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ILLUSTRATIONS DES REMARQUES D'AMPACIMON S.A.

5 juin 2020

Raccordement de champs éoliens (Source: Ampacimon s.a.)

Deux lignes (225 kV et 90 kV), destinées au raccordement de parcs éoliens en France, ont été étudiées. L'effet d'un sous-dimensionnement intentionnel du conducteur a été évalué pour différents types de conducteurs. Avec le DLR, la capacité du parc éolien peut être supérieure à la capacité de raccordement dictée par le réglage statique de la ligne. L’essentiel des gains est causé par le vent, qui, justement, alimente les aérogénérateurs. L'impact des différents gains DLR moyens a été comparé. Le gain DLR moyen dépend de l'emplacement de la ligne et de son exposition globale aux facteurs de refroidissement. Plus le gain moyen est élevé, plus la possibilité de sous-dimensionner le conducteur est grande.

<u>Hypothèses techniques:</u>

Ligne existante (225kV, circuit simple sur 10km long + circuit double sur 3.7 km)
Conducteur AZALEE 666, diam 31,50 mm
Réglage statique IST 1090 A
Gain DLR moyen supérieur ou égal à 16%

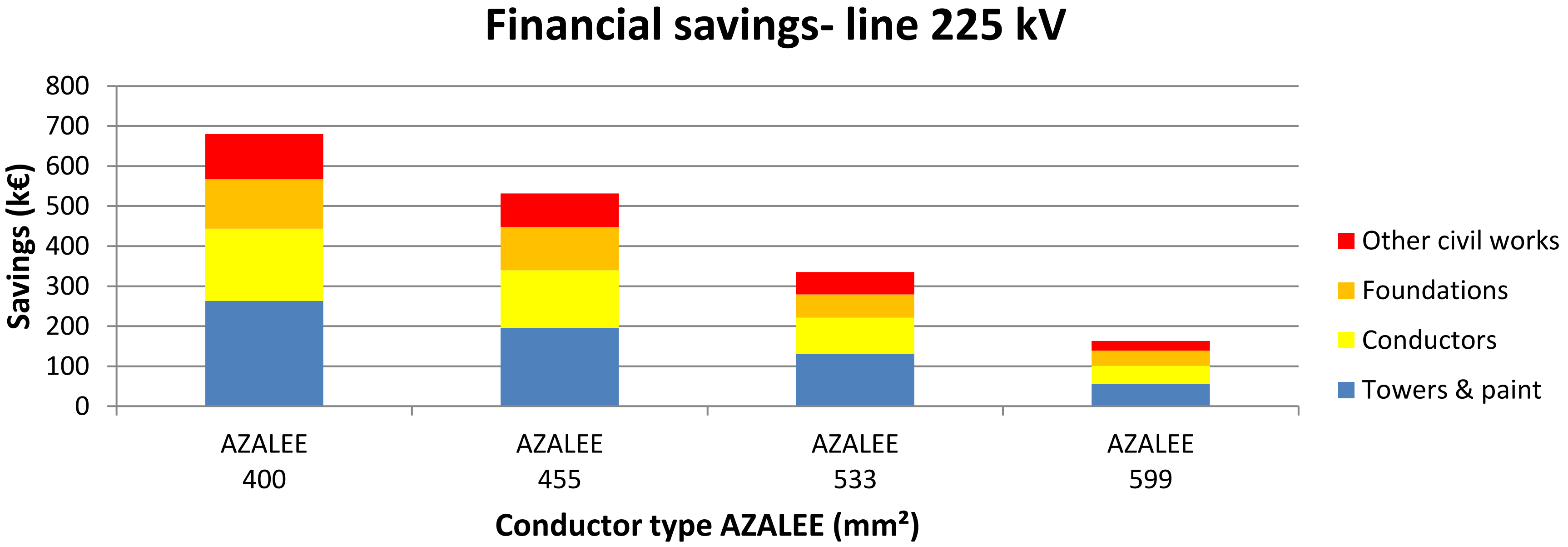
<u>Coûts évités:</u>

Matériaux (nouveau conducteur) : 99 900 kg * 4,50 €/kg ≈ 450 000 €
Travaux d’installation : 615 000 €
TOTAL=1 065 000€
soit 60 000 €/km en circuit double et 40 000 €/km en circuit simple

Pour un investissement DLR de 300.000€
Délai de recuperation de l’investissement = 3 mois
Calculs détaillés pour une une ligne 225 kV et une ligne 90 kV pages suivantes

