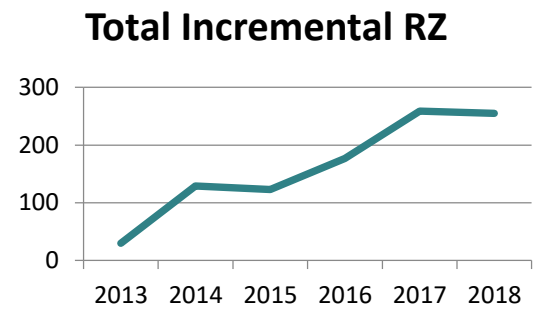


Splitting of the zones Langerbrugge (=LAWest + LAEast) and Hainaut (HTEast + HTWest) as from 05/2017

Number of activations of Incremental Red Zones

2013-2018

Incremental red zones were mainly due to a high wind generation in LAW (68%) and grid maintenance and a high generation in HTE (resp. 46% & 27%)



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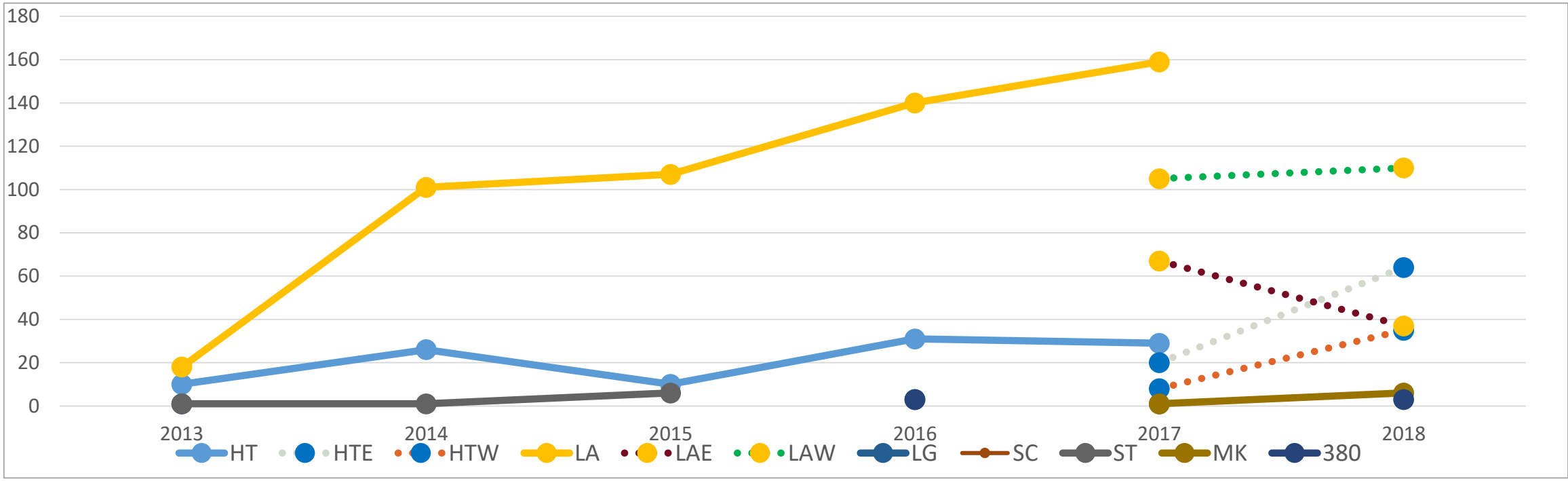


Splitting of the zones Langerbrugge (=LAWest + LAEast) and Hainaut (HTEast + HTWest) as from 05/2017

Congestion Risk Indicator

ICAROS

The goal of the CRI is to avoid BAL actions by Elia that would aggravate a congestion issue.

The CRI is used as a **filter** on activations of energy of contracted and non-contracted aFRR/mFRR .

