Accelerating the Energy Transition: **Dynamic Line Ratings for an Optimized Grid**

14th January 2021

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Enabling Network Technology throughout Europe

AGENDA

Welcome & Introduction by Alex Houghtaling, Vice President, LineVision
The current status of DLR by Frederic Vassort, Board Vice-Chair of currENT and CEO, Ampacimon

- **Uroš Salobir,** ENTSO-E. DLR technology maturity and importance of adoption to achieve Green Deal targets.
- **Mathieu Fontaine,** Project Manager of DLR at RTE will describe DLR application for wind integration.
- **Balint Nemeth,** Head of High Voltage Laboratory at Budapest University of Technology and Economics. How DLR is used to release cross-border trade capacity to meet the 70% rule.
- **Janko Kosmač,** Head of process system department from ELES. How DLR is integrated into the SCASDA/EMS and used in power system operation.
- **Victor Le Maire,** Belgian Transmission Grid National Control Centre. Financial outcomes of reduced congestion.
- **Georgios Papaefthymiou,** Senior Expert Power System Development and Operation at 50hertz/EGI, will present the incorporation of DLR information in grid planning processes at 50hertz.

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Previous WEBINARS

1 Accelerating the Energy Transition:
Optimized Power Grids for a Clean and Green Future (October)

2 Accelerating the Energy Transition:
The Role that Direct Current (DC) Grids can Play (December)

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Introduction to currENT

Our vision is a European power network that is the recognised world leader in enabling decarbonisation through the efficient use of modern grid technology.

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Uroš Salobir

Vice Chairman, RDIC at ENTSO-E

Mathieu Fontaine

Project Manager of DLR at RTE

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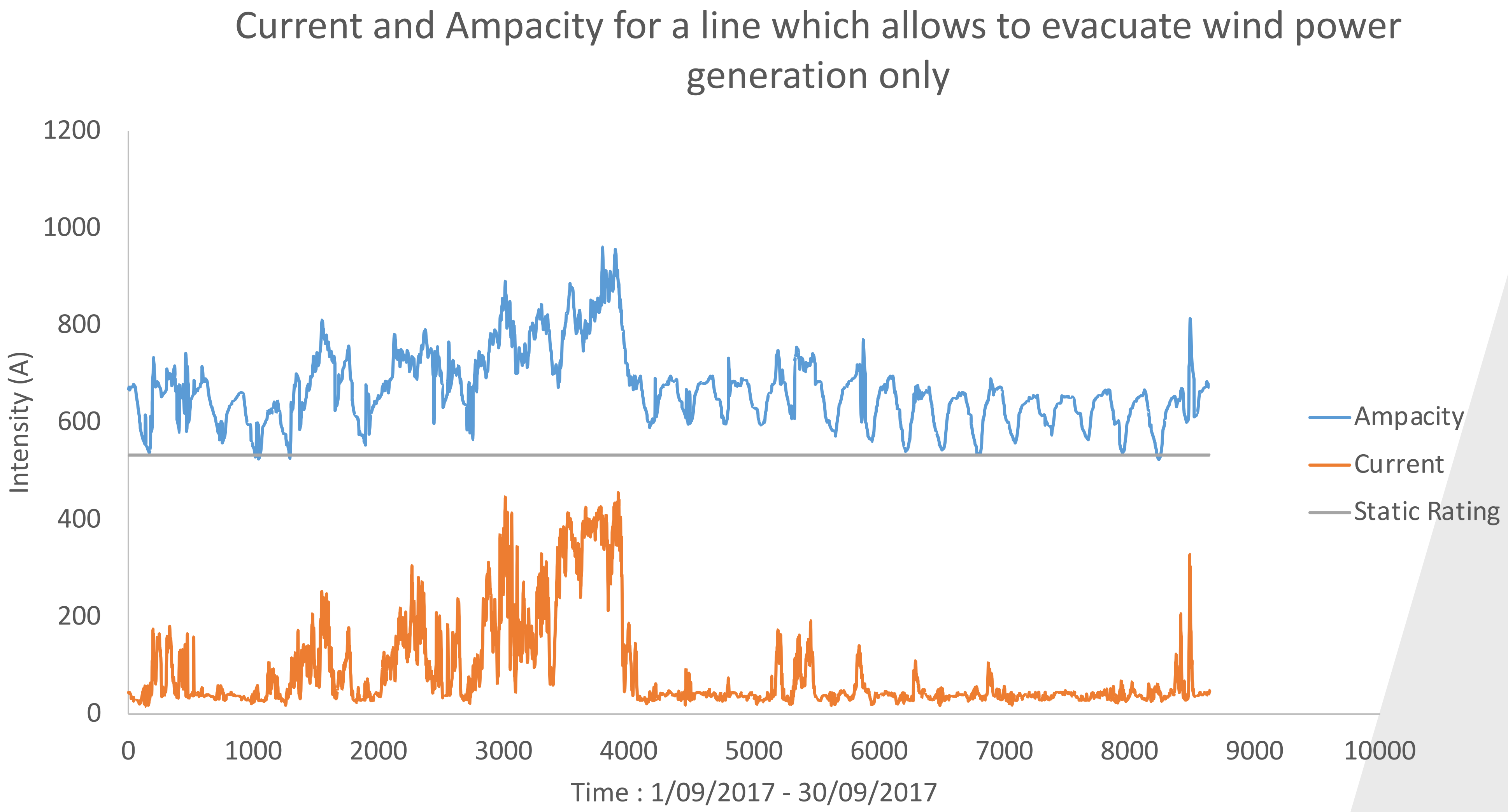

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Balint Nemeth

Head of High Voltage Laboratory
at Budapest University of
Technology and Economics

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Budapest University of Technology and Economics

DLR to release cross-border trade capacity to meet the 70% rule.

Accelerating the Energy Transition:
Dynamic Line Ratings for an Optimised Grid

Education
Laboratory testing
Research & Development

Bálint NÉMETH PhD
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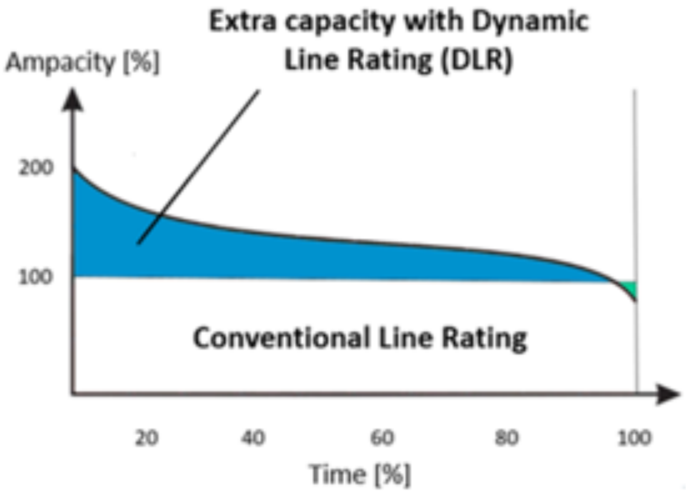
Head of High Voltage Laboratory at BME

Cross-border benefits of Dynamic Line Rating

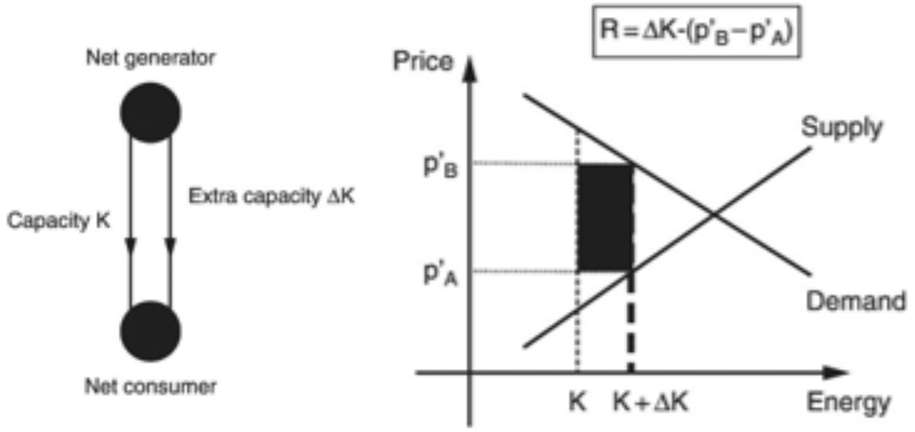


Dynamic Line Rating advantages:

