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BUSINESS NETWORK INNOVATION

WEBINAR

BY

BUSINESS NETWORK INNOVATION

20 MARCH 2019

SMART GRID WORLD OF INNOVATIONS: DYNAMIC LINE RATING

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SMART GRID WORLD OF INNOVATIONS: DYNAMIC LINE RATING

Programme

1.	Introduction	12:30	**Guido Guida**, Chair of RD Committee of ENTSO-E
2.	The benefits, risks and future applications of DLR	12:35	**Frederic Vassort,** CEO of Ampacimon
3.	Applying DLR in cables	12:50	**Jozua van Oosterom**, Energy Solutions
4.	Applications in TSO world	13:05	**Victor le Maire,** Planning Engineer at the National Control Center of Elia
5.	Questions and comments	13:20	Moderated and concluded by **Susanne Nies,** Manager of Strategy and Communications at ENTSO-E

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GUIDO GUIDA

Chair of RD Committee of ENTSO-E

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BUSINESS NETWORK INNOVATION

Ecosystem of **energy transition** players driven by **business perspective**

Bridge between ENTSO-E and start-ups, citizen initiatives, opinion leaders, institutions, energy businesses

Over **130 members**: Tesla, GE, Utrecht University, ESA, Ampacimon

Webinars and luncheons: Storage, Dynamic Line Rating, Artificial Intelligence, Common grid model and energy data architecture...

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www.entsoe.eu/research-and-innovation/business-coalition/

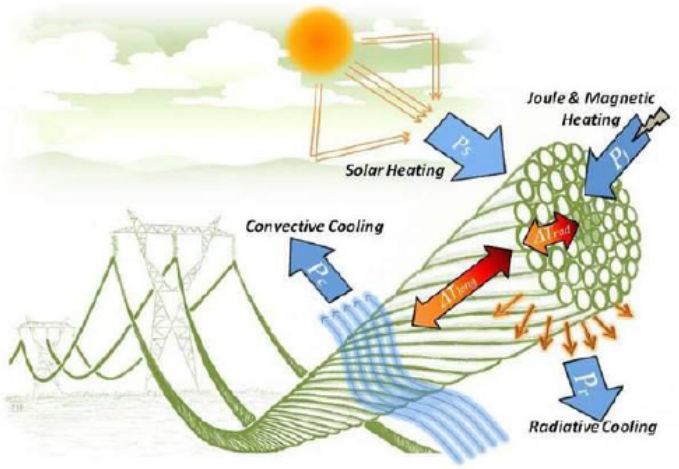
ENTSO-E UPCOMING CONFERENCES

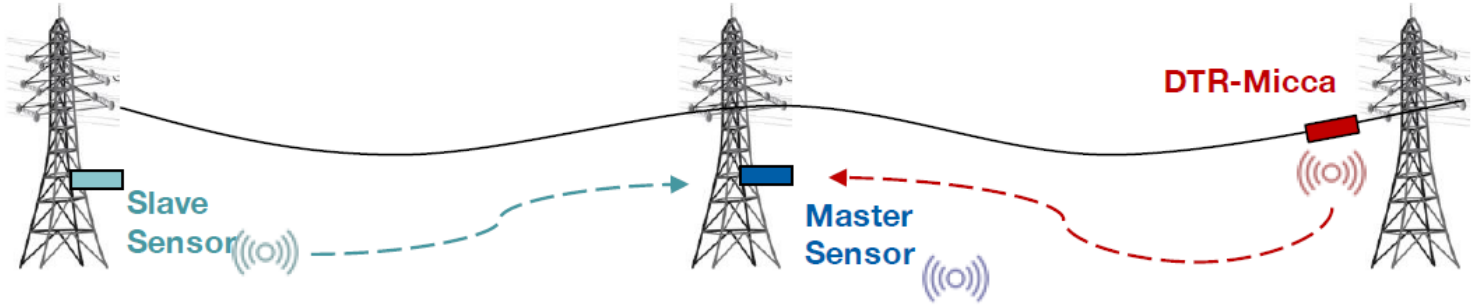
TERNA example

Innovative DTR

Cooperative Smart Sensor Networks: a distributed DTR architecture

- To address the problem of dynamic loading of overheads lines a **decentralized non-hierarchal architecture** based on **cooperative dynamic** agents has been conceptualized
- Similarly to self-organizing biological populations, dynamic thermal rating assessment is achieved by **cooperation of the single agents** that communicate with a reduced number of surrounding elements by short range communication link





AI & ELECTRICITY:
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FREDERIC VASSORT
CEO of Ampacimon

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Ampacimon

Smart solutions for a dynamic grid

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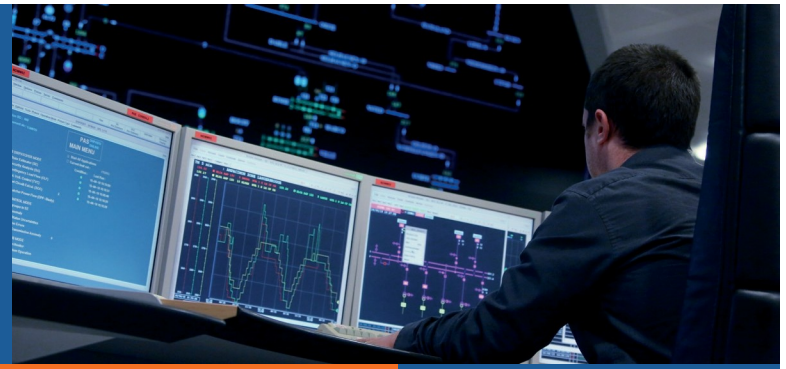
GRID MONITORING AND DYNAMIC LINE RATING



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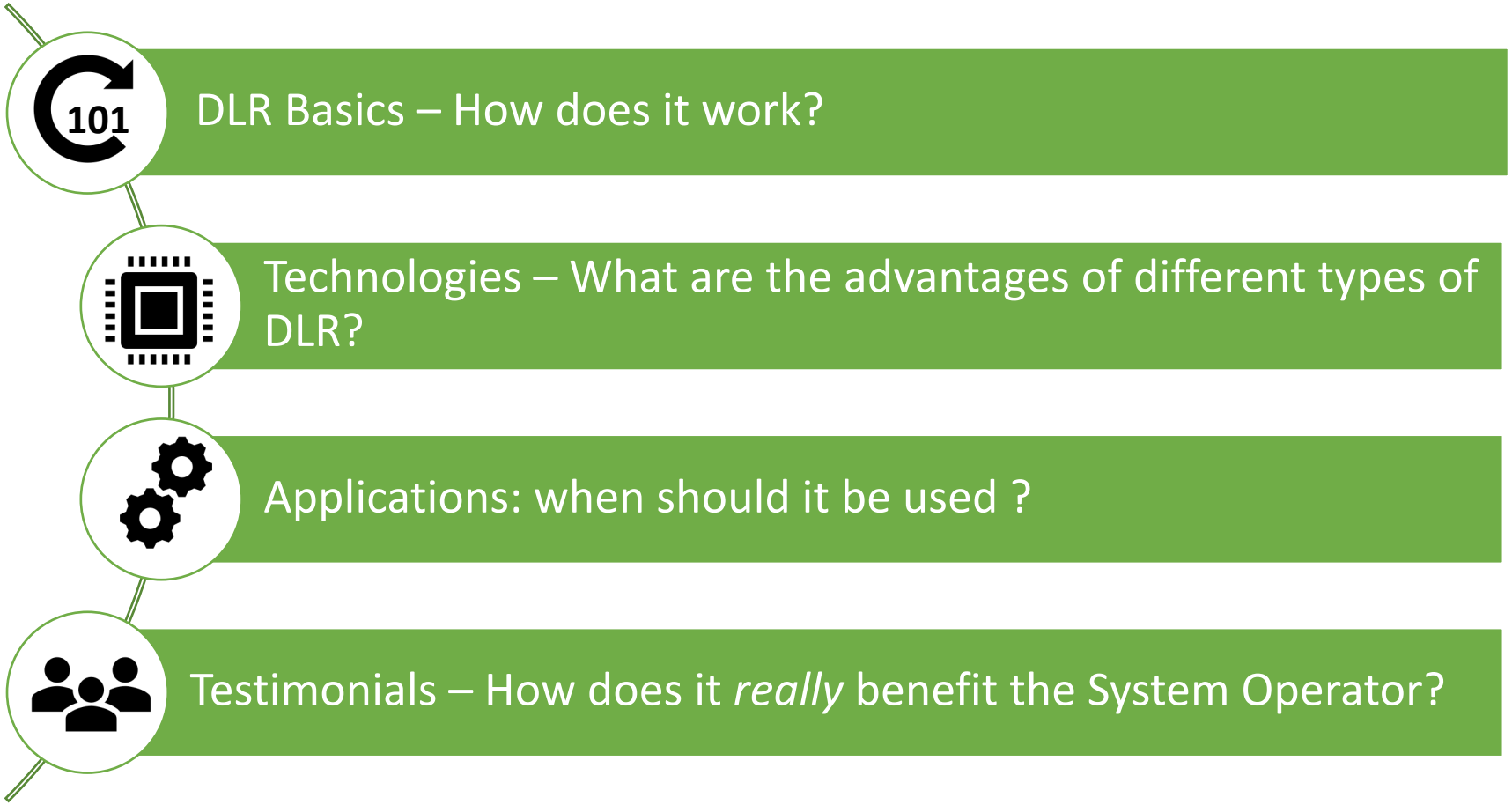
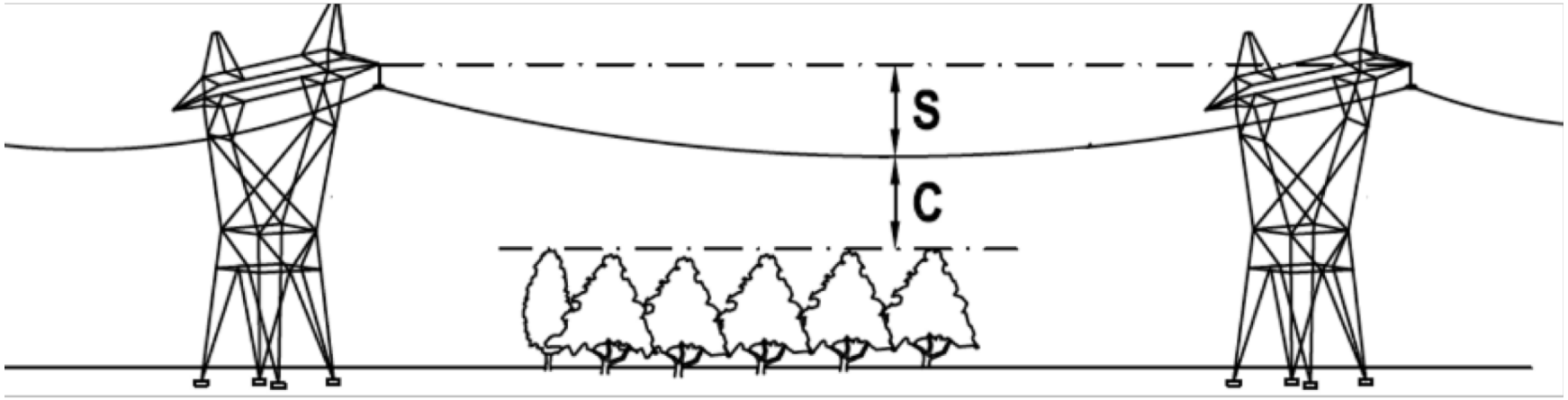
Grid monitoring and Dynamic Line Rating



What is DLR and how does it work?