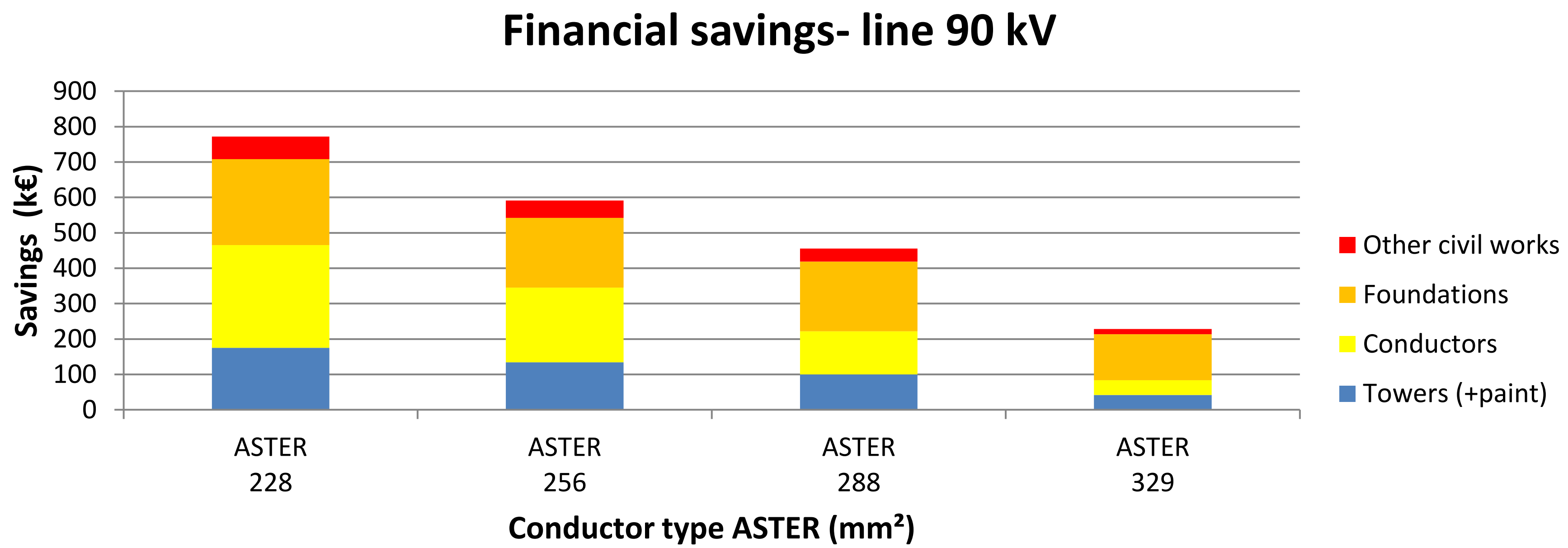
Raccordement de champs éoliens (Source: Ampacimon s.a.)

	AZALEE 599 vs AZALEE 666	AZALEE 533 vs AZALEE 666	AZALEE 455 vs AZALEE 666	AZALEE 400 vs AZALEE 666
Required DLR Gain	**6%**	**16%**	**23%**	**34%**
Savings Towers(€)	21.000	48.000	72.000	97.500
Savings paint towers(€)	35.500	83.000	123.000	166.000
Savings conductor (€)	45.000	90.000	144.000	180.000
Savings foundations (€)	37.500	58.500	108.500	123.500
Savings other civil eng.(€)	24.000	56.000	83.500	113.000
Total (€)	163.000	355.500	531.500	680.000
Cost Ref line (€)	7.700.000	7.700.000	7.700.000	7.700.000
Saving (%)	2.1 %	4.6 %	6.9 %	8.8 %



Raccordement de champs éoliens (Source: Ampacimon s.a.)