- Real-time monitoring of the OHL
- Increased system stability
- **Increased transfer capacity up to 20-30 % in the 95 % of the time**

Cross-border benefits:

- Increasing export-import transport – solve bottlenecks
- Lower energy prices - Higher social welfare
- Less redispatching
- Integration of more renewable energy sources
- Increased energy security (export)
- More resilient system
- Faster Market coupling – Internal Energy Market



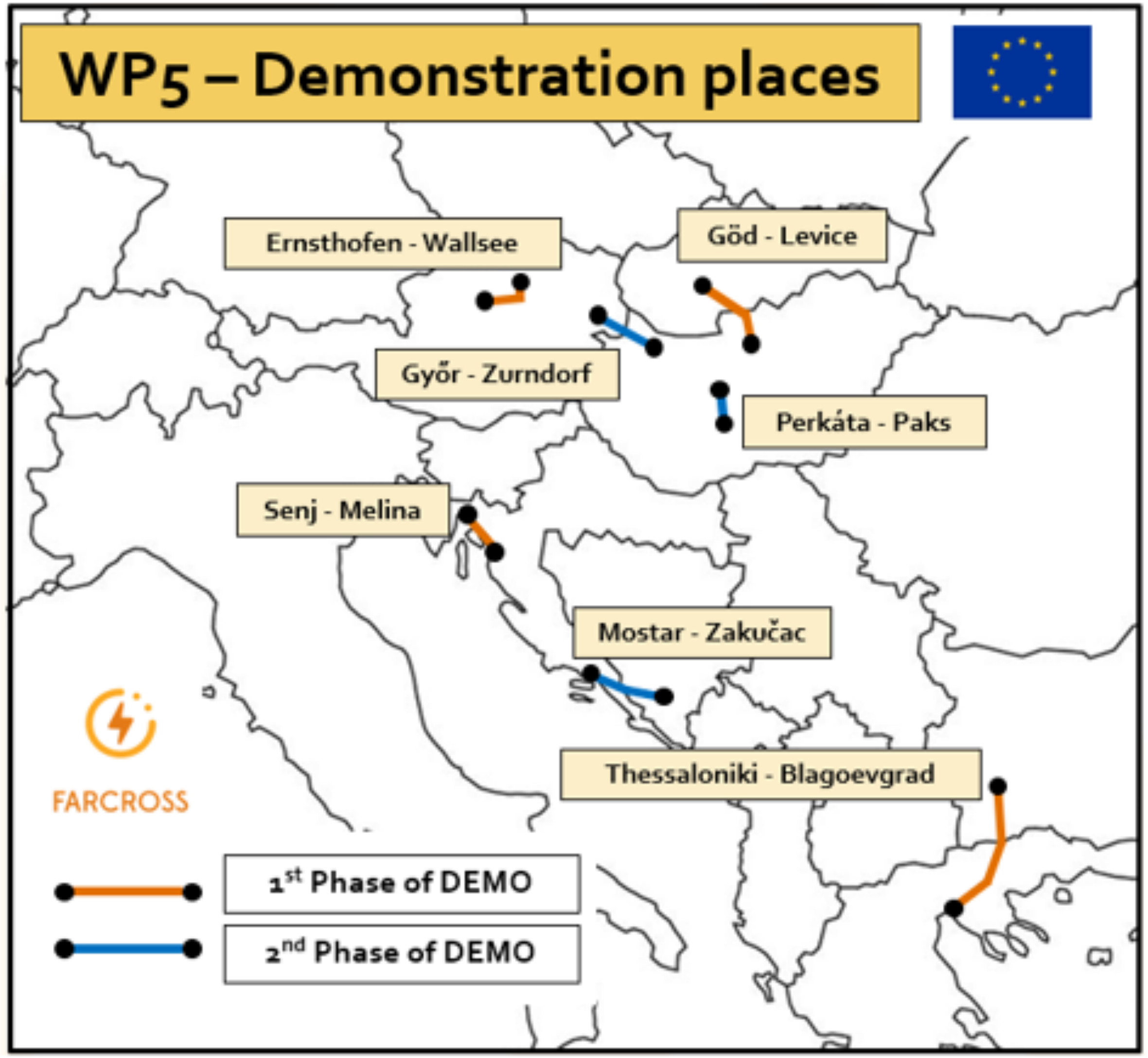
Source: Chatzivasileiadis, S., & Ernst, D. (2017). The State of Play in Cross-Border Electricity Trade and the Challenges towards a Global Electricity Market Environment.

FARCROSS Project

2019-2023, (Horizon 2020, EU)

- **WP5 - DRL-H DEMO**: Complex grid management technology for handling cross-border transmission line capacity-related issues
- 4 location: **Austria, Hungary, Croatia, Greece**
- 6 TSOs, 8 chosen OHL (**4 cross-border**) is equipped with 3 type of sensors (**IMOTOL, LineVision, OTLM**) and weather station

- **Unified sensor tests**
- **Comparison of the sensor measurements**
- **Complex grid management model**



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FARCROSS

Education
Laboratory testing
Research & Development

Thank you for your attention!

Bálint NÉMETH PhD
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Head of High Voltage Laboratory at BME

HIGH VOLTAGE LABORATORY BUDAPEST

Janko Kosmač

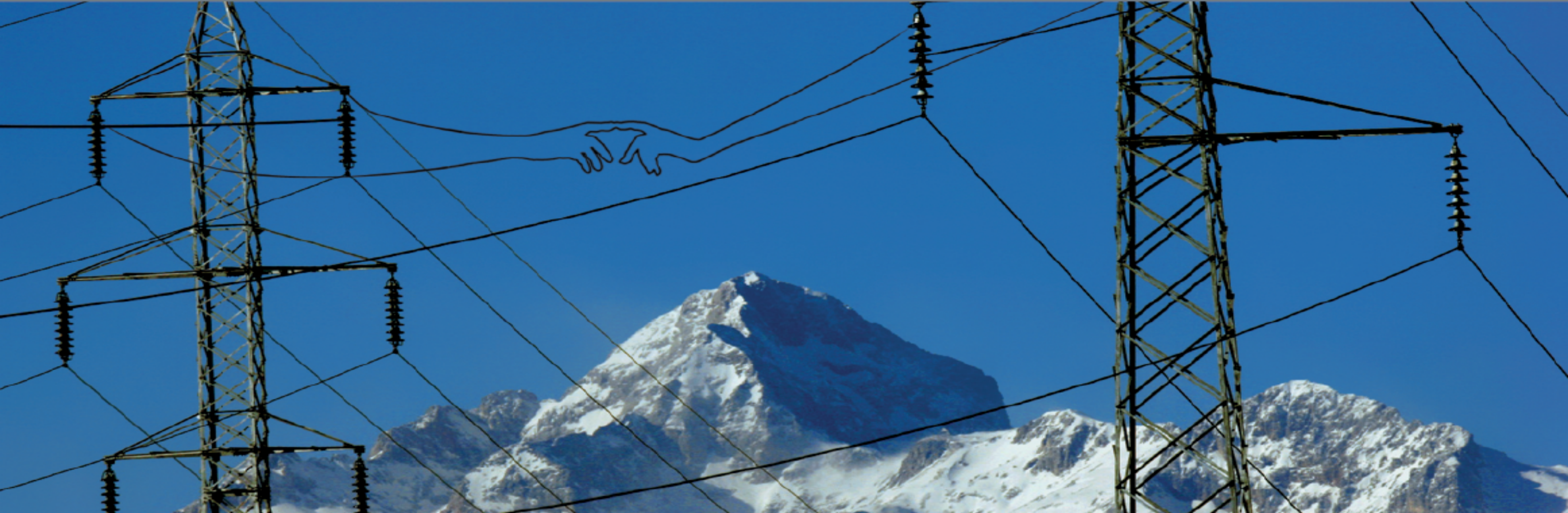
Head of Process System Department,
ELES

DLR Integration with SCADA/EMS and Use in Power System Operation

dr. Janko Kosmač

ELES
TRANSMITTING ENERGY.
MAINTAINING BALANCE.