- Line Sag and conductor temperature -



<u>Security limits</u>:

- Maximum conductor temperature (T_{cmax})
- Minimum clearance (C)

<u>Static vs. Dynamic ratings:</u>

Maximum current based on:

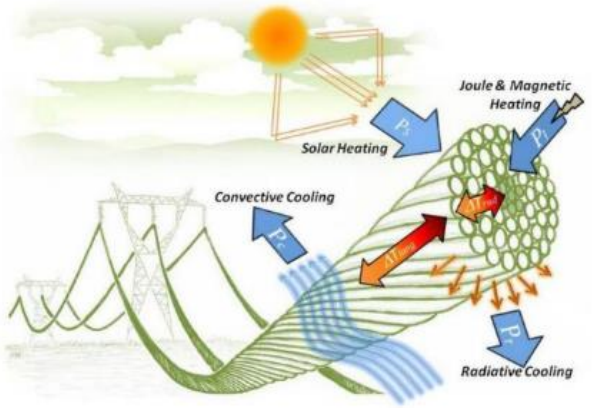
- Static Line Rating (SLR): fixed, conservative ambient conditions
- Dynamic Line Rating (DLR): variable, real-time ambient conditions

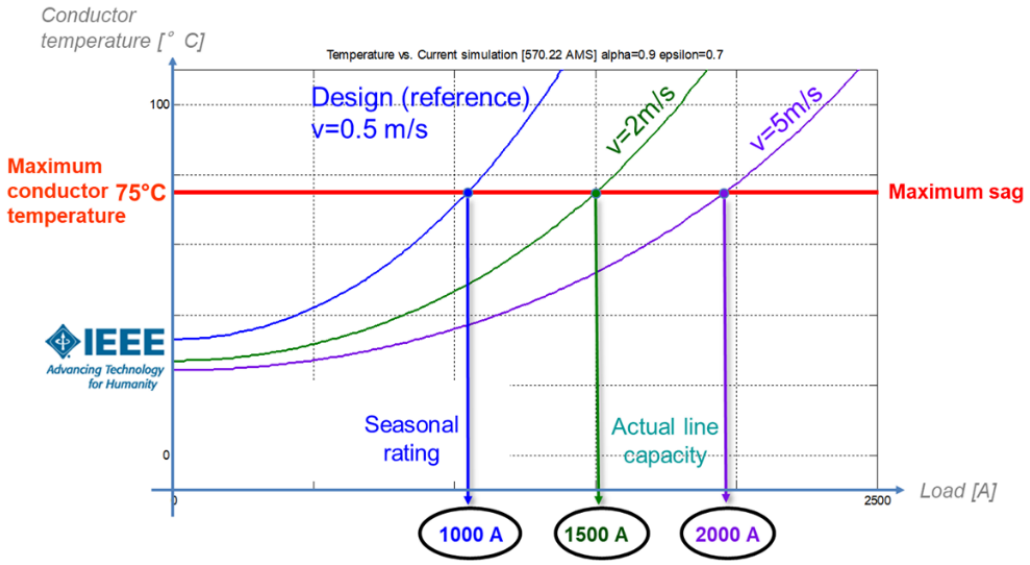
What is DLR and how does it work?

- Weather sensitivity of line ratings -

Ambient conditions impacting rating

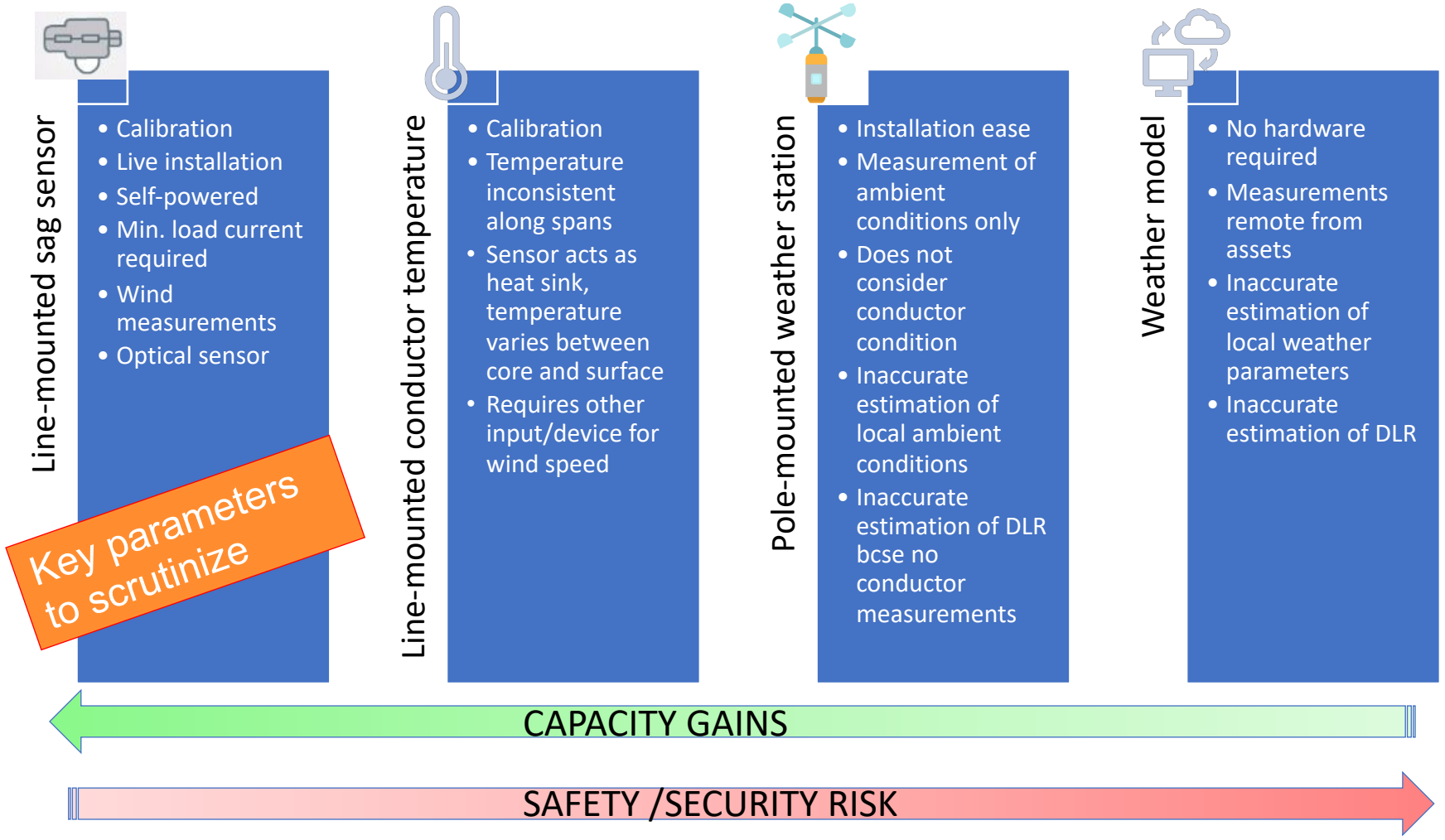
- **Wind speed**
- Temperature
- Solar irradiation





DLR technology comparison

- Advantages and disadvantages -



Applications

Congestion management measures in Europe

ENTSO-E Bidding Zone Configuration Technical Report

Costs 1 Billion EUR in 2017 and 2018 in Germany alone!

- Cost of congestion is approx. 100 kEUR per hour, or 4 mEUR per day *1
- Average redispatch cost is 23kEUR/GWh *2

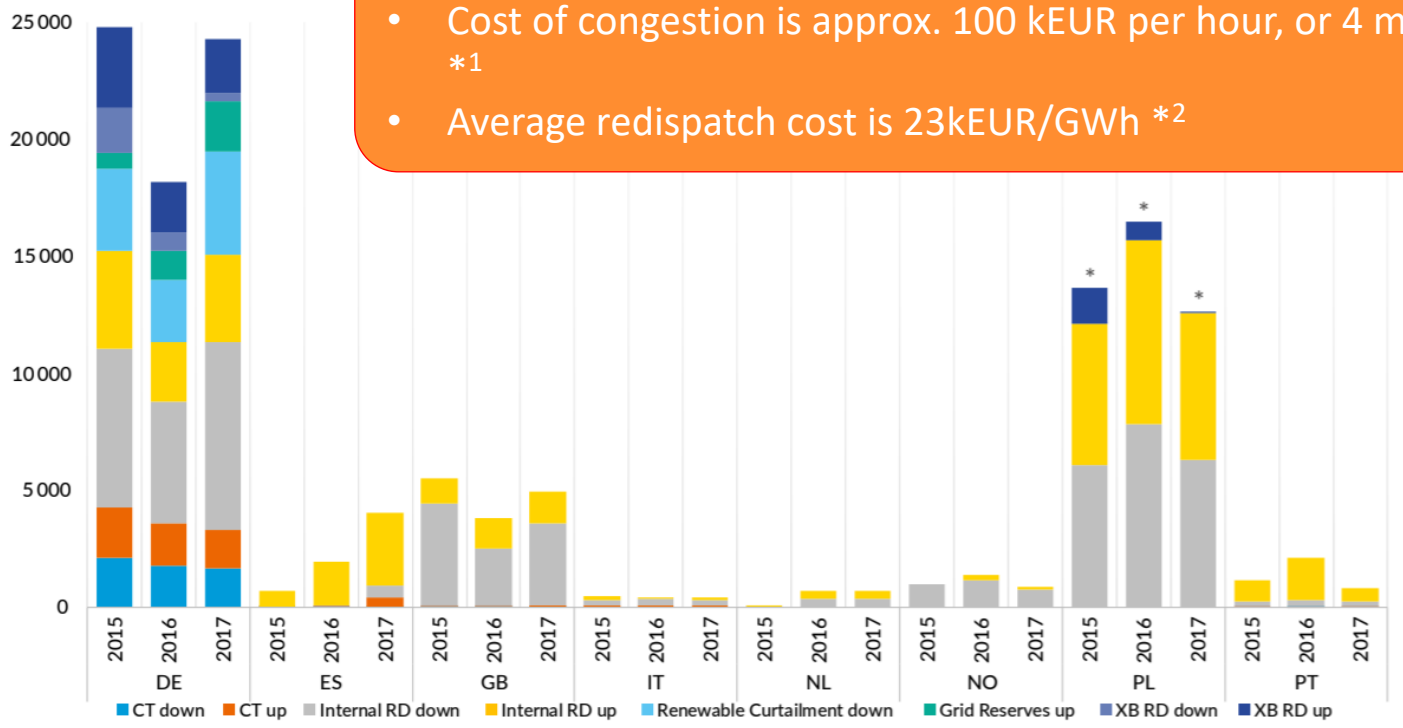


Figure 94: Total volume of measures applied, GWH (1/2)