The CRI represents the congestion risks in a Belgium electrical zone and is determined :

- For a direction: incremental, decremental or both
- For a specific duration
- With 3 levels: Low, Medium (with a MW cap) & High

Due to freedom of dispatch in ID, CRI cannot block Intraday Schedule Amendment (>< present Red zones: external stakeholders are forbidden to change generation schedules due to a congestion)

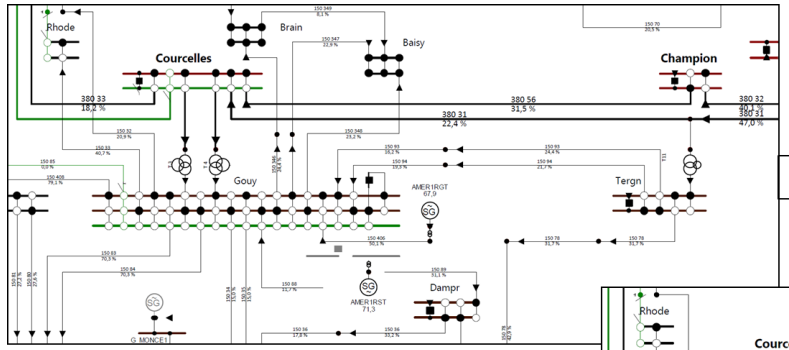
CRI could be used to prepare Redispatching activation in case of ID Schedule Amendment.

Different process with different time horizons are linked to the CRI

1.		**ZONE DETERMINATION** Process to define the electrical zones subject to a level of CRI	Around once a year
2.		**LEVEL DETERMINATION** Process to define level of CRI (high, medium, low) for each zone	Once in DA Around 3 times in ID
3.		**FILTER OF BALANCING BIDS** Process to filter BAL bids based on the level of the electrical zone	Close to real time

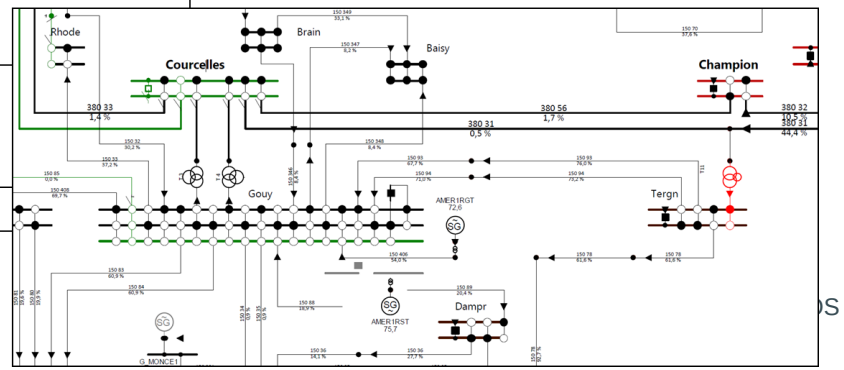
Some useful concepts

- **N-1 principle**: Any element of the grid (line, TFO, production unit, …) can be lost without (simple contingency):
  - Creating any unacceptable overloads or transgression of exploitation limits
  - Leading to cascading effects
- **Critical Network Element** (CNE): grid element that is monitored by a security analysis with N-1 principle.
- **Contingency** (C) : Trip of a grid element, a generating unit…



N state: grid with present outages

N STATE



N-1 STATE

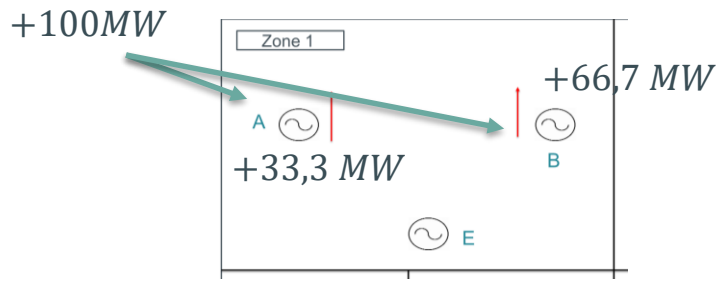
N-1 state: grid with present outages + simulation of an outage (incl. in the contingency list)

Some useful concepts

- **Generation Shift Key** (GSK) defines how a change in net position is mapped to the generating units in a zone.