currENT webinar
14th January 2021



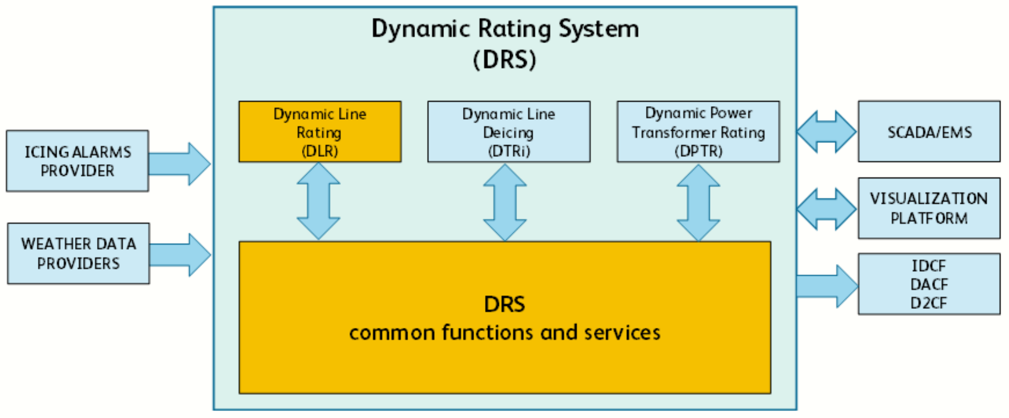
Brief ELES' DLR system introduction

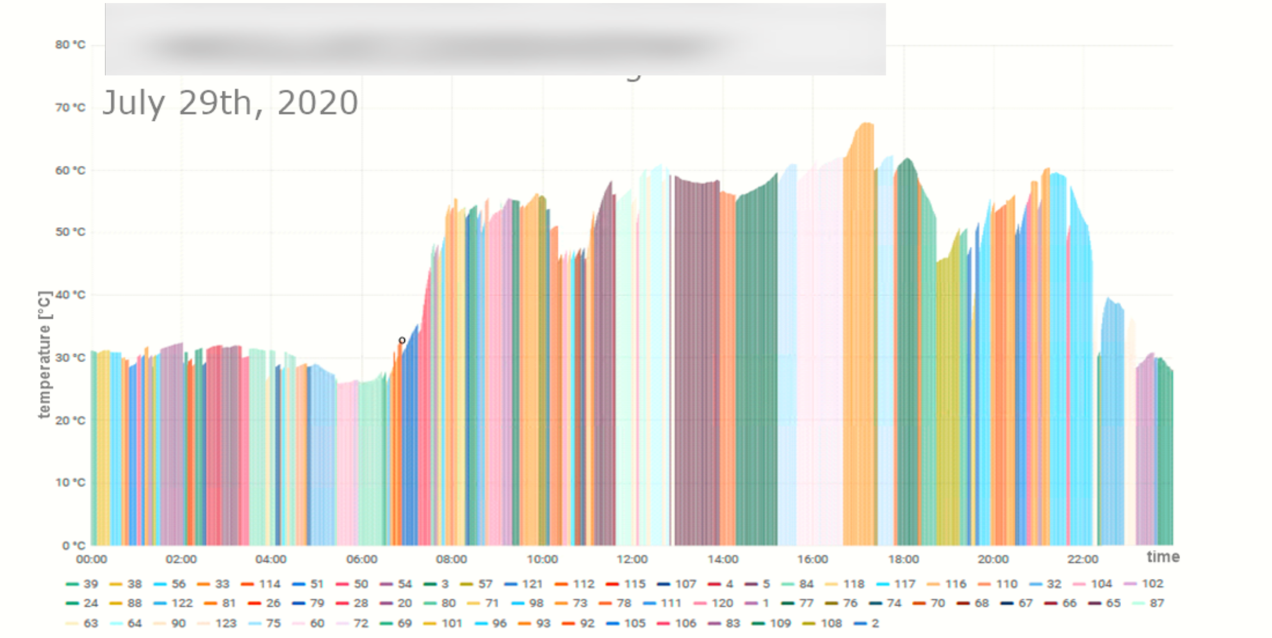
I. DLR is part of Dynamic Rating System SUMO

II. our DLR uses indirect method (weather data)

III. DLR is performed for all spans of the line

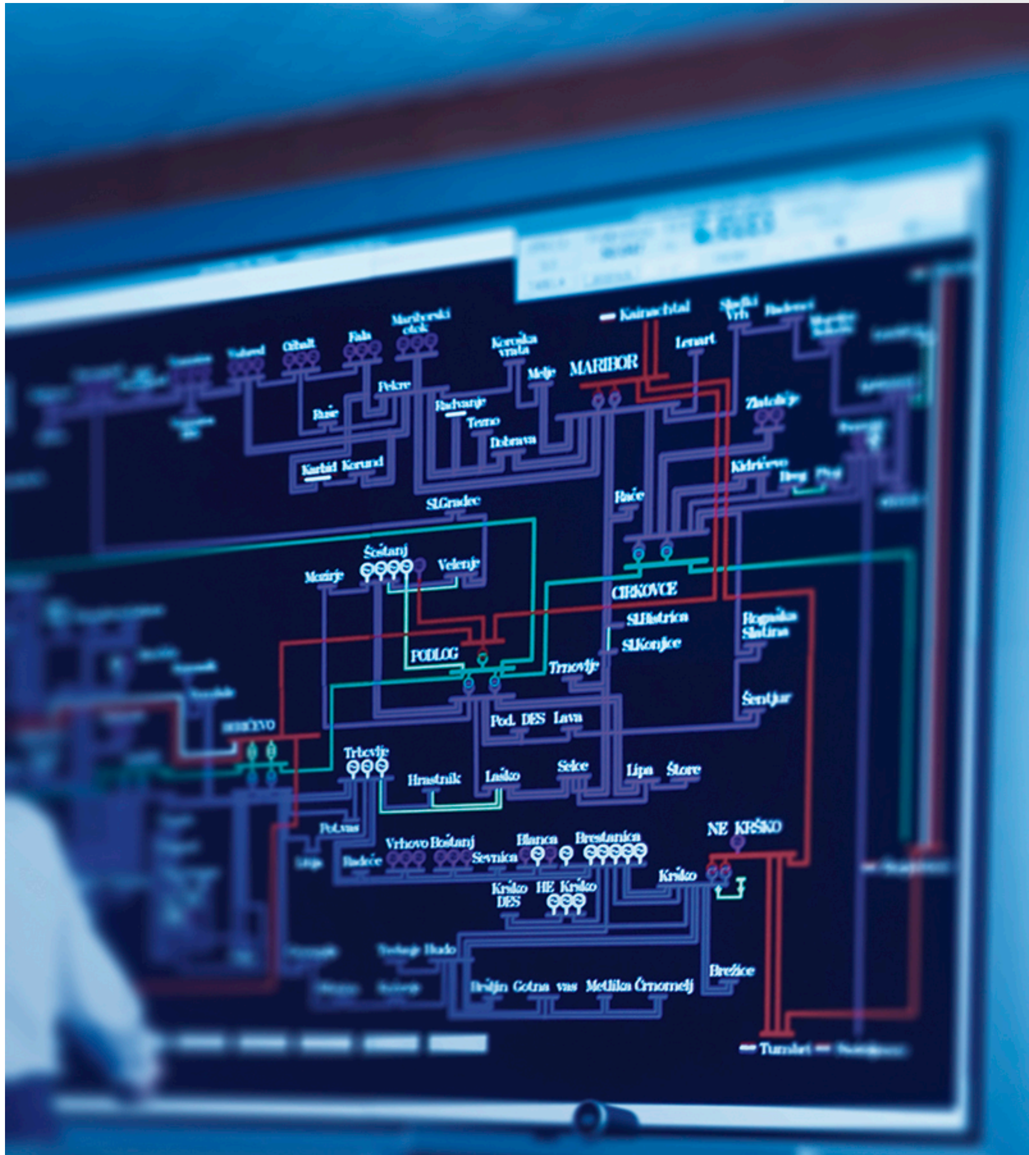
IV. in use since 2016 for 31 power lines (8 × 400 kV, 7 × 220 kV, 16 × 110 kV)