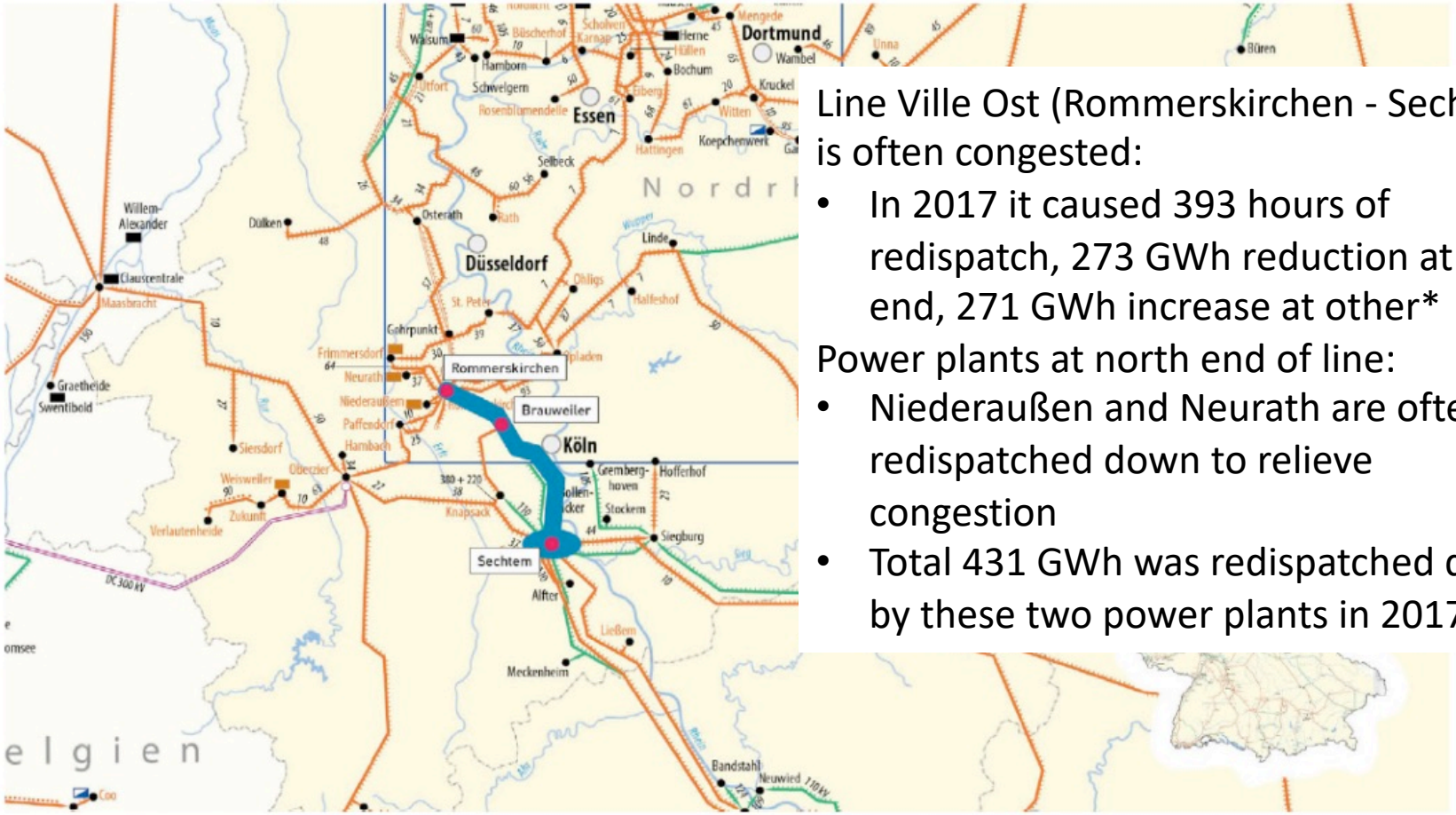
The Figure shows evolution of (total) volumes of activated remedial actions for different categories. By far the highest total volume can be observed in the case of Germany (on the level of 20 TWh/year or more), followed by Poland[33] (around 15 TWh/year).

33 *Due to the fact that PSE applies ISP, cost and volume reported by PSE cover the whole ISP i. e. not only congestion management and thus reported cost and volume should be deemed as strongly overestimated. For a more detailed explanation, see s. 4.3.1.

*1 Based on total cost of congestion management including the "Netzreserve" costs in addition to redispatch and curtailment (not shown in fig. ~480 mEUR

*2 Redispatch cost divided by redispatch amount

Congestion management in Germany
TSO line (Rommerskirchen - Sechtem)



Line Ville Ost (Rommerskirchen - Sechtem) is often congested:

- In 2017 it caused 393 hours of redispatch, 273 GWh reduction at one end, 271 GWh increase at other*

Power plants at north end of line:

- Niederaußen and Neurath are often redispatched down to relieve congestion
- Total 431 GWh was redispatched down by these two power plants in 2017

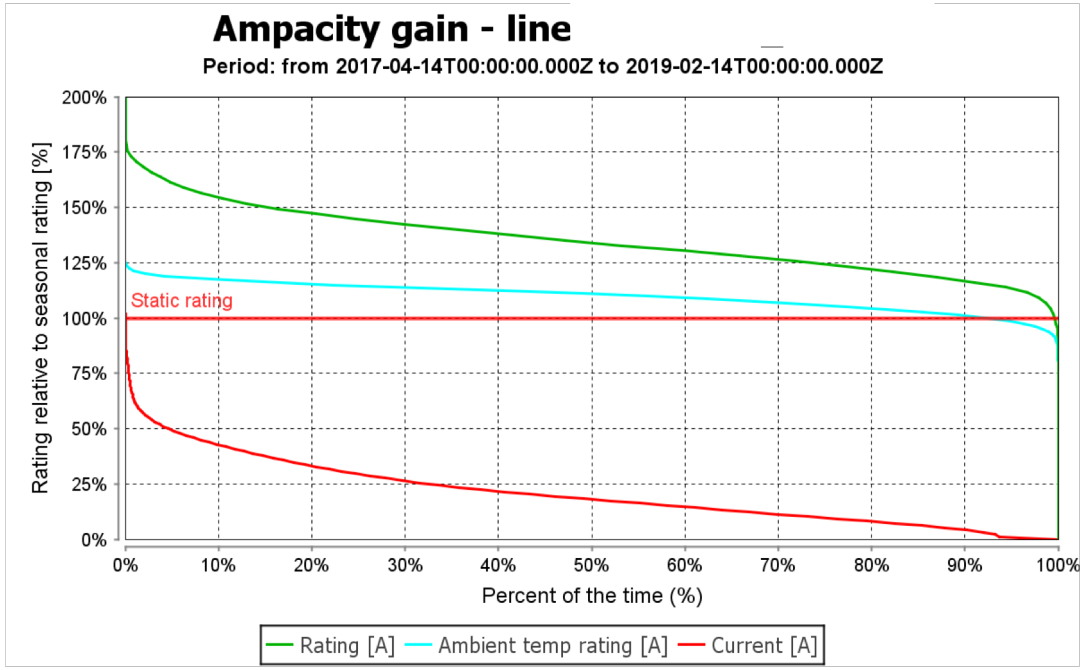
Graphics: German Grid Development Plan 2030 2nd Draft Startnetz

* According to Monitoring Report by BNetzA

Testimonial 1

Congestion management
Typical DLR equipped line

- 115% gain 90% of time
- 111% gain 95% of time
- 106% gain 98% of time



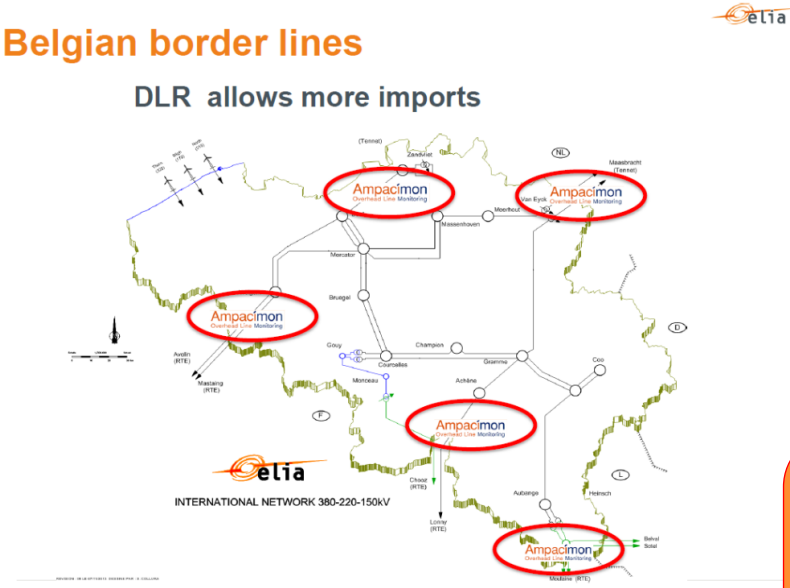
In a typical day, 6hr redispatch of 200MW max can be instructed.
This is 1200MWh which could be avoided, or 27kEUR for this day alone.