	ASTER 329 vs ASTER 366	ASTER 288 vs ASTER 366	ASTER 256 vs ASTER 366	ASTER 228 vs ASTER 366
Required DLR Gain	**6%**	**16%**	**23%**	**34%**
Savings Towers(€)	13.000	31.300	42.000	55.000
Savings paint towers(€)	28.500	69.000	92.200	120.000
Savings conductor (€)	42.000	121.500	210.500	290.000
Savings foundations (€)	129.750	197.250	197.250	242.250
Savings other civil eng.(€)	15.000	36.500	48.500	63.500
Total (€)	**228.000**	**455.500**	**591.500**	**771.000**
Cost Ref line (€)	4.900.000	4.900.000	4.900.000	4.900.000
Saving (%)	**4.7 %**	**9.3 %**	**12.1 %**	**15.7 %**



Marchés de l'énergie (source: Elia TSO)

Défi

- Fort risque de pénurie en Belgique à l'approche de l'hiver 2015
- Interconnexions (France et Pays-Bas) limitées à 3000 MW
- Urgence

Solution

- Accord entre Elia et ses voisins pour augmenter les échanges transfrontaliers
- 8 lignes (380 kV) equipées en quelques mois
- Ampacité dynamique en temps réel
- Prévisions J+1 et J+2 l'hiver suivant

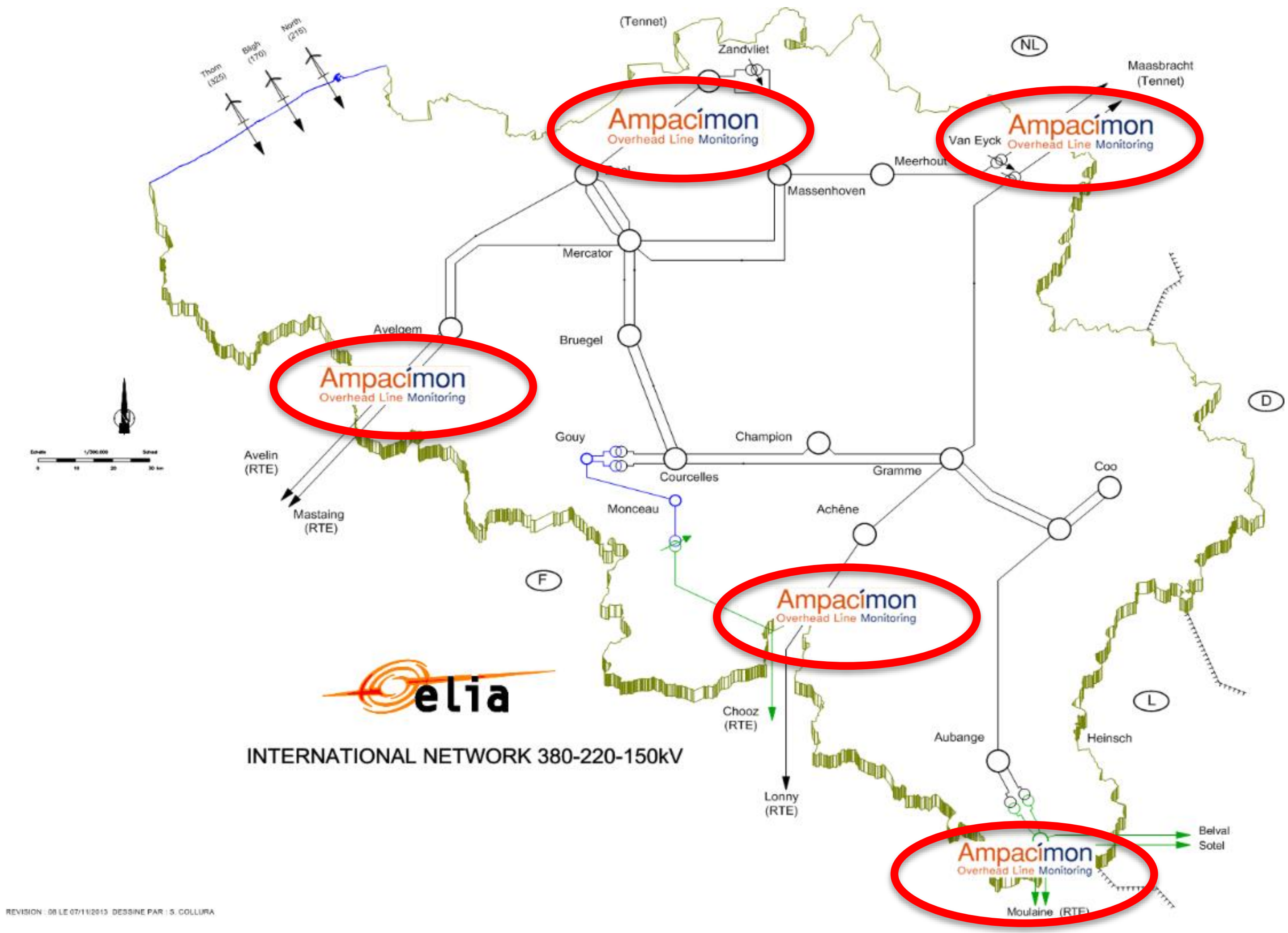
Bénéfices constatés

- Gains de capacité jusqu'à 40% en temps réel (1200 MW) → Amortissement en quelques semaines
- Les prévisions J+2 permettent une augmentation de la capacité totale d'importation de ces liaisons de 10-15% (450MW)