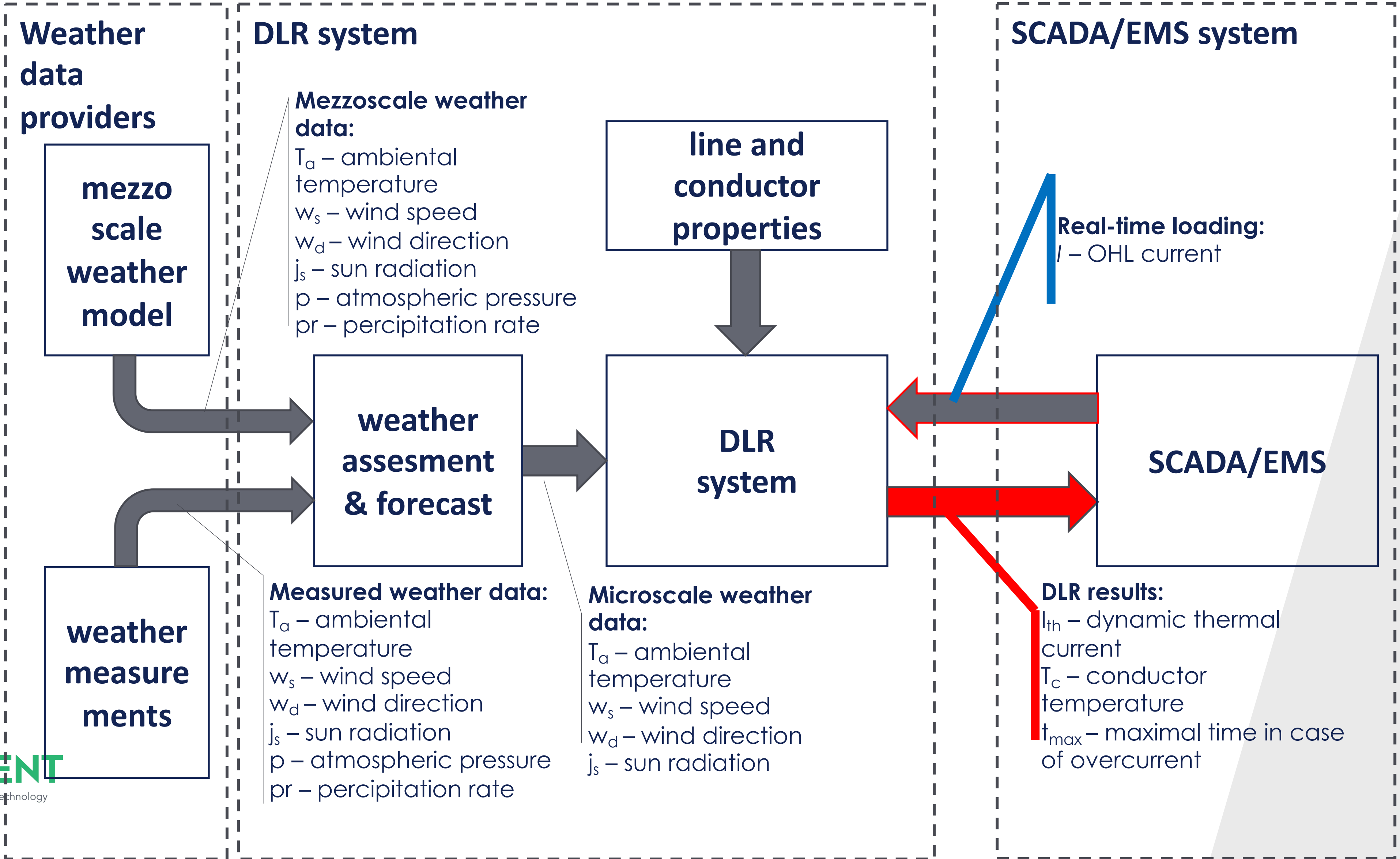


Why DLR must be integrated in SCADA/EMS?

- SCADA/EMS is foremost important operators' tool as it is the main interface to the power system
- current carrying capacity is one of the essential information of the element and represents a corner stone of transmission system
- changing the corner stone is delicate job and should be performed with great care



Basic structure of DLR system



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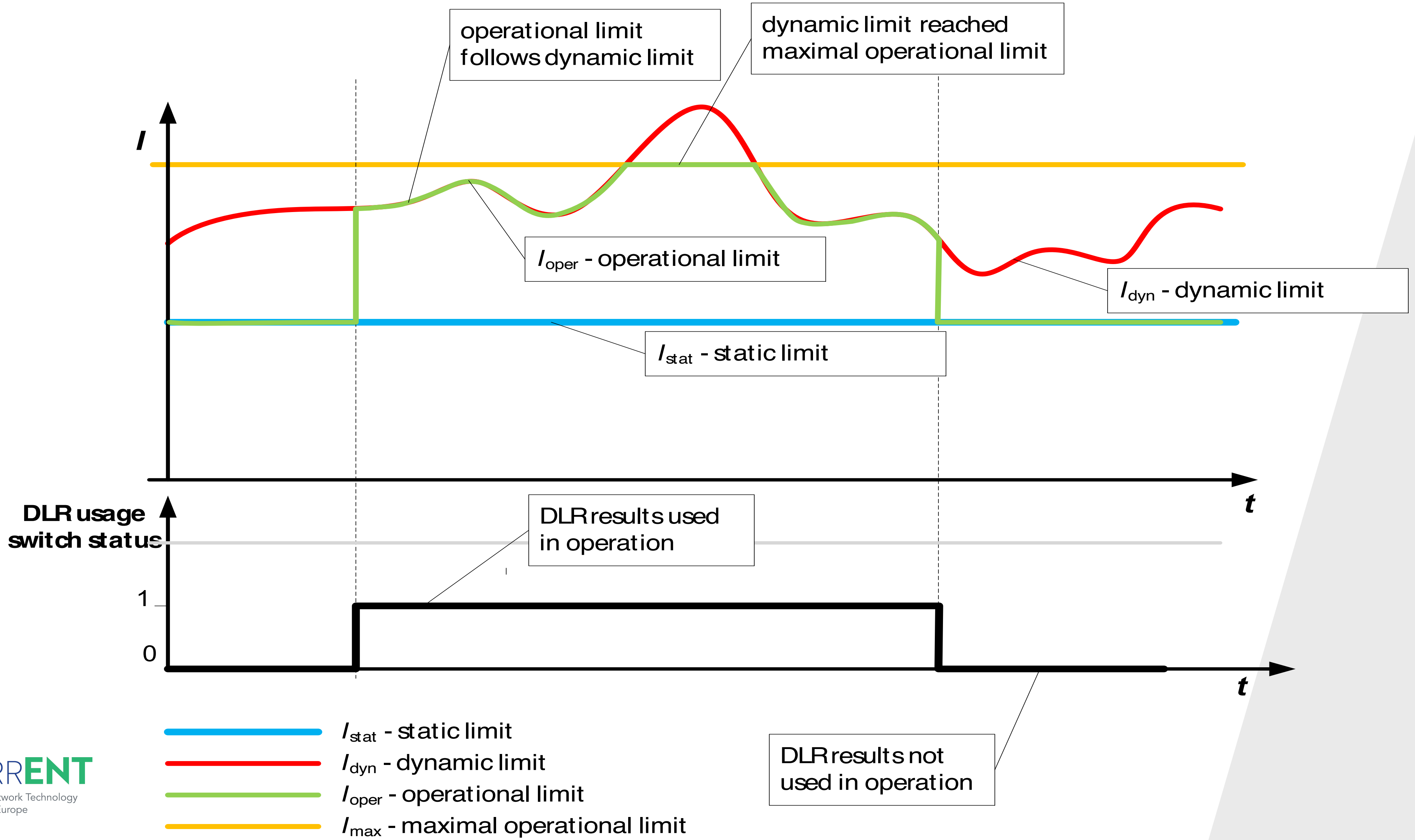
Integration concept and the operational limt



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Integration with SCADA/EMS

- Winter day (9th January 2021)

Notranji 220 kV DV											
Št.	Uporabi SUMO DTR	DV	P [MW]	I [A]	Iobr [A]	I/Iobr [%]	Istat [A]	Idin [A]	Maks. čas preob. [min]	Temp. vod. [°C]	Stanje DTR
3	VKL	[redacted]	-33	82	1200,0	6	960	1211,2	∞	-0,7	✓

- Summer day (29th July, 2020)

Notranji 220 kV DV											
Št.	Uporabi SUMO DTR	DV	P [MW]	I [A]	Iobr [A]	I/Iobr [%]	Istat [A]	Idin [A]	Maks. čas preob. [min]	Temp. vod. [°C]	Stanje DTR
3	VKL	[redacted]	108	294	914,8	32	960	914,8	∞	45,2	✓

main switch

operational limit

dynamic limits

conductor temperature

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Conductor temperature measurements