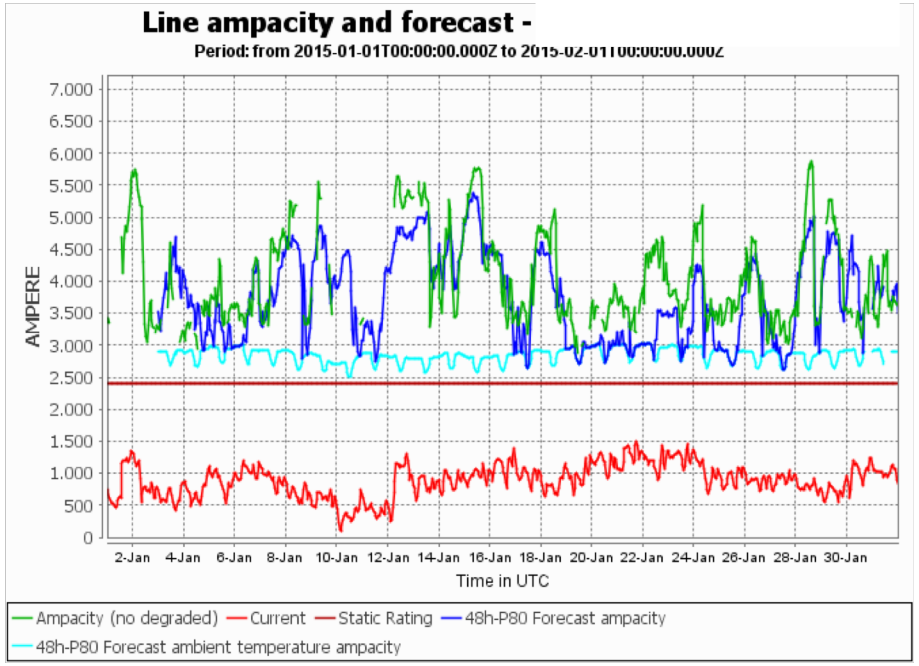
Testimonial 2

Cross-border exchange for market integration

Increase import capacity to secure electricity supply

All Belgium cross-border lines equipped with DLR





Example: 19/2/2015, market limited by Belgian lines. D-2 ahead forecast of 3% gain on limiting lines released 22% gain on x-border exchange. Result: in 4 hours, the gain on the CWE welfare computed to 247 250 €

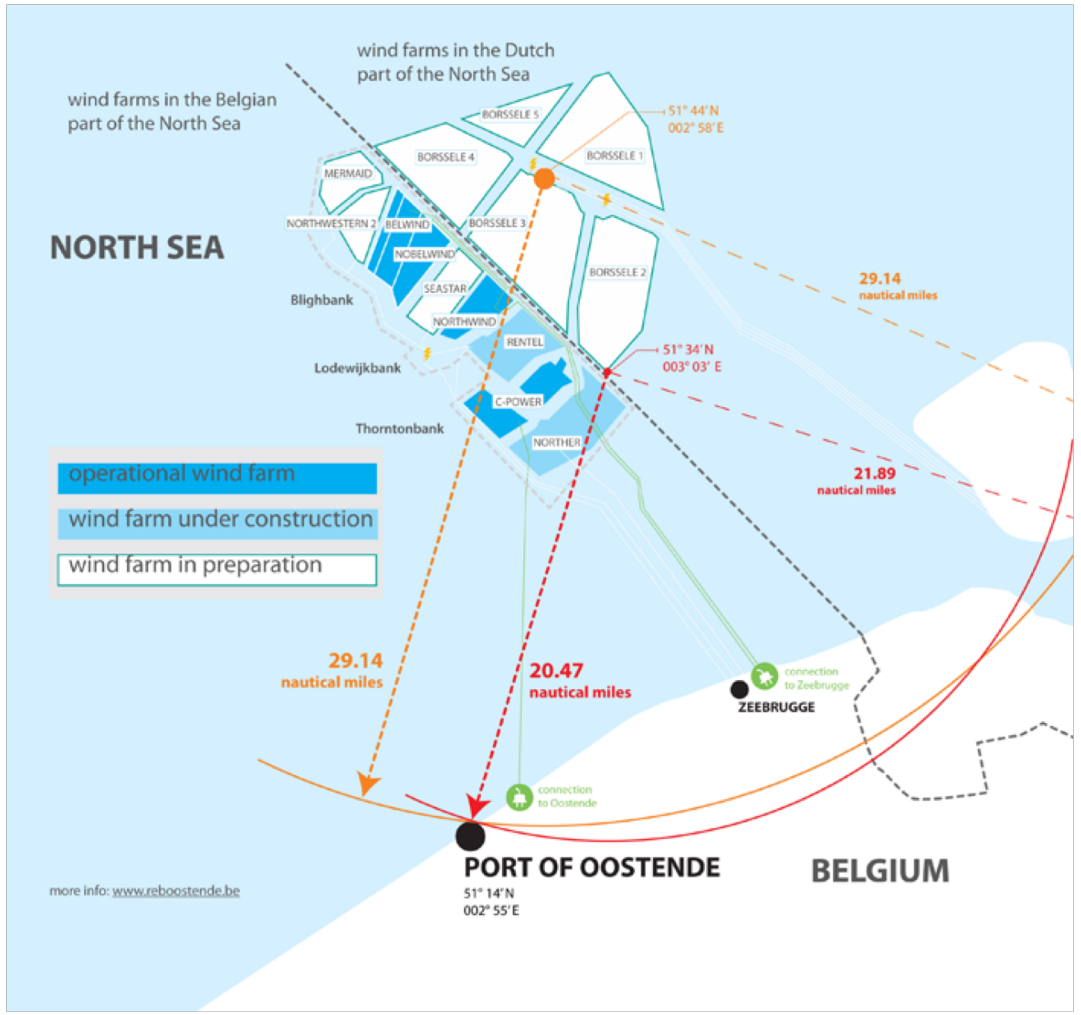
Wind integration: offshore wind developments on west coast Belgium

712 MW installed and operational

- 325 MW connected to Oostende
- 387 MW to Zeebrugge

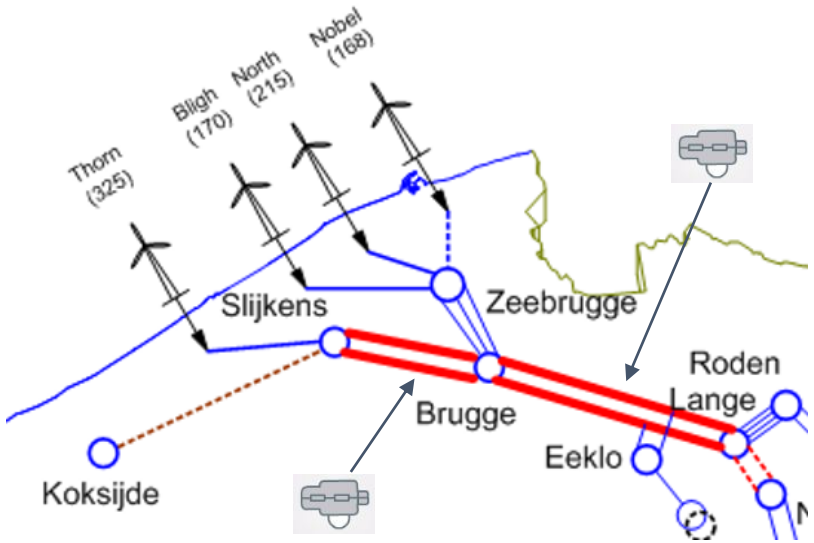
Additional 811 MW in preparation to be connected to Zeebrugge

Finally 2251 MW installed capacity for Belgium



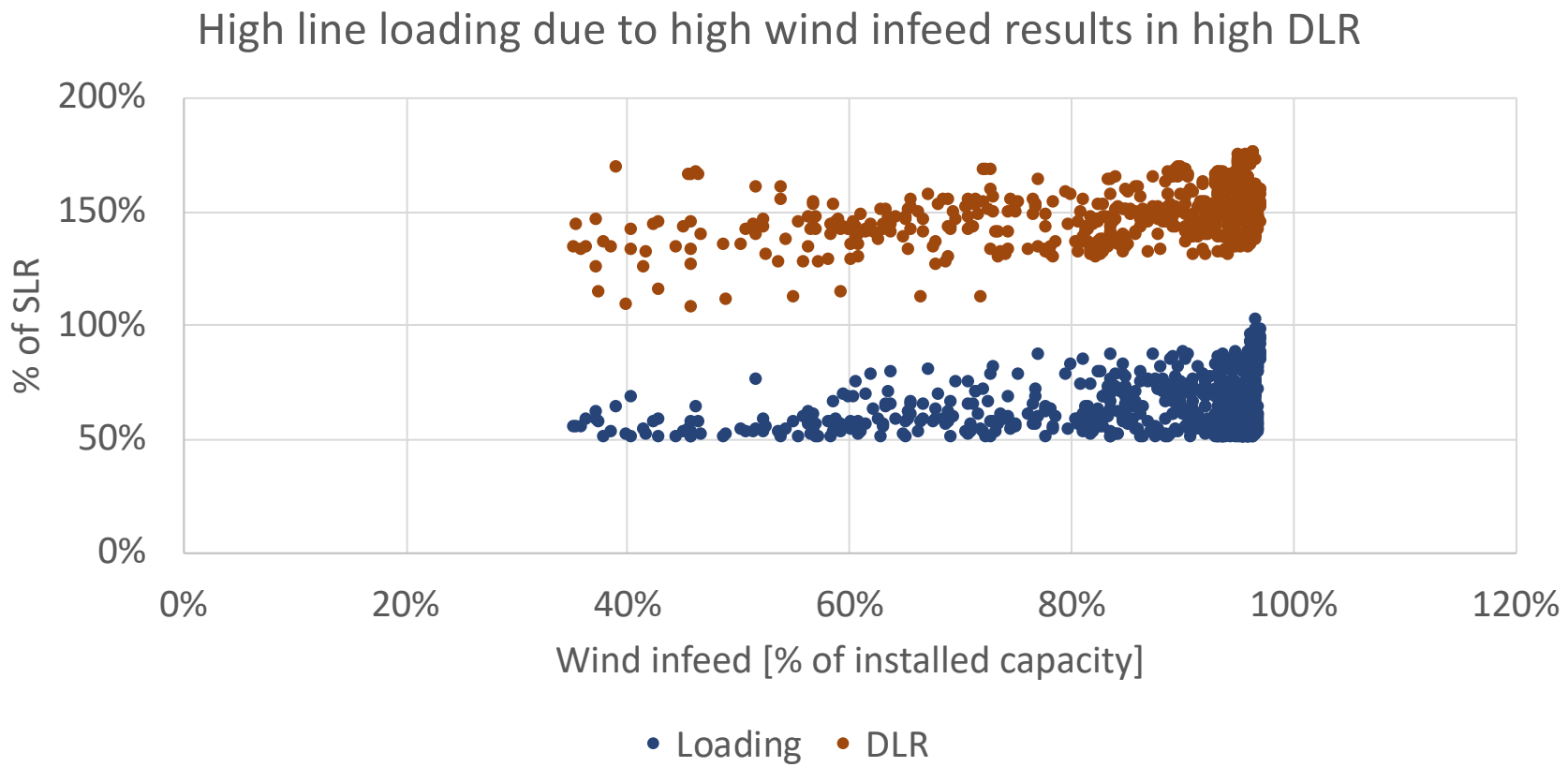
High line loading on 150KV lines connecting the offshore wind

- Elia has offshore wind developments on west coast that feed in to Slijkens and Zeebrugge
  - 150kV lines Slijkens – Brugge - Langerbrugge subject to congestion with high wind infeeds
  - DLR installed on Slijkens-Brugge since 2010 and Brugge – Langerbrugge since 09/2016



DLR is always above SLR when needed

Wind infeed above average + line load above 50% (2018)



120% gain captures 10% of additional wind energy without need for reinforcement

Take aways

- DLR technologies are now well proven, sensors-based, and including Scada/EMS integrated software to optimize grid operations

- Congestion management (redispatch reduction), Interconnectors optimization, Renewables integration are obvious use cases, with EXTREMELY quick pay-backs

- Won’t replace new/upgraded lines, but can help significantly thanks to very quick deployments, flexibility and low investment

Further trainings

Basics of Dynamic Line Rating – DLR

- Course description : http://www.wlenergy.fr/2016/12/16/dynamic-line-rating/#
- Contact info : info@wlenergy.fr / francois.hussenot@wleenrgy.fr / T +33 (0) 9 82 44 12 23