A retenir

- Mise en œuvre pas-à-pas: études, puis données temps réel, puis prévisions
- Les sections hors-Belgique sont devenues limitantes

Marchés de l'énergie (source: Elia TSO) *(suite)*



Marchés de l'énergie (source: Elia TSO) *(fin)*

Augmentations significatives et prévisibles

Line		RT Ampacity average gain	RT Ampacity gain 90% of the time	D-2 Forecast P98 90% of the time
380. [redacted]	[redacted]	+ 38%	+ 30%	12%
380. [redacted]	[redacted]	+ 36%	+ 26%	9%
380. [redacted]	[redacted]	+ 56%	+ 42%	13%
380. [redacted]	[redacted]	+ 32%	+ 21%	8%
380. [redacted]	[redacted]	+ 43%	+ 30%	8%

Source: Elia

ELIA INSTALLS MORE AMPACIMON TECHNOLOGY

Elia is continuing to roll out the use of Dynamic Line Rating, a concept developed in partnership with Ampacimon. Elia has fitted Ampacimon sensors on the most critical lines on its grid.

These metering devices, designed primarily for real-time use, enable a more accurate assessment of the transmission capacity of equipped lines on which they are fitted. The capacity actually available for use can then be optimised based on the weather conditions. When the ambient temperature is low and there is wind, the overhead lines are cooler and can transmit more electricity.

Though Ampacimon technology had only ever been used in real time before, Elia took things one step further in December 2016 by integrating Ampacimon forecasts into Day-2 and Day-1 operational processes. If those forecasts allow, the capacity of eight critical lines could potentially be boosted by 5% over their seasonal limits. If there is a cold spell, Elia may even be able to increase the potential gain to 10%.

Bénéfices économiques (source: Elia Asset Management)

Défi pour Elia

- Une ligne THT fait face à une augmentation de charge prevue de 2% par an
- Le renforcement est inévitable à terme
- L’exploitation a des objectifs de gestion

Solution envisagée

- Mise en oeuvre immédiate du DLR Ampacimon
- Report de 5 ans des travaux de renforcement

Bénéfices escomptés (cf détail des calculs page suivante)

- Les gains DLR (> 10% calculés par simulation) compenseront l’augmentation de charge prévue
- Règles d’exploitation integrant les gains DLR, sécurité améliorée par la supervision via capteurs

<u>A retenir</u>

- Les calculs de flux financiers (Valeur actuelle nette) démontrent un retour sur investissement rapide même pour une extension a minima (ajout d’un circuit)
- Les capteurs DLR pourront être redéployés sur d’autres lignes, améliorant encore le résultat financier de l’opération

Bénéfices économiques (source: Elia Asset Management) *(suite)*

Financial impact

Ampacimon system

- Economic analyses
  - Cost of capital: 6%
  - Load increase: 2%/year
- Investments

Ampacimon system

- 1 line of 5 modules + server
- 1 line of 5 modules without server
- Total cost (supposition): 440.000 €

Existing substations

- Building new HV bay 380 kV (open):1.410.000 €/bay
- Building new HV bay 380 kV (GIS): 1.605.000 €/bay

Bénéfices économiques (source: Elia Asset Management) *(suite)*

Financial impact

Option 1: New Transmission line 10 km 380 kV 2*707 AMS (double circuit)

- 1.240.000 €/km - 10 km (total: 12.400.000 €)
- 4 HV bays (open): 5.640.000 €

Result

NPV (new transmission line double circuit in year Y):≈ -17.000.000 €

NPV (Ampacimon + new transmission line double circuit in year Y + 5): ≈ -13.150.000 €

Gain (actualized) ≈ 3.850.000 €

Pay back period: 5 months

elia Powering a world in progress

Bénéfices économiques (source: Elia Asset Management) *(fin)*

Financial impact

Option 2: Second circuit 10 km 380 kV 2*707 AMS

- 170.000 €/km - 10 km (total: 1.700.000 €)
- HV bays: 1 open en 1 GIS: 3.015.000 €