Use of temperature measurements:

I. conductor temperatures are integrated in SCADA/EMS and used in alarming

II. evaluation of DLR algorithm quality (needs weather station)

III. evaluation of weather estimation and forecast module performance

Temperatura na 220 kV DV				
DV	SM	Temperatura vodnika [°C]		
		[illegible]	[illegible]	[illegible]
[illegible]	089	-4,6	/	-3,2
	111	-0,7	-1,0	-2,4
	116	-0,3	/	-1,7

Thank you for your attention!

janko.kosmac@eles.si

Victor Le Maire

Belgian Transmission Grid National Control Centre

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DLR (Ampacimon) in operation at Elia
Financial outcomes of reduced congestion

Victor le Maire

Ampacimon - Dynamic Line Ratings

DASHB | 150/70 | 380/220 | BeReady

	Reference	Measured Flows RT [MVA]	Limit Season [MVA]	Limit 1h Capped [MVA]	Limit 15min Capped [MVA]	Service Avail [ON/OFF]
150kV	BRUGG 150.05 EEKLO	58,9	173,6	225,7		
	LANGE 150.05 EEKLO	77,8	173,6	225,7		
	BRUGG 150.06 EEKLO	59,1	173,6	225,7		
	LANGE 150.06 EEKLO	78,1	173,6	225,7		
	LANGE 150.07 NIEUW	140,3	246,4	320,3		
	LANGE 150.08 NIEUW	137,1	246,4	320,3		
	SLYKE 150.15 BRUGG	33,5	174,7	227,1		
	SLYKE 150.16 BRUGG	33,7	174,7	227,1		
	BAUDO 150.313 CHIEV	26,4	196,0	208,7		
	BAUDO 150.314 CHIEV	26,6	196,0	208,3		
70	MOUSC 70. 49 TOURS	9,4	70,6	82,5	8,6	
	TOURN 70. 49	8,5	70,6	85,1		
	LEUZE 70. 119	13,4	48,7	57,4		

	Reference	Measured Flows RT [MVA]	Limit Season [MVA]	Limit 1h Capped [MVA]
380kV	GRAMM 380.10 ACHEN	38,0	1473,9	1916,1
	GRAMM 380.11 LIXHE	381,7	1473,9	1773,1
	GRAMM 380.12 ZUTE+	327,6	1473,9	1916,1
	ACHEN 380.19 LONNY	56,2	1474,3	1847,0
	VANYK 380.23 MEERH	33,1	1611,3	1901,0
	DOEL 380.25 ZANDV	405,1	1312,1	1581,5
	DOEL 380.26 ZANDV	380,9	1312,1	1581,5
	VANYK 380.27 MAASB	38,6	1611,3	1611,3
	VANYK 380.28 MAASB	102,3	1474,3	1548,7
	ZANDV 380.29 RILND	524,1	1842,4	2287,8
	ZANDV 380.30 RILND	47,4	1842,4	2287,3
	COURC 380.31 STAM+	170,6	1473,9	1572,2
	GRAMM 380.31 STAM+	360,4	1473,9	1916,1
	AVLGM 380.79 MASTA	91,9	1474,3	1575,7
	AVLGM 380.80 AVELI	144,6	1711,6	1788,0
	VANYK 380.91 LIXHE	27,3	1474,3	1552,4
220	AUBAN 220.513 MOULA	98,9	495,5	533,8
	AUBAN 220.514 MOSMA	54,2	495,5	495,5

Journey from Pilot to Business-as-usual

Getting familiar with the technology

2008: Prototype test

- Development of 1h **forecast values** to improve usability

2011: Coastal area with congestions due to wind infeed

- **SCADA integration** complete

2014: Roll-out on a dozen lines to improve cross-border import capacity

- Within **3 months** (construction, placement, calibration, SCADA integration)

Refine specifications for use cases

2015: Development of **Forecast DLR**

- Crucial for market coupling (Flow-based)
- Subjected to regulator approval

2016: Automate DLR integration into CACM and CSA processes

- Dynamic rating **automatically implemented in IGMs* files**
- About 6% gain on average in market coupling capacities
- Capping rule to reach 99.9% confidence w.r.t. "Forecast 1h"

Business as usual

2017: Second roll-out wave

- Lines equipped to ease HTLS works (very long outages without restitution times)

2018: Mobility of modules

- Modules are dismounted and replaced elsewhere
- Licenses could be transferred at low costs from one line to another

2019: Integrated into regulatory planning period

- Driving business case for DLR as a temporarily solution for grid congestions

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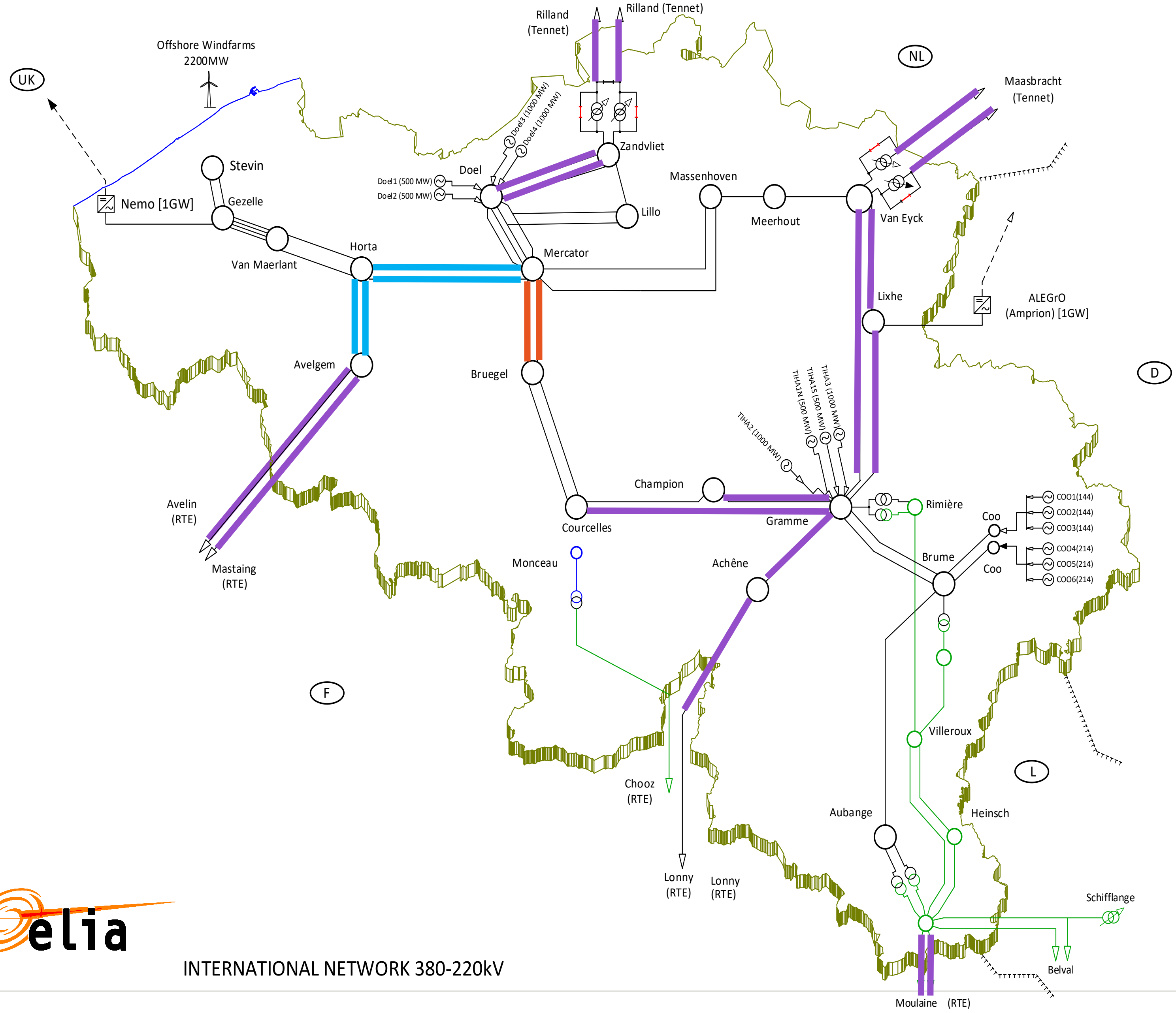
- TSO's standards and risk aversion required 6 years latency from prototype to industrialization
- Tailored-made hardware and software