Ex: $\Delta P = +100MW$ in zone 1

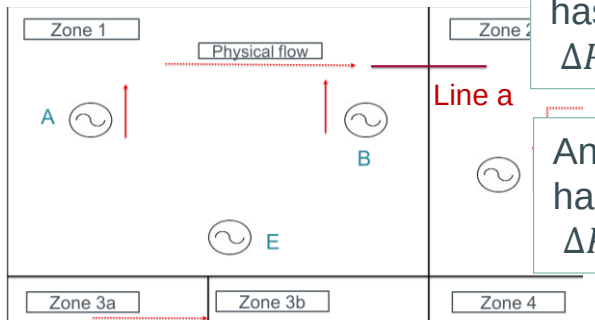
GSK	[-]
Zone 1	
Unit A	0,333
Unit B	0,667
Unit E	0



- **Power Transfer Distribution Factor** (PTDF) allows to assess what is the impact of a change of generation of a unit or in a zone on a line.

Ex:

$$\mathrm{PTDF}_{Unit\ A \rightarrow line\ a} = 0{,}10$$
$$\mathrm{PTDF}_{Unit\ B \rightarrow line\ a} = 0{,}25$$
$$\mathrm{PTDF}_{Zone\ 1 \rightarrow line\ a} = 0{,}20$$



An increase of generation of $\Delta P = +100MW$ in Unit A has an impact of
$\Delta P * \mathrm{PTDF}_{Unit\ A \rightarrow line\ a} = 10\ MW$ on line a.

An increase of generation of $\Delta P = +100MW$ in Unit B has an impact of
$\Delta P * \mathrm{PTDF}_{Unit\ B \rightarrow line\ a} = 25\ MW$ on line a.

Determination of zones

Annual process

Determination of the zones

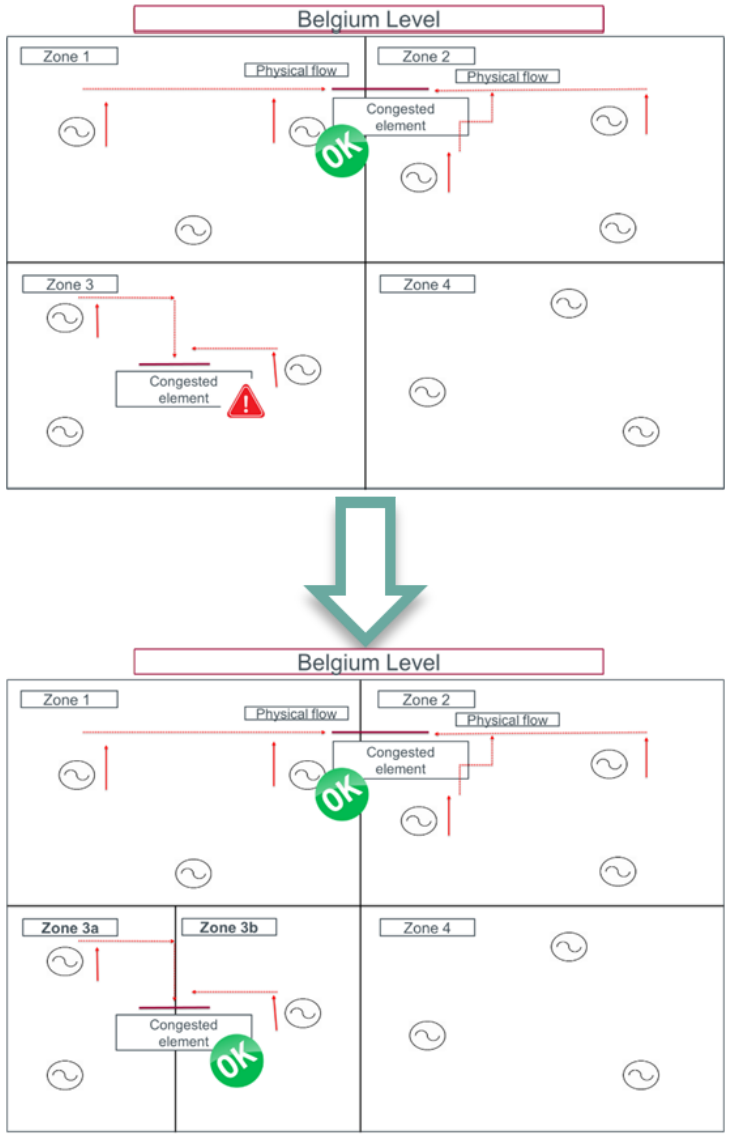
Approach:

- Lines with a congestion risk are cross-electrical zone lines
- Inside a zone: copper plate hypothesis.

Concretely:

Once a year (or via a trigger), analysis of relevant congested lines based on historical values:

- If a relevant congested line is inside a zone: split of zone.
- Possibility to split zone by voltage level. Ex: HTE_150 and HTE_70 (*future proof*)
- Determination of CNE* and Contingencies* via min PTDF
- Determination of a realistic MW threshold between medium and low CRI by zone



The determination of zones should allow Elia to filter out balancing bids that have relevant impact on congested elements

* Same concepts but different elements than Flow-Based

Determination of CRI level

Day ahead and Intraday process

Determination of the CRI level

CRI has 3 different levels in a direction:

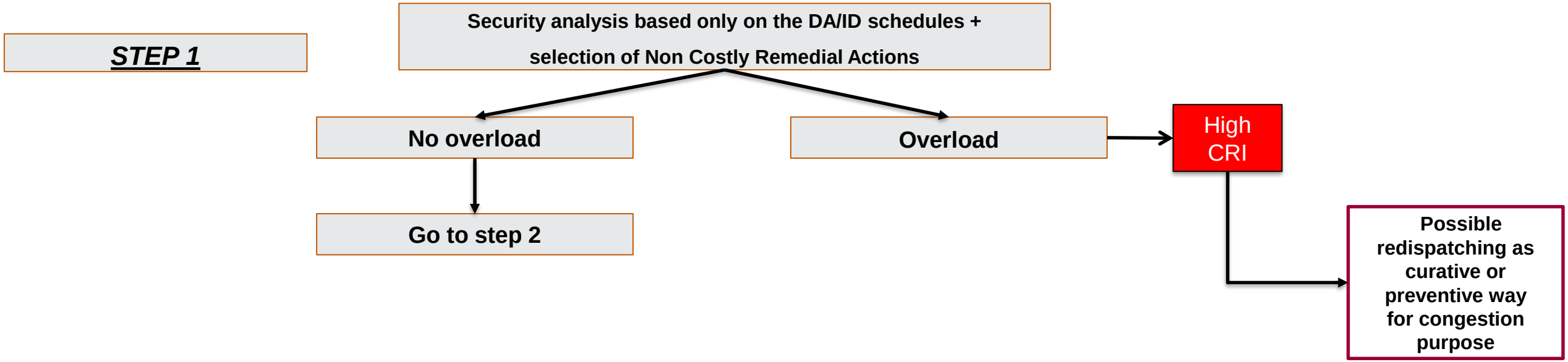
- High CRI with 0 MW cap
- Low CRI with no MW cap
- Medium CRI with a MW cap to determine

ZONE	CRI Incre	CRI Decre	MW cap I	MW cap D
1	MEDIUM	LOW	**900 MW**	**/**
2	HIGH	LOW	**0 MW**	**/**
3	LOW	MEDIUM	**/**	**- 600 MW**
4	MEDIUM	HIGH	**400 MW**	**0 MW**

Two steps in this determination:

1. Global Security Analysis (incl. application of Remedial Actions) based on DA/ID schedules
2. Zonal Security Analysis (incl. application of Remedial Actions) to determine MW cap.