Result

NPV (second circuit in year Y): ≈-4.500.000 €

NPV (Ampacimon + second circuit year Y + 5): ≈-3.750.000 €

Gain (actualized): ≈ 750.000 €

Pay back period: 19 months

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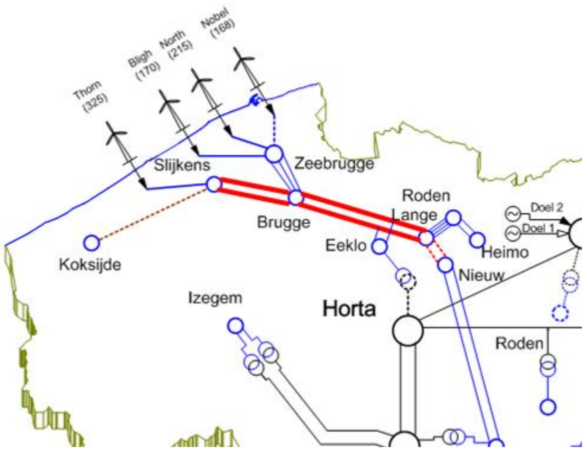
Powering a world in progress

Retour sur investissement (source: Ampacimon s.a.)

Etude de l’impact économique des prévisions DLR à 1 heure:



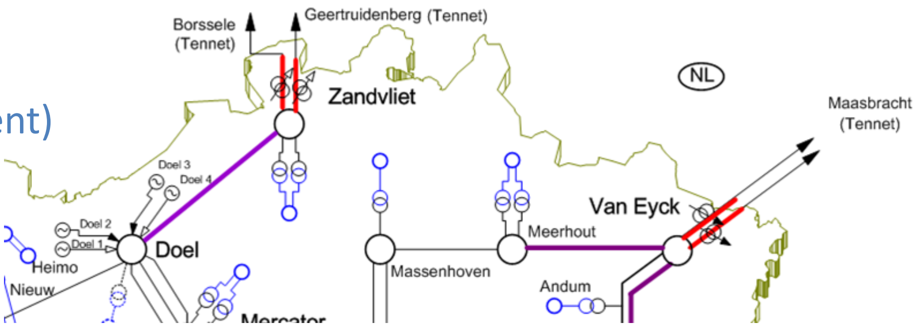
Redispatching interne = coûteux **(~40€/MWh)**

→ L’installation du DLR sur le réseau de répartition 150kV en zone côtière a été bénéfique

Redispatching International= très coûteux **(>500€/MWh)**

→ L’installation du DLR sur les interconnexions 380 kV

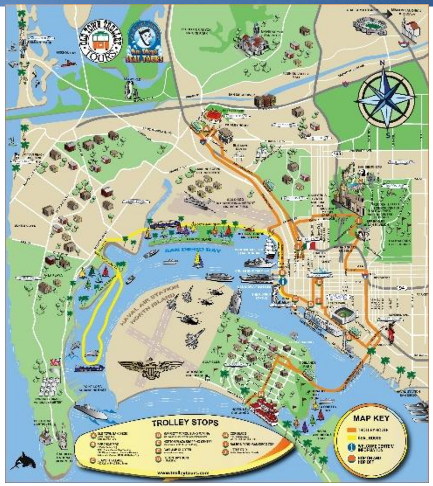
Délais de récupération en mois, voire en semaines



Bénéfices supplémentaires (non valorisés clairement)

- Robustesse augmentée en cas d’incident
- Moindre impact des coupures
- Réaffectation possible des capteurs sur d’autres lignes

Retour sur investissement (source: Ampacimon s.a.)



Une demande de recalibration (25 M USD) rejetée par le régulateur. D’après la simulation, le DLR serait une alternative efficace pour des gains résultant en une capacité supérieure à la charge maximum autorisée en N-1.