Tutorial on Dynamic Line Rating

- @ the Wind Integration Workshop http://windintegrationworkshop.org/
- 14th or 15th October, Dublin


Ampacimon
Smart solutions for a dynamic grid

VICTOR LE MAIRE

ELIA National Control Center, Planning engineer

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DLR in operation at Elia

03/2019 – Enstoe webinar

History

2008: First collaboration with Ampacimon, installation of prototype on a test line 380kV

2011: 2 lines equipped in RT operation (congestion due to wind infeed)

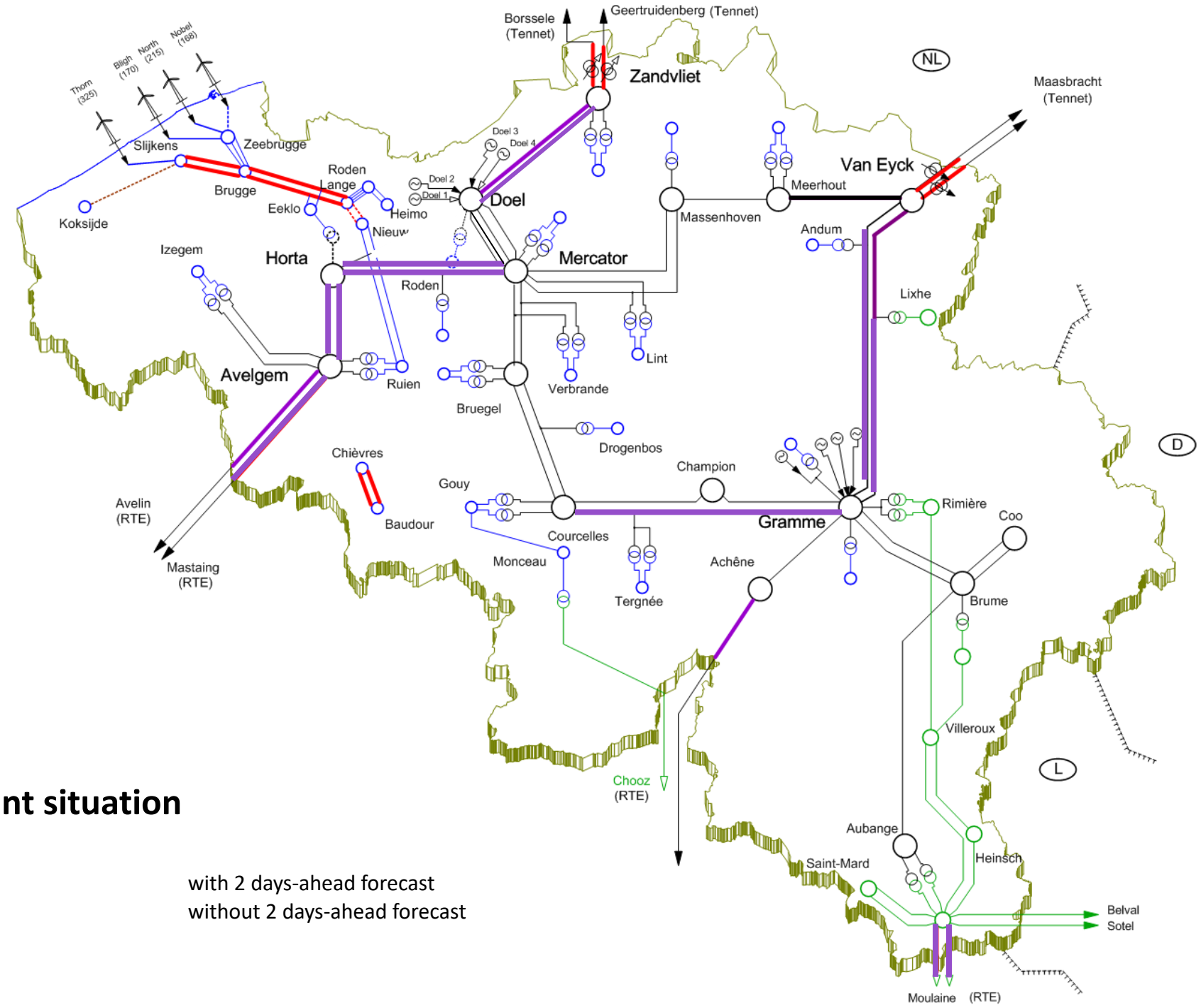
2014: “BeReady” situation → first roll-out on a dozen lines (150kV and 380kV)

2015: New algorithm the “Forecast Horizon” (+55h) → first tests

2016: Use of 5 Horizon licences in D2CF, DACF and IDCF files (i.e. increase of market exchange capacities up to 105% peak hours and 109% off-peak)

2017: 8 newly equipped lines + 4 extra Horzion licences (notably for easing HTLS works)

2018-2019: Switching modules and licenses from one line to another



Current situation

Purple	with 2 days-ahead forecast
Red	without 2 days-ahead forecast

Maintenance policy & line-ends limitations

- Increasing current by 30% on a line ~ 70% extra heat
- Increasing temperature = increasing aging of assets
  - → maintenance policy has been adapted (especially for line-ends/bays)
  - → more preventive maintenance
  - → Extra thermo-visions & visual control (line-ends/bays + conductor junctions)

Line-ends/bays are not supervised by DLR:

- → Make sure those are not limiting
- → Foresee upgrades to tap maximum potential of DLR

EMS (RT tool)

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	22.8	173.6	177.7		
	LANGE 150.05 EEKLO	10.6	173.6	177.0		
	BRUGG 150.06 EEKLO	23.0	173.6	177.7		
	LANGE 150.06 EEKLO	10.4	173.6	180.6		
	LANGE 150.07 NIEUW	96.8	246.4	320.3		
	LANGE 150.08 NIEUW	95.4	246.4	320.3		
	SLYKE 150.15 BRUGG	36.1	174.7	190.6		
	SLYKE 150.16 BRUGG	35.2	174.7	227.1		
	BAUDO 150.313 CHIEV	7.4	196.0	196.0		
	BAUDO 150.314 CHIEV	5.9	196.0	196.0		
70	MOUSC 70. 49 TOURS	9.7	70.6	85.1	8.6	
	TOURN 70. 49	6.6	70.6	72.6		

	Reference	Measured Flows RT [MVA]	Limit Season [MVA]	Limit 1h Capped [MVA]
380kV	GRAMM 380.11 LIXHE	260.8	1473.9	1658.1
	GRAMM 380.12 ZUTE+	285.5	1473.9	1816.0
	ACHEN 380.19 LONNY	689.6	1474.3	1916.5
	VANYK 380.23 MEERH	265.6	1611.3	1611.3
	DOEL 380.25 ZANDV	0.1	1312.1	1569.3
	DOEL 380.26 ZANDV	289.6	1312.1	1581.5
	VANYK 380.27 MAASB	268.9	1611.3	1611.3
	VANYK 380.28 MAASB	96.8	1474.3	1579.6
	ZANDV 380.29 BORSS	557.3	1842.4	2232.8
	ZANDV 380.30 GEERT	100.6	1842.4	2231.6
	COURC 380.31 STAM+	365.9	1473.9	1684.5
	GRAMM 380.31 STAM+	736.3	1473.9	1539.7
	MERCA 380.73 HORTA	586.3	1474.3	1916.5
	MERCA 380.74 RODE+	636.9	1474.3	1684.9
	HORTA 380.74 RODE+	500.9	1611.3	1611.3
	AVLGM 380.79 MASTA	0.4	1474.3	1474.3
	AVLGM 380.80 AVELI	1.6	1711.6	1711.6
	VANYK 380.91 LIXHE	59.2	1474.3	1579.6
	HORTA 380.101 AVLGM	341.2	1473.9	1916.1
	HORTA 380.102 AVLGM	308.5	1611.7	1971.4
220	AUBAN 220.513 MOULA	126.4	495.5	596.3
	AUBAN 220.514 MOSMA	131.9	495.5	561.8

14/09/2017

High N-> S flows + 380.74 in outage

D-1 : PSTs = 6/6/6/6 + 150kV topological measures (still problematic, redispatching prepared)

RT: PSTs = 4/4/4/4, 380.73 highly loaded, no topological measures left, DLR avoid redispatching

Conclusions

Ampacimon has become a mature technology, integrated in all our operational processes; allowing on the one hand to reduce re-dispatching costs, increase robustness, while at the same time it can have a positive impact on capacity calculation processes.

Care has to be taken however for managing the operational risks when considering Dynamic Line Rating for capacity calculation. One can’t afford to provide capacity to the market, based on forecasts, without sufficient certainty. Elia applies a 99,9% risk level in line with our industry standards (same risk level applied for dimensioning reserves), in Belgium NRA approval is requested by CREG.

Many thanks for your attention!

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Energy Solutions, Electrical engineer