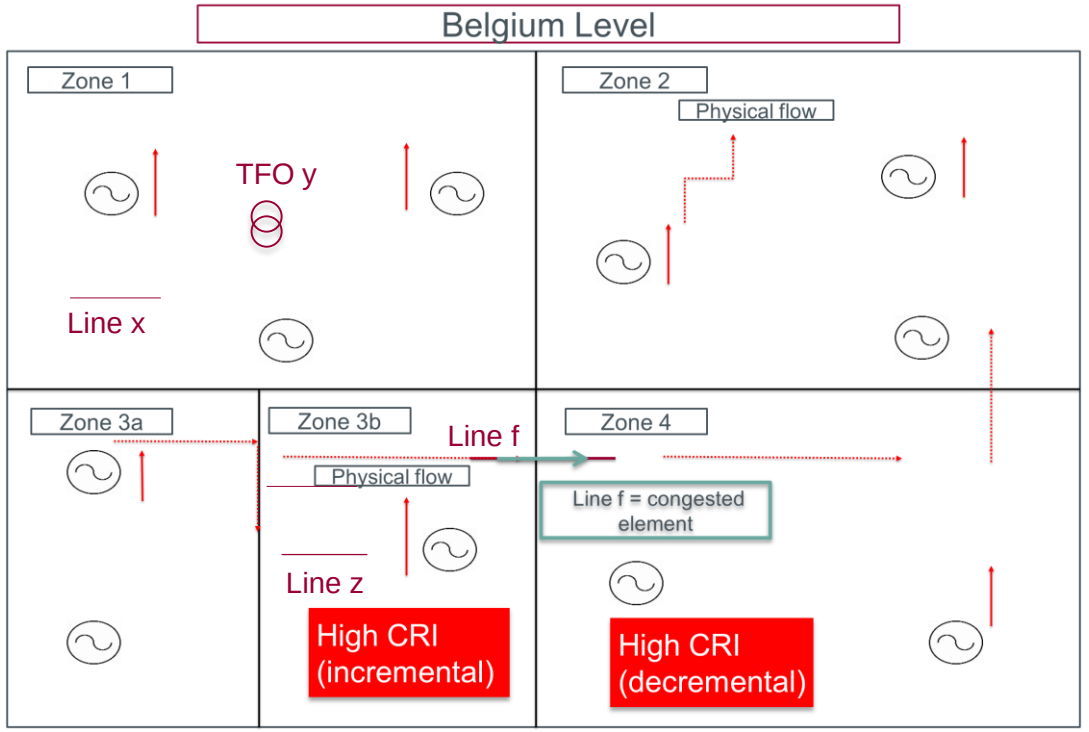
Determination of CRI level – step 1: Global Security Analysis



Determination of CRI level – step 1: Global Security Analysis - example

Results of step 1

CNEC		Loading (incl. FRM*) [%]
Cross-zonal lines (CNE)	Contingency (C)	
Zone 1 -> Zone 2		
a	x	80%
c	x	75%
a	y	90%
c	y	50%
Zone 1 -> Zone 3a		
b	x	53%
d	x	60%
b	y	37%
d	y	75%
Zone 3b -> Zone 4		
f	z	125%



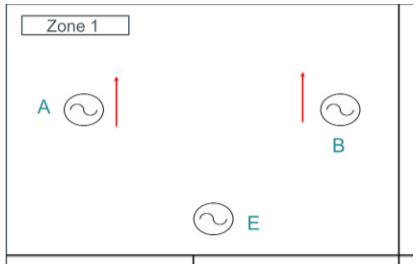
*FRM : Flow Reliability Margin covers the forecast uncertainties (international flows, generation…) with a certain risk level

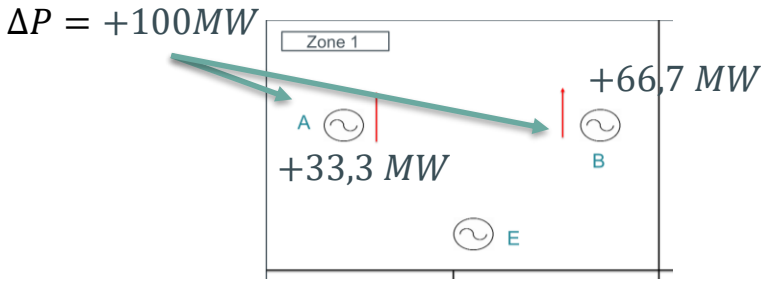
Determination of CRI level – Step 2 : Zonal Security Analysis

Analysis by zone of the impact of a increase and decrease of production in a zone on the CNEC

- Calculation of PTDF using GSK and 2 load flows calculation ($\Delta P = 0$ & $\Delta P \neq 0$).