California ISO

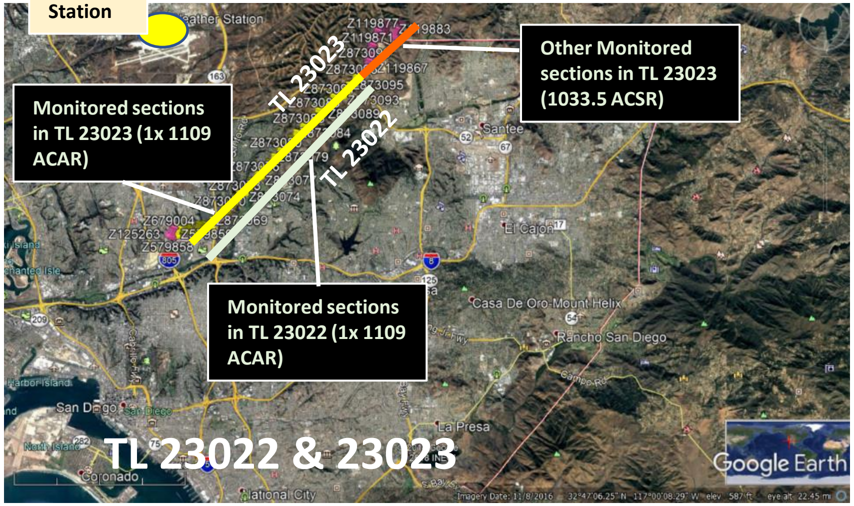
SDGE

A Sempra Energy utility

DLR simulation analysis

TL 23022: Average (yearly) of >**34.4%** over static rating

TL 23023: Average (yearly) of >**16.2%** over static rating



Project Title:	*District:*	*Need-Date:*	*Project:*
TL23022 & TL23023 (MS-ML) Reconductor	**Beach Cities**	**June 2018**	**P16XYZ**

Issues
- Delay of SX-PQ leading to NERC violations
- Generation at Otay Mesa is potentially trapped by a single outage of TL23042

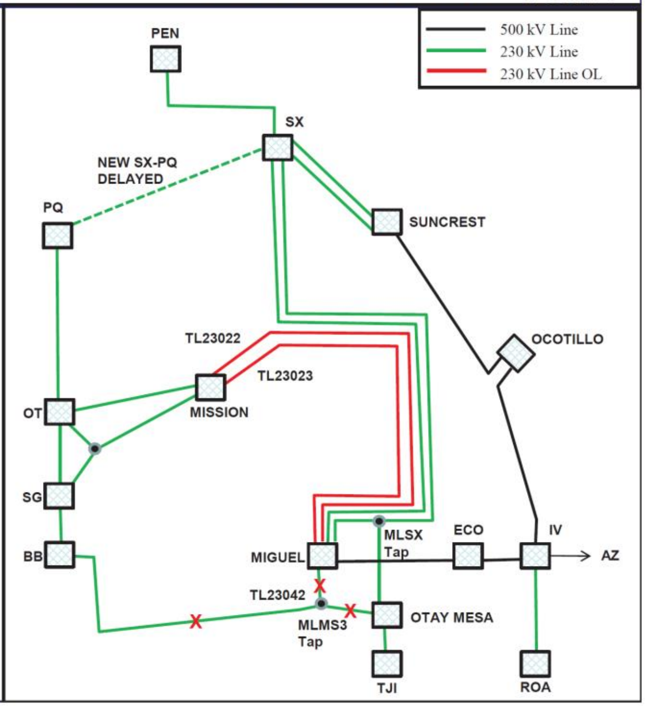
Driving Factor (1):
- NERC Cat P6 (N-1-1) violation in 2018
  - The N-1 of TL23042 followed by the N-1 of either TL23022 or TL23023 will overload the emergency rating of the other remaining line to 123% and cannot be mitigated by generation redispatch.

Driving Factor (2):
- NERC Cat P1 (N-1) violation in 2018
  - In a scenario with flow going North on path 44 and high imports coming in from AZ these two lines will overload the continuous rating to 113%, this following the loss of TL23042 and cannot be mitigated by generation redispatch.

Driving Factor (3):
- NERC Cat P3 (G-1, N-1) violation in 2018
  - The G-1 of PEN followed by the N-1 of TL23042.
  - With PEN out, adjusting Otay Mesa generation can put us at an unnecessary reliability risk.

Scope:
Recondcutor a portion of TL23022 and TL23023 to achieve a 912 MVA rating.

Cost: $23.3M-$25.6M



Expérience en exploitation (source: Article IEEE PES mars/avril 2020)

Main Use Cases Identified and First Results

Ski Resort Supplied by Two OHLs
With Low Static Ratings

During winter, the demand for electricity at ski resorts in the French Alps increases to the extent that some of the transmission lines operate at or very close to their static limits. One solution to this problem would be to build a new transmission line. An option to avoid such a significant investment is to use DLRs and operate the transmission line closer to its true limit. Indeed, the high load demand in winter correlates with low ambient temperatures. Moreover, the conductor’s exposure to the wind chill at this time would also increase the maximum current-carrying capability of the line above its static rating, which is based on more conservative ambient assumptions.