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Applying DLR in cables

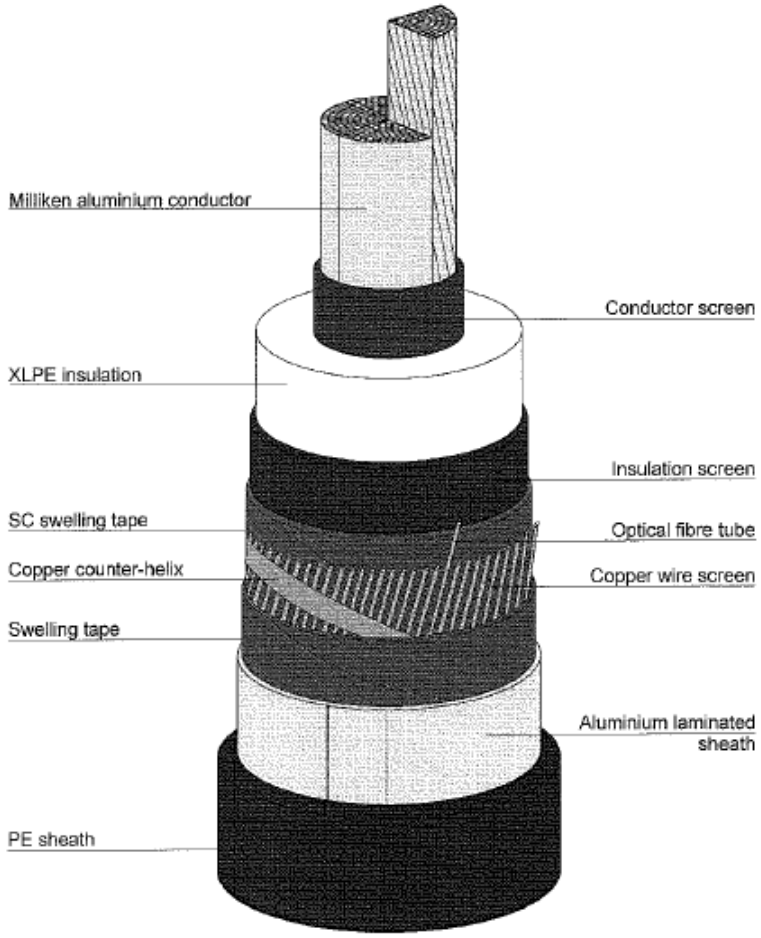
Webinar ENTSO-E

20-03-2019

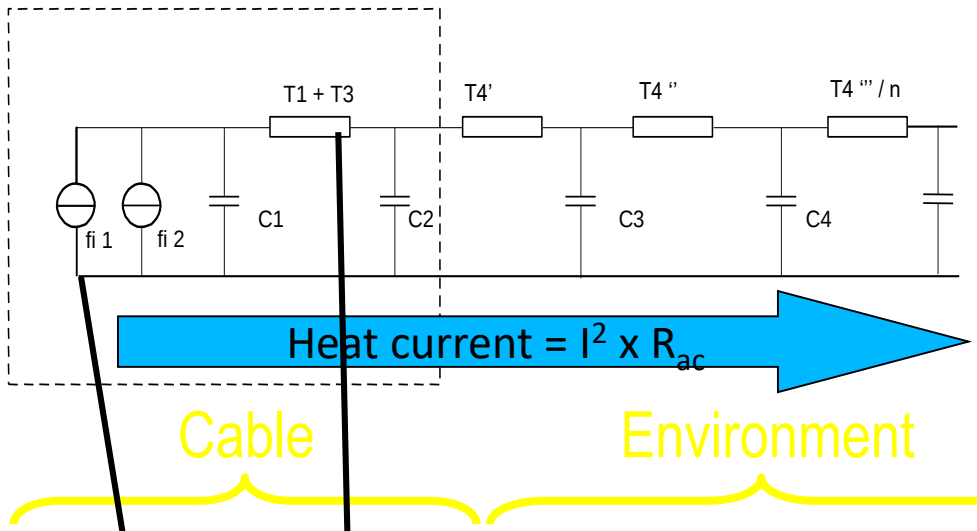
Overview

Used abbreviations:

- DLR (Dynamic Line Rating)
- DCR (Dynamic Cable Rating)
- RTTR (Real Time Thermal Rating)



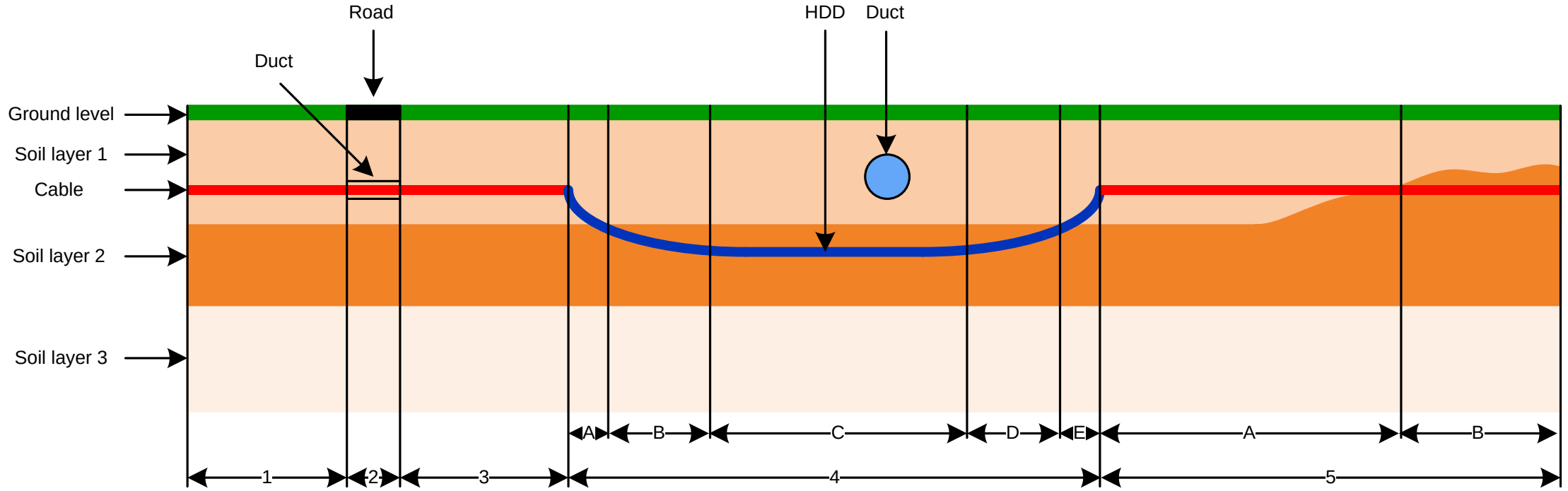
Thermal model



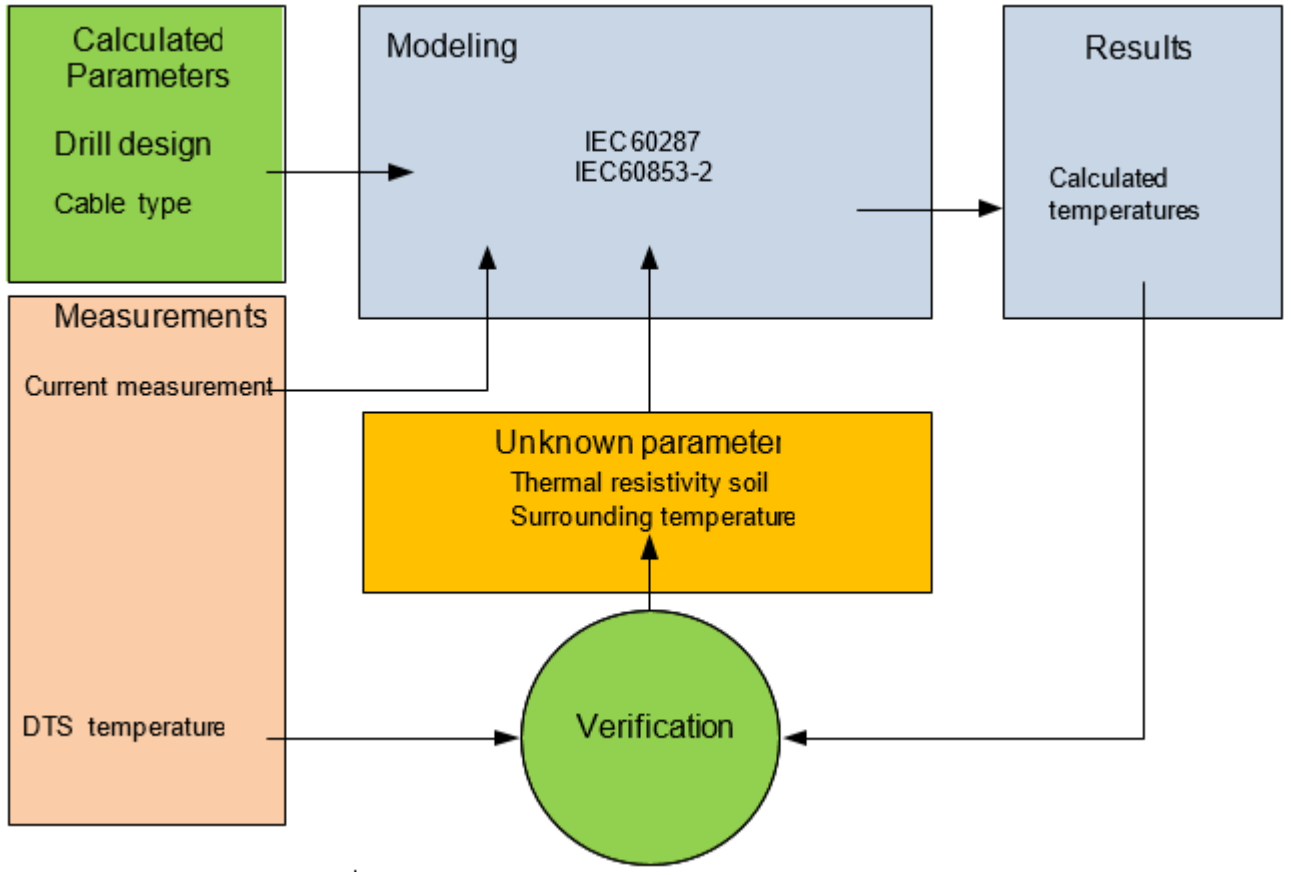
- Cable construction
- Earthing

- Laying configuration
- Burial depth
- Thermal properties
- Soil temperature
- Ducts
- etc

Thermal zones



Calculation model



Temperature monitoring

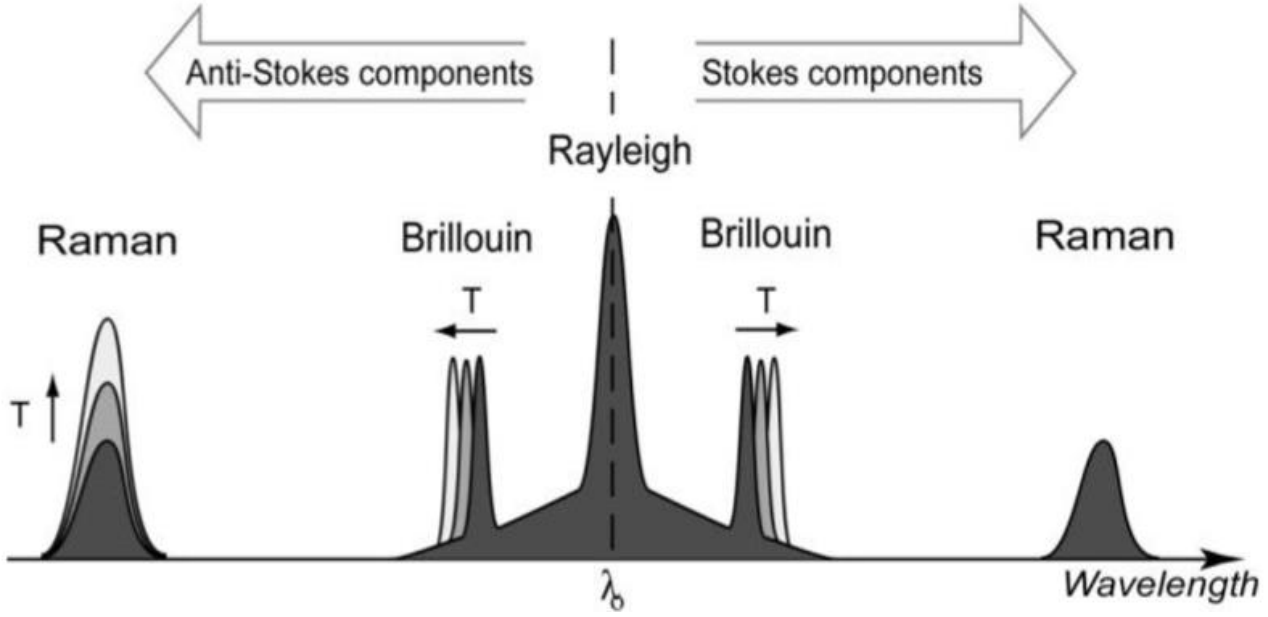
Hotspot monitoring using:

- PT-100 temperature sensors
- 4G modem
- Solar panel

Temperature monitoring

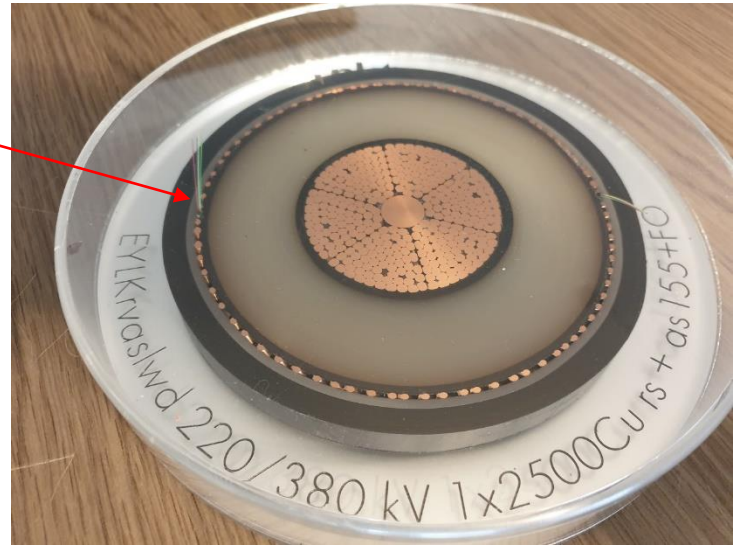
Distributed Temperature Sensing (DTS)