- First time a TSO is implementing DLR in market data
- High confidence level implemented

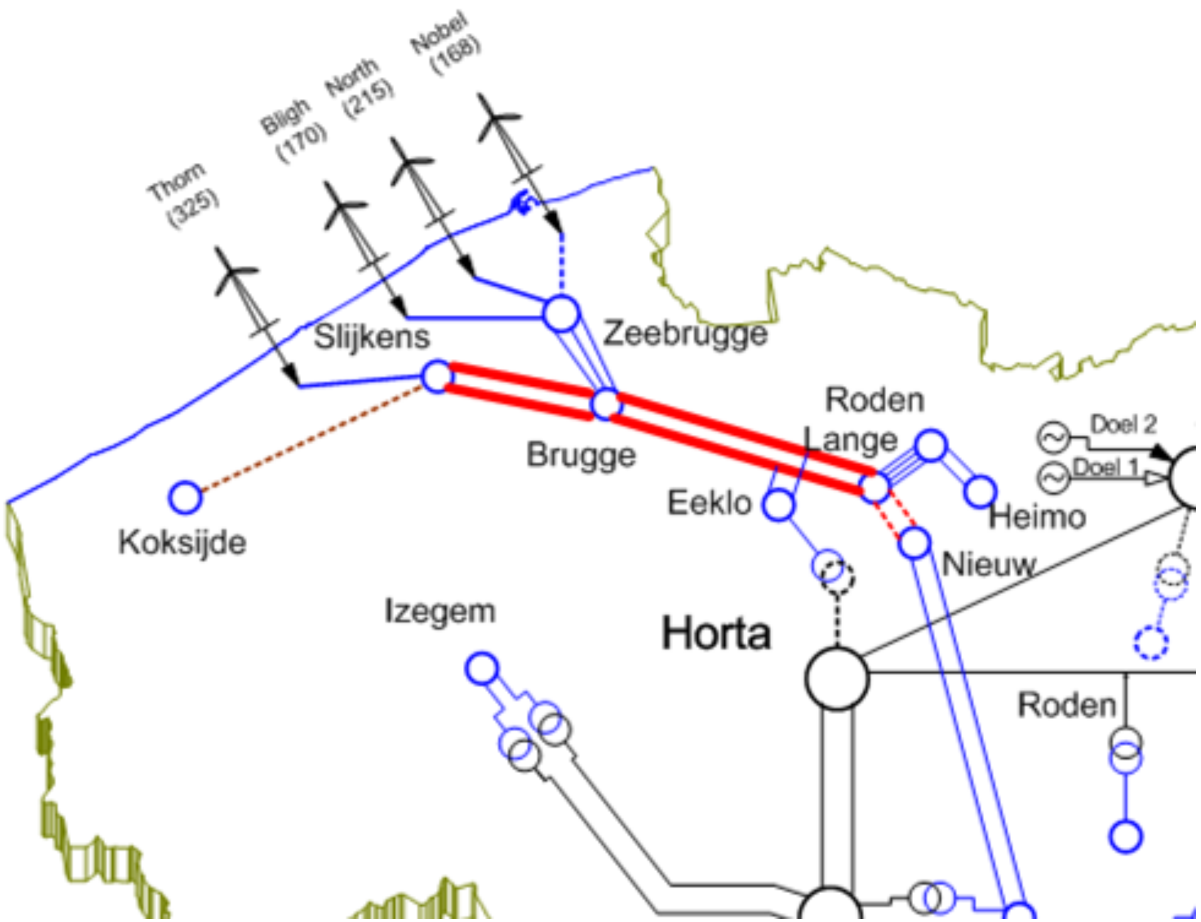
- Completely accepted/trusted technology (operation, processes, procedures etc.)
- Installed wherever valuable and technically feasible



Purple installed
Blue removed (HTLS)
Red to be installed

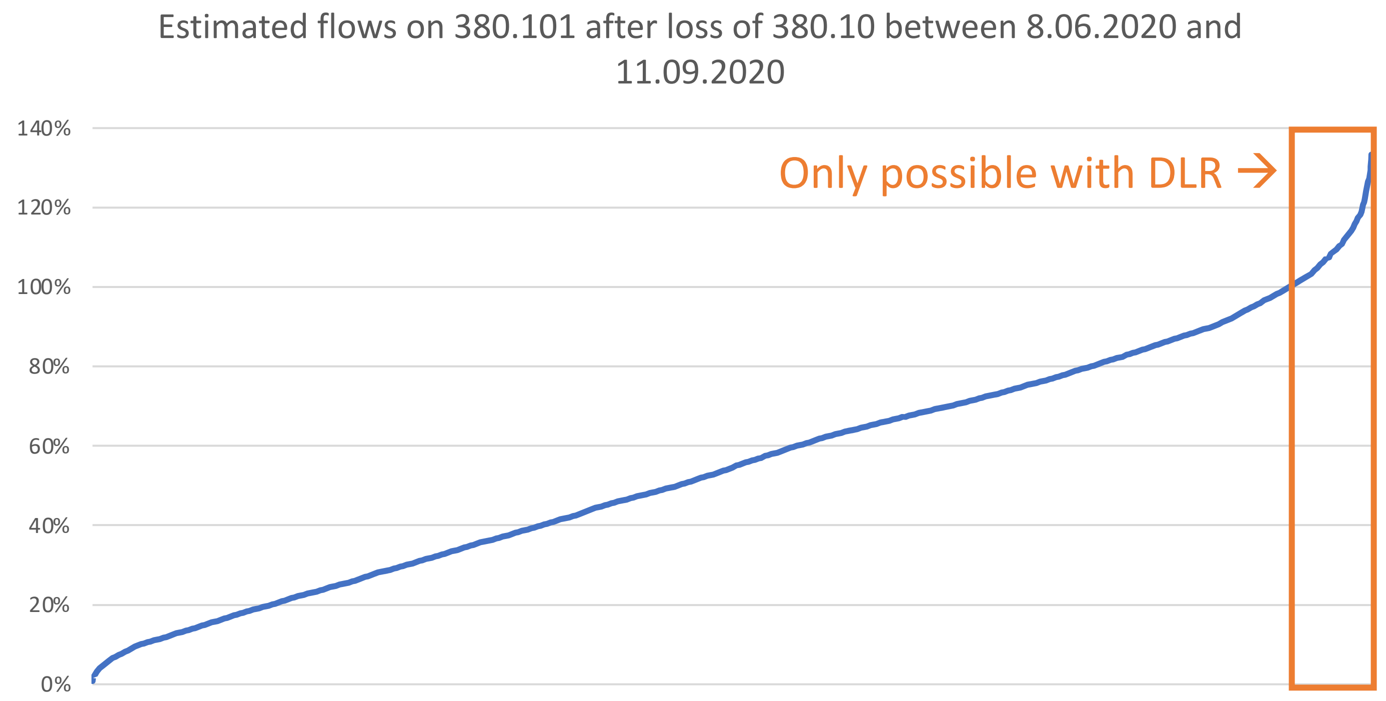
INTERNATIONAL NETWORK 380-220kV

Financial outcomes of reduced congestion



- Internal redispatching = costly measures (typically ~40€/MWh)
  - → Installation of DLR in 150kV coastal area was clearly beneficial
  - → Sometimes the compensation bid is not available in BE
- International redispatching = very expensive measures (higher volumes & prices)
  - → Installation of DLR in 380kV interconnections was clearly beneficial
  - → Ampacimon investments are paid pack with only a few days/year of avoided redispatching

Avoided costs between 8.06 and 11.09.2020



Long outage of 380.102 between Horta – Alvgm, lot of pressure on remaining line in case of export to France

→ Loss of 380.10 (tie-line with FR) = ~33% of flow reported on 380.101

→ **~150h** with overloads while several remedial actions already applied (sometimes even redispatching and counter-trading)

→ Ampacimon was clearly a game-changer during this period while similar outages are ongoing since 4 years in HORTA substation