From 2013 to 2017, one OHL in the French Alps was equipped with DLR sensors to confirm the theoretical application of this technology. Based on the static-rating value, during periods of low winter temperatures, operators must change the network topology and feed the substation with a single line to comply with the N-1 criteria. Since the area is exposed to power outages from faults on a nearby line, a new underground line was installed in 2017. Before the new line was commissioned, the use of dynamic ratings enabled the operators to avoid changing the grid topology, which could have detrimentally impacted reliability for approximately 200 h/year.

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Delivery of Electricity Generated by Wind Farms

In France, wind turbines are usually built in rural areas, away from inhabited locations where the electrical grid is more developed (meshed, with lines that have high static ratings). Thus, the aggregation of the wind turbines may require the addition of new lines to enable the delivery of all of the electricity produced. Wind speed is one of the most influential factors for cooling conductors. The times when line currents are very high coincide with periods when wind power generation is at its peak, meaning that, at the same moment, wind is blowing on the conductors to help cool them. This suggests that DLR applications may avoid a major capital investment in new transmission lines.

Since the beginning of 2018, two OHLs have been monitored as use cases: one at 63 kV and another at 90 kV. Based on a one-year analysis, the use of dynamic ratings provided an additional 50% wind-power capacity connection. Indeed, without DLRs, connecting wind power plants would have been infeasible due to insufficient transmission capacity.

A specific use case has been identified for a strategic 400-kV OHL that supplies the southwest of France. A failure on another 400-kV line may cause an overload and lead to a supply interruption for the whole area. Under those conditions, operators must start local thermal power plants to avoid the potential for a blackout. Since the costs associated with this action can add up quickly, DLR implementation was used to prevent them. The strategic line is often exposed to high and steady wind speeds, offering a better ampacity than its standard static rating. Within two years, the money saved from redispatching the thermal power plants covered the cost of the DLR system.

“Success story” de RTE – projet “Ampacité 2” (source: ThinkSmartGrids, European Utility Week 2019)

think SMARTGRIDS

Rte

Dynamic Line Rating

Field	HV & EHV Electricity Transmission
Country	France
Year	2017-2018
Budget	500 k€
Beneficiary	Transmission operator, Consumers, Community

DESCRIPTION

- **Issues:** allow for more renewable energies, augment line transit,
- **Project goal:** for the transmission operator: increase the capacity and service of existing infrastructure without investments on the grid.

IMPLEMENTATION

- Installation without interruption (live working) of ampacity controlling devices on the lines.
- Coupling with regional network control & operation system with integration of specially developed functions and software tools + data collection from environment (weather, …) and grid
- 3 lines equipped in France to date.
- Success factors: quick implementation. Immediate results.

IMPACTS

- +30% of transmission capacity at crucial moments of constraints.
- Time of return on investment of 8 month,
- Reduction of call to expensive peak generation, thus reducing tafiff costs. Less fossil fuel consumed. More capacity for renewables. No additional infrastructure.
- Future objectives: weather based allocation for transformers and high voltage lines,