GSK	[-]
Zone 1	
Unit A	0,333
Unit B	0,667
Unit E	0





- Using PTDF and results of loading in step 1, we get the impact of an increase (/decrease) of production (ΔP) in the zone with a “simple” calculation:

$$Loading_{line\ a,after\ increase} = Loading_{line\ a,step1} + PTDF_{zone1 \rightarrow line\ a} * \Delta P$$

- The MW cap for the zone is defined by the most limiting CNEC by increasing(/decreasing) ΔP.
- If the MW cap is above the MW threshold defined in the zone determination process, the zone is in low CRI and has no MW cap.

*Power Transfer Distribution Factor (PTDF) allows to assess what is the impact of a change of generation in a zone on a line (CNEC).

Determination of CRI level – Step 2 : Zonal Security Analysis

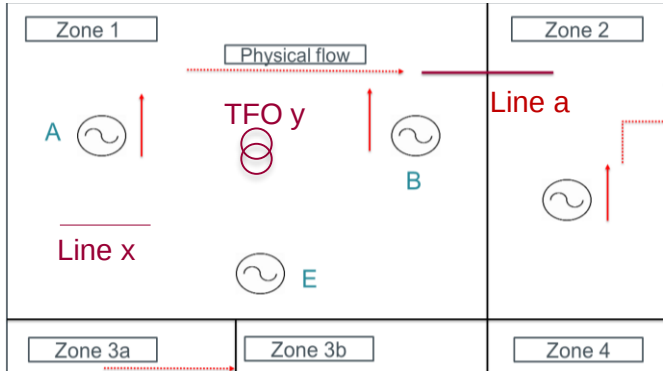
Analysis by zone of the impact of a increase and decrease of production in a zone on the CNEC

Example for zone 1:

Result of step 1

Incremental		Increase in production in zone 1 [MW]												
CNE	C	0	20	40	60	80	100	120	140	160	180	200	220	240
a	x	80%	82%	83%	85%	86%	88%	90%	91%	93%	94%	96%	98%	99%
b	x	53%	59%	64%	69%	75%	80%	85%	91%	96%	101%	107%	112%	117%
c	x	75%	76%	77%	78%	79%	80%	81%	82%	83%	84%	85%	86%	87%
d	x	60%	60%	59%	59%	58%	58%	57%	57%	56%	56%	55%	55%	54%
a	y	90%	92%	93%	95%	96%	98%	**100%**	101%	103%	104%	106%	108%	109%
b	y	37%	42%	47%	53%	58%	63%	69%	74%	79%	85%	90%	95%	101%
c	y	50%	51%	52%	53%	54%	55%	56%	57%	58%	59%	60%	61%	62%
d	y	75%	75%	74%	74%	73%	73%	72%	72%	71%	71%	70%	70%	69%

Most limiting CNEC



In zone 1, an increase of production above 120 MW would create the first congestion.

Determination of CRI level – Step 2 : Zonal Security Analysis

Medium CRI or Low CRI

Example for zone 1:

In zone 1, an increase of production of above 120 MW would create the first congestion.