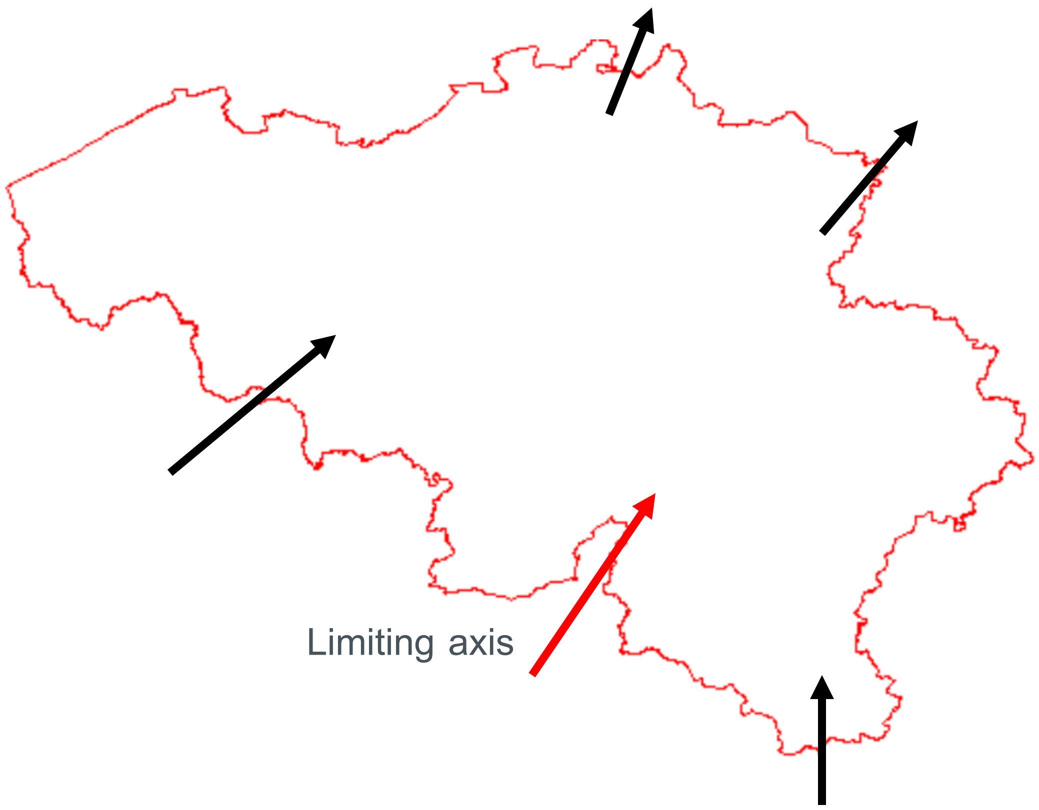
ANNEX: Impact of DLR on flow-based capacity allocation: leverage effect

Simple example:

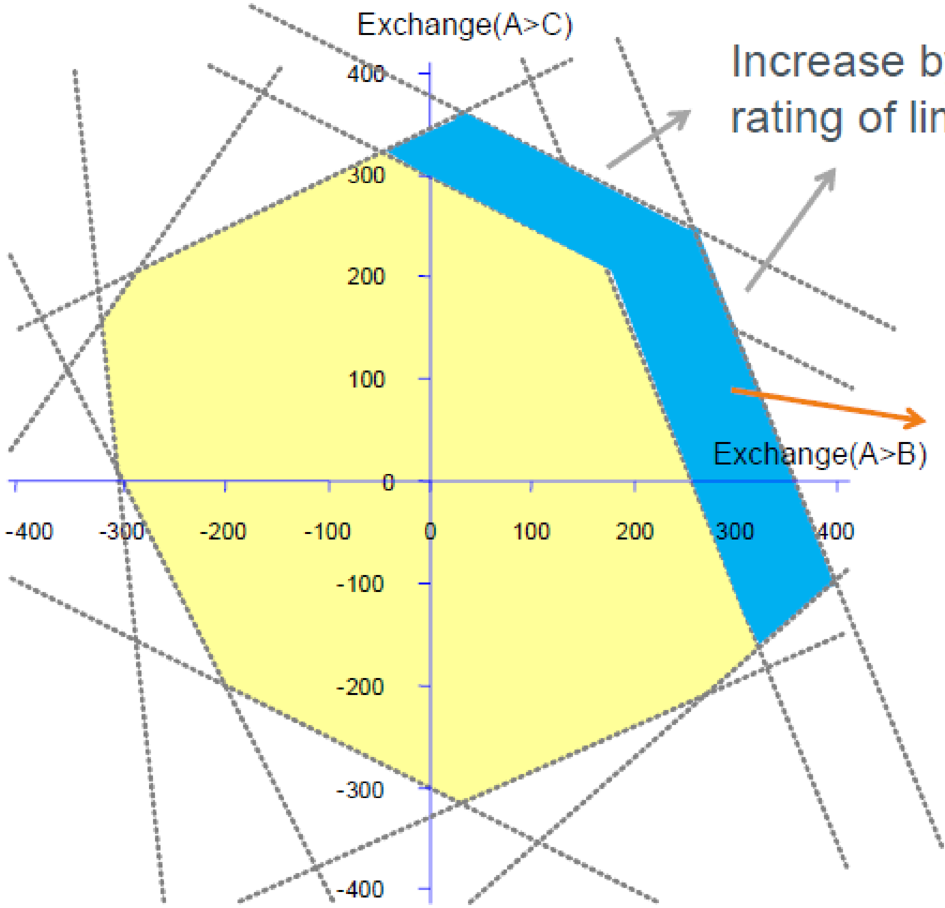
S → N flows and not a single extra MW can be transferred from FR to BE without causing an overload in the Security Analysis

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*



ANNEX: 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 €

Georgios Papaefthymiou

Expert Power System Development and Operation at 50hertz/EGI

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Accelerating the Energy Transition: Dynamic Line Ratings for an Optimised Grid

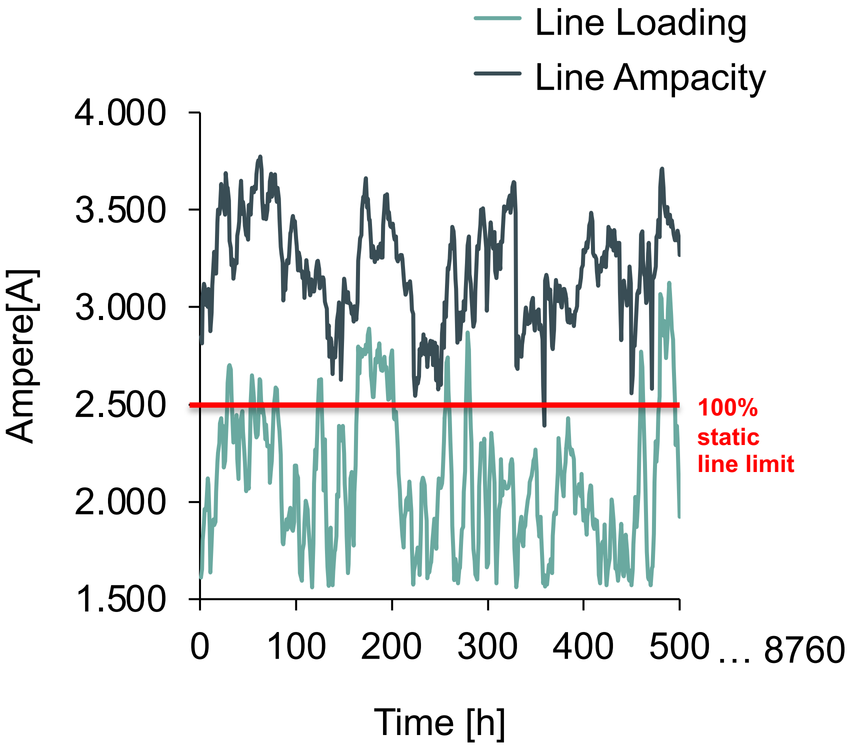
Incorporation of DLR information in grid planning processes at 50hertz

14-01-2021 | Dr. Georgios Papaefthymiou
Elia Grid International – A subsidiary of the Elia Group

„NORE-principle“: Network Optimisation before Reinforcement and Expansion (‘new copper’)