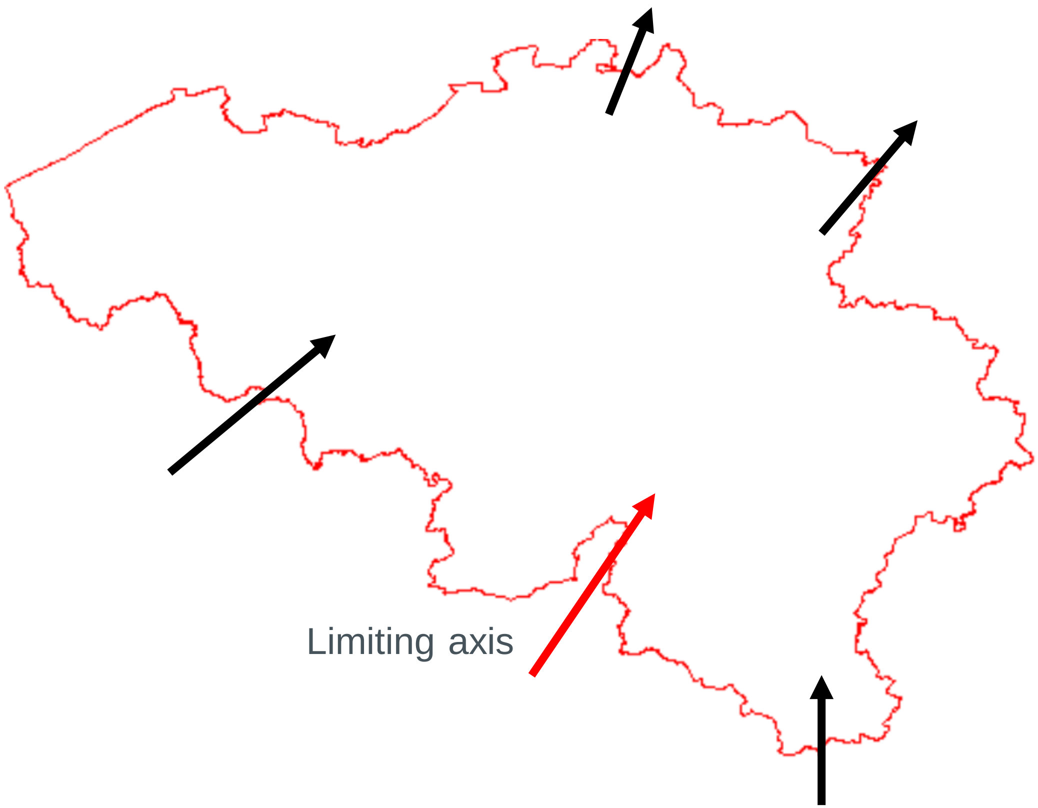
Effet levier des gains DLR (source: Elia TSO)

Un exemple relaté par les responsables du centre national de conduite belge:

« S → N flows and not a single extra MW can be transferred from FR to BE without causing an overload in the Security Analysis »

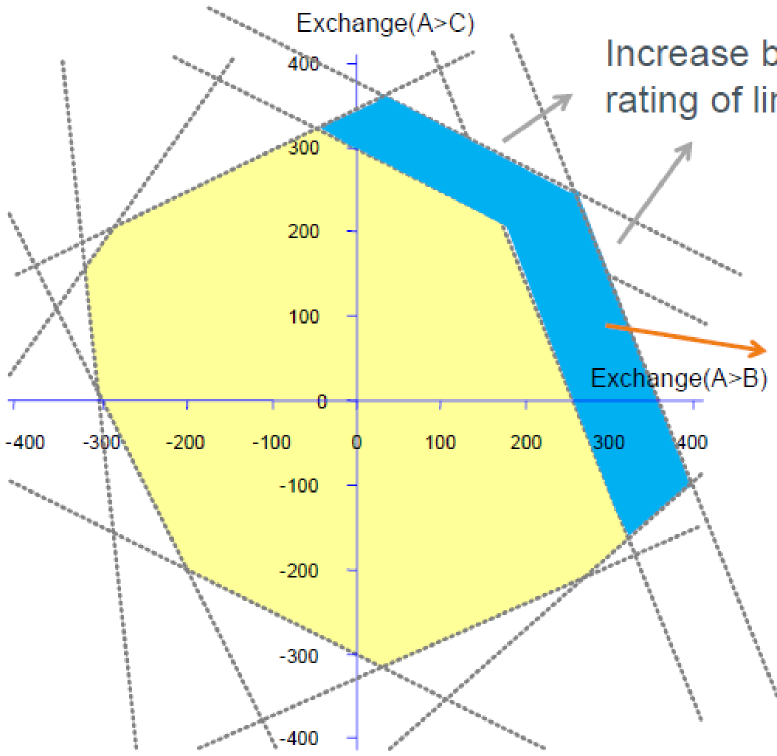
« Increasing the ampacity of the limiting element by 50MW will probably increase the FR → BE capacity by much more thanks to extra MW going through the other tie-lines

- → *Giving a few extra ampacity on critical lines increases significantly the FB domain through this leverage effect*
- → *But giving a few extra ampacity while in RT the margin happens to be NOT available requires significant measures to solve the problem through the same leverage effect »*



Effet levier des gains DLR (source: Elia TSO) *(suite)*

Impact of DLR on flow based (capacity allocation)



Increase by 3% the rating of limiting lines

Increase by 22% the available volume for the market

Ex:19/2/2015, market limited by Belgian lines. By using the 2-day ahead forecast, less constrain. During only 4 hours, the gain on the CWE welfare has been computed to 247.250 €