- If 120 MW > threshold per zone (calculated in the zone determination process)

  ➔ **Low CRI** (without MW cap)

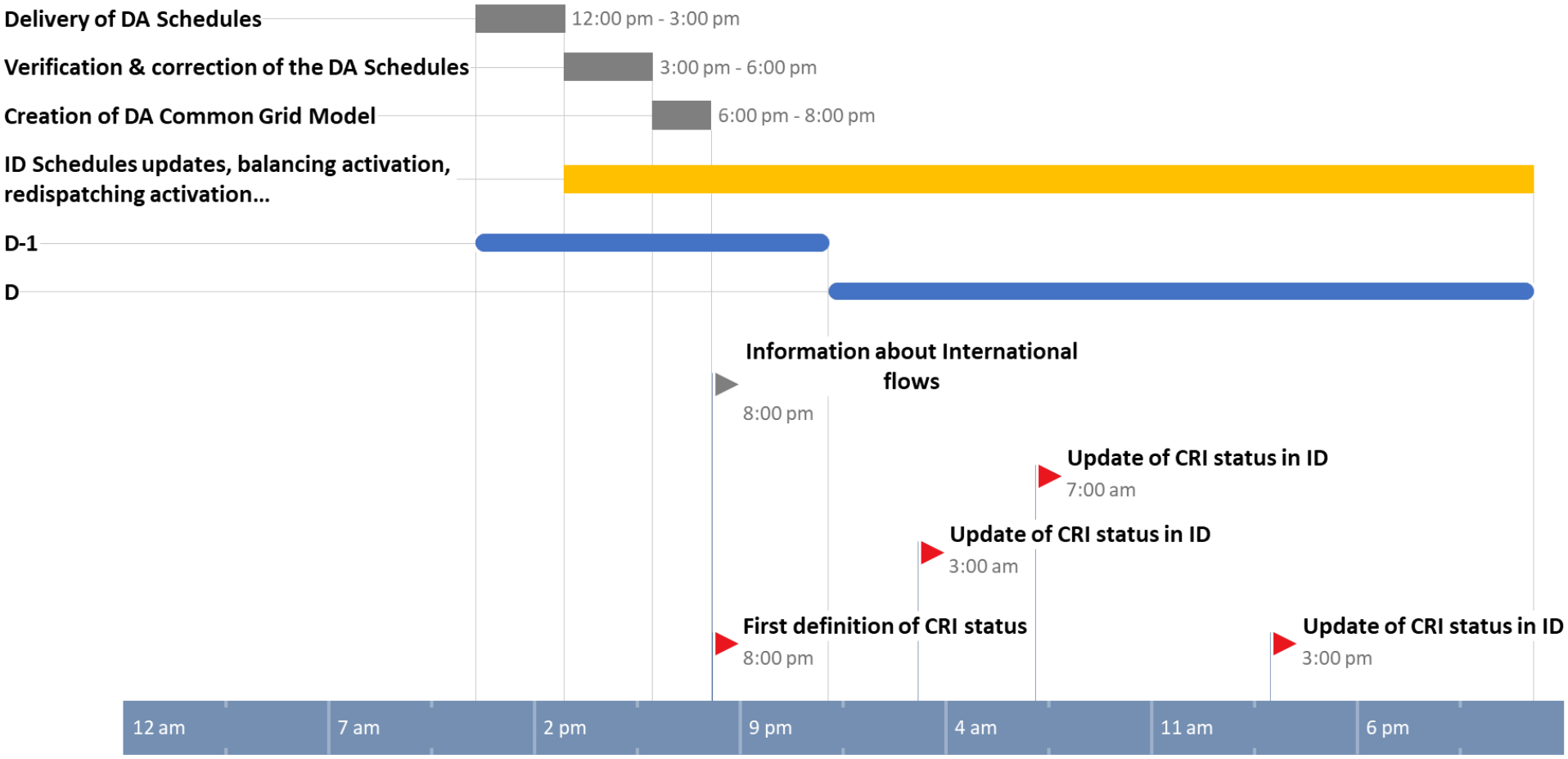
- If 120 MW < threshold per zone

  ➔ **Medium CRI** with MW cap = 120 MW

Same zonal process for all other zones to get a status for all zones:

ZONE	CRI Incre	CRI Decre	MW cap I	MW cap D
1	MEDIUM	LOW	**120 MW**	**/**
2	HIGH	LOW	**0 MW**	**/**
3	LOW	MEDIUM	**/**	**- 200 MW**
4	MEDIUM	HIGH	**400 MW**	**0 MW**

Indicative timing



+ ad hoc updates if needed

Thank you.