380/220-kV-Transmission-NETWORK

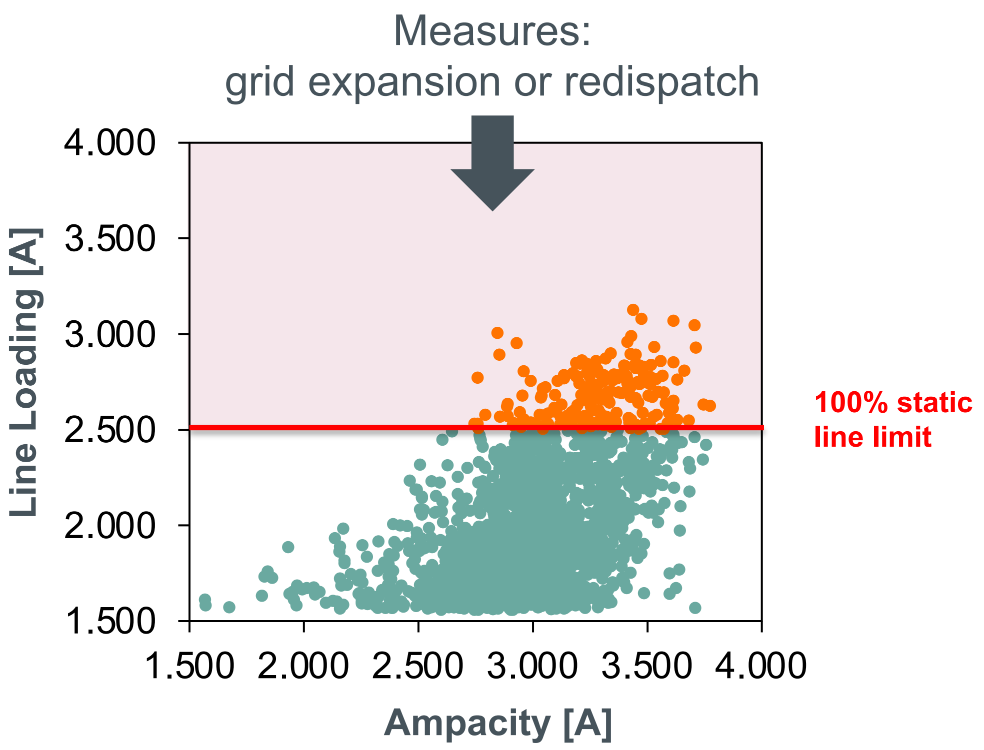
OPTIMIZATION	REINFORCEMENT	EXPANSION
load flow control (e.g. PST)	Upgrade of voltage (220 → 380 kV)	New 380 kV lines and substations
Dynamic line rating	Re-wiring (e.g. HTLS conductors)	New HVDC lines



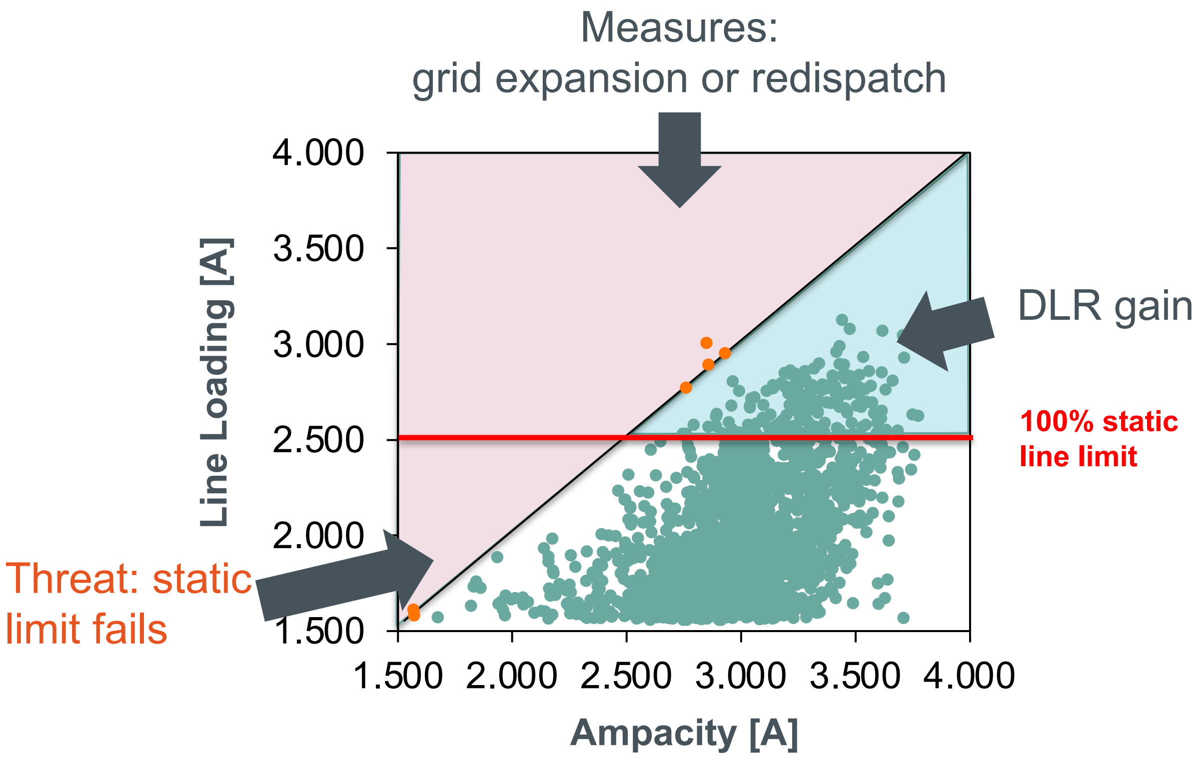
Robustness analysis: can line investments be postponed through line monitoring?

Robustness analysis: mapping the flow vs ampacity behaviour of each line (illustratory example)

Traditional



Incorporation of DLR information



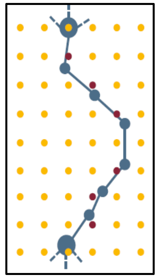
Dynamic line rating is a central optimisation option but impacts of increased line loading should be carefully assessed

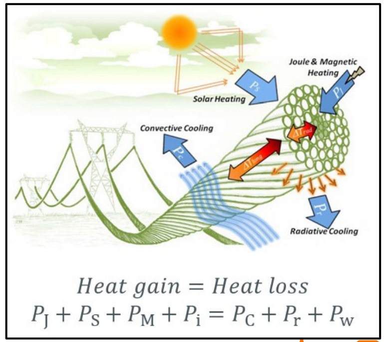
- **Dynamic Line Rating should be incorporated in the assessment of the robustness of future grid investments**
- **Highly data intensive and complex modeling process:** asset information, power flow information, weather conditions on high time and geographic granularity (asset level)
- **System impacts should be carefully analyzed** to prepare for increased line loading, e.g. line losses, static/dynamic reactive power demand, transient stability, etc.
- **Asset impacts should be carefully considered:** are assets ready for higher loading?

Weather info | Asset data | Power flow results

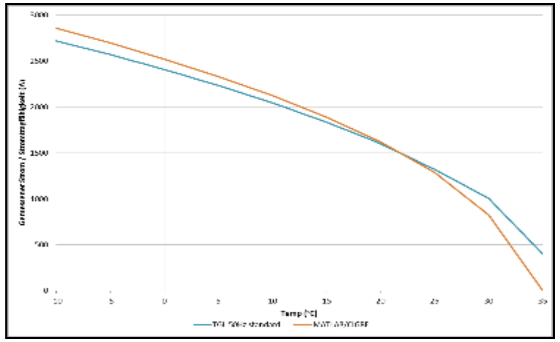
Toolbox

- Calculation of DLR (CIGRE Model)
- Allocate rating to overhead line part
- Combine rating with power flow results (check if DLR helps)
- Analyse & map results





Ampacity



Temperature

Thank you very much!

Contact
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Dr. Georgios Papaefthymiou
Senior Expert Power System Development & Operation
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UPCOMING WEBINAR

4 Accelerating the Energy Transition: **Cyber security** (Q1)

The escalating complexity of our electricity grid – more intermittency, more devices, more software, more and faster ways that supply and demand interact

The benefits of innovation, including undreamed of optimization opportunities from big data, machine learning, software as a service, and the power to control a wide range of far-flung devices and systems,

The challenges, including more intermittency and less inertia from generation, more complex interaction between supply and demand, interoperability, and the central issue of maintaining utility operations that are secure from cybersecurity threats, and

Real-world experiences by utilities in addressing cybersecurity while meeting the coming challenges. Digitalization of our electricity grid is coming, and the focus of the webinar will be on the resulting cybersecurity challenges.

Thank you for your attendance

To keep up to date with our activities:

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