- Brillouin
- Raman

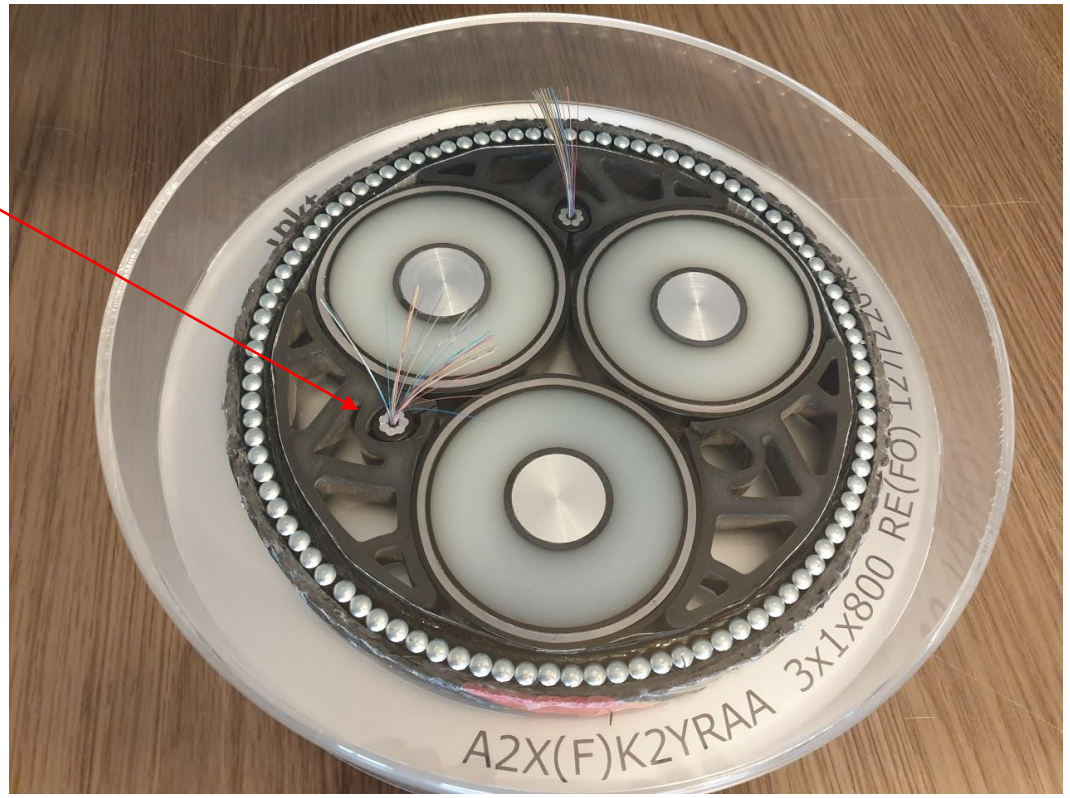


Temperature monitoring

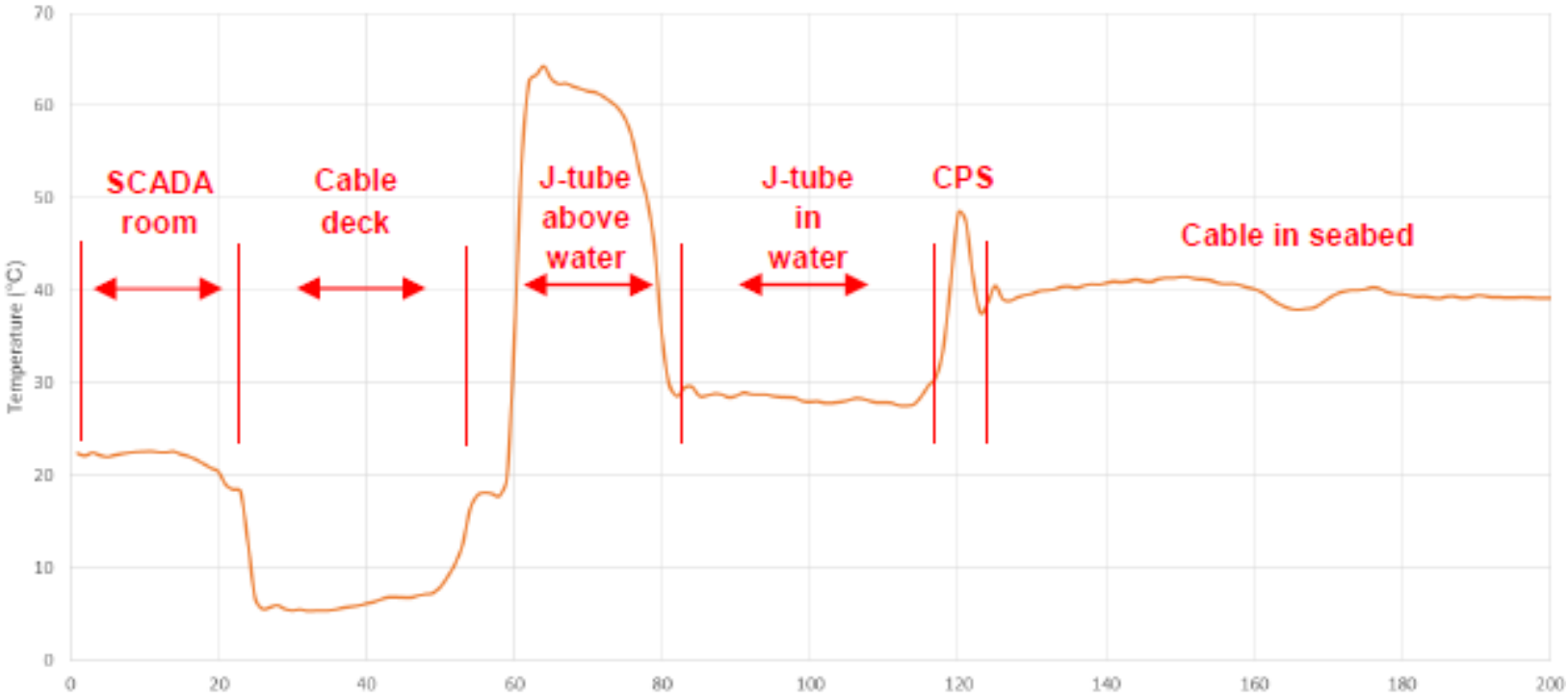
Fibre optic



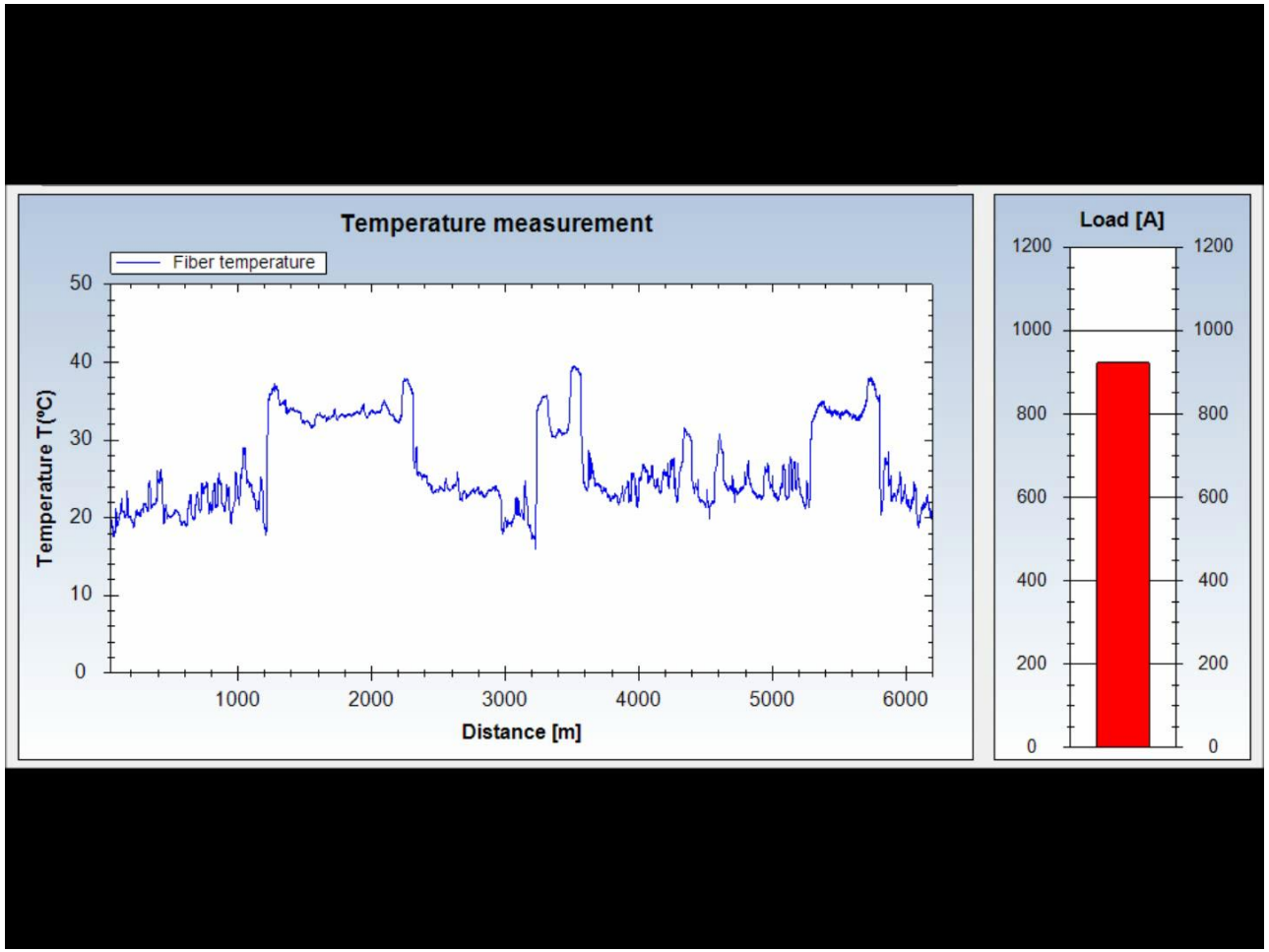
Fibre optic

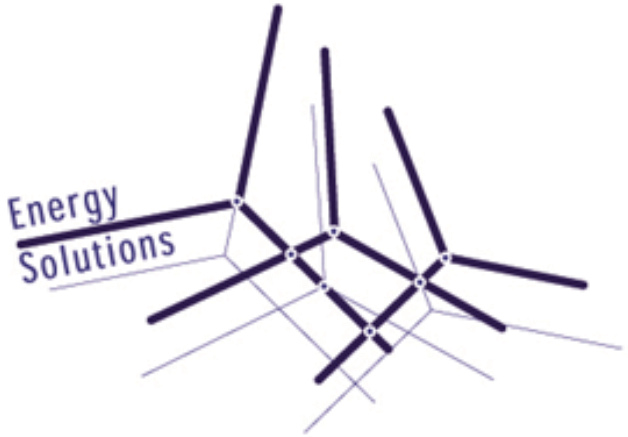


Temperature monitoring



Temperature monitoring





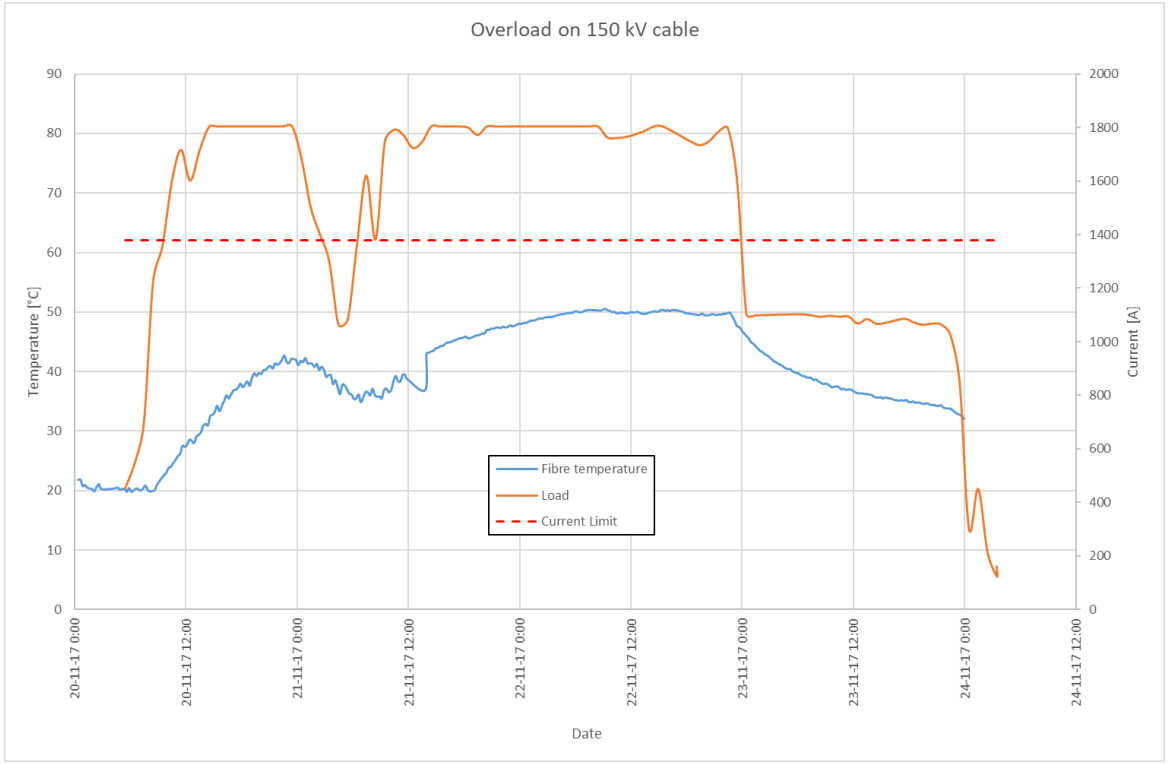
Practical examples

- Overload on 150 kV cable during one cable out of service
- Thermal problem on wind farm export cable
- Thermal problem on 150 kV cable connection

Examples

150 kV connection with two parallel circuits:

- Failure in one of the circuits
- Lots of wind production connected to cable
- Other circuit is loaded for 130% for multiple days



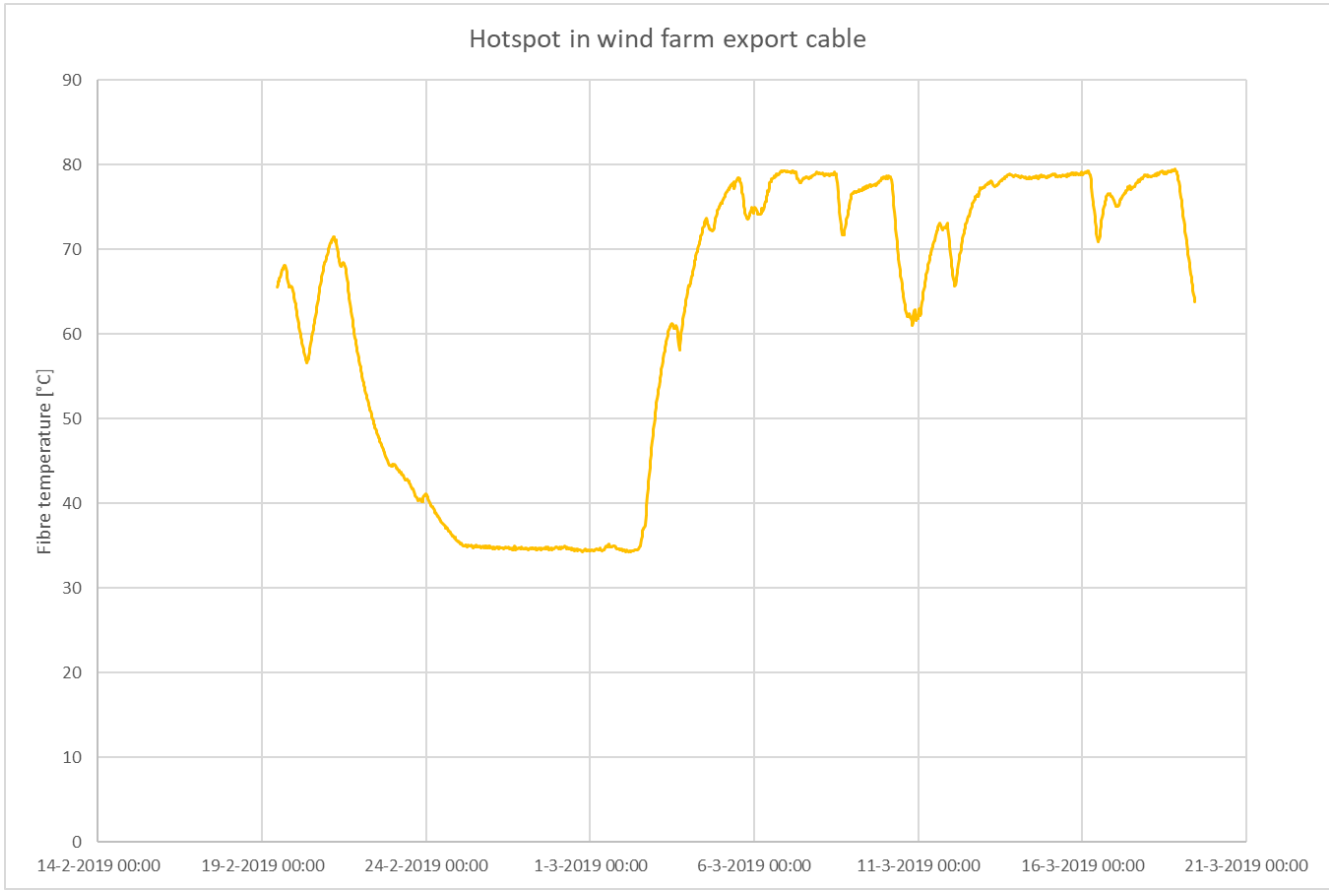
Energy Solutions

Examples

Wind farm with thermal hotspot in cable:

- Prevented overheating of the cable
- Maximum use of cable at high wind production

Examples

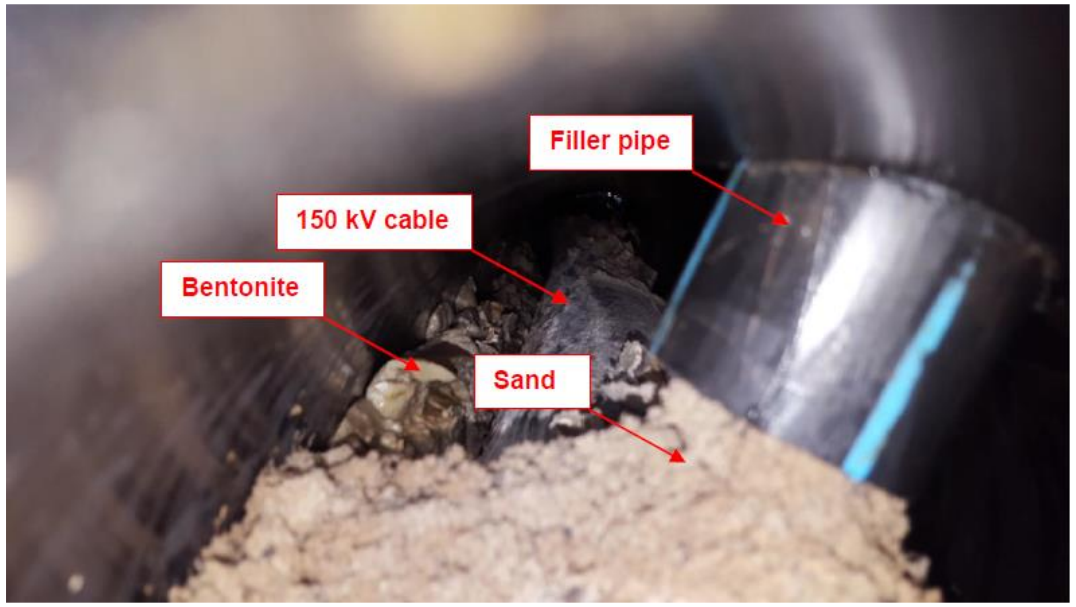

Hotspot in wind farm export cable
Fibre temperature [°C]
90
80
70
60
50
40
30
20
10
0
14-2-2019 00:00
19-2-2019 00:00
24-2-2019 00:00
1-3-2019 00:00
6-3-2019 00:00
11-3-2019 00:00
16-3-2019 00:00
21-3-2019 00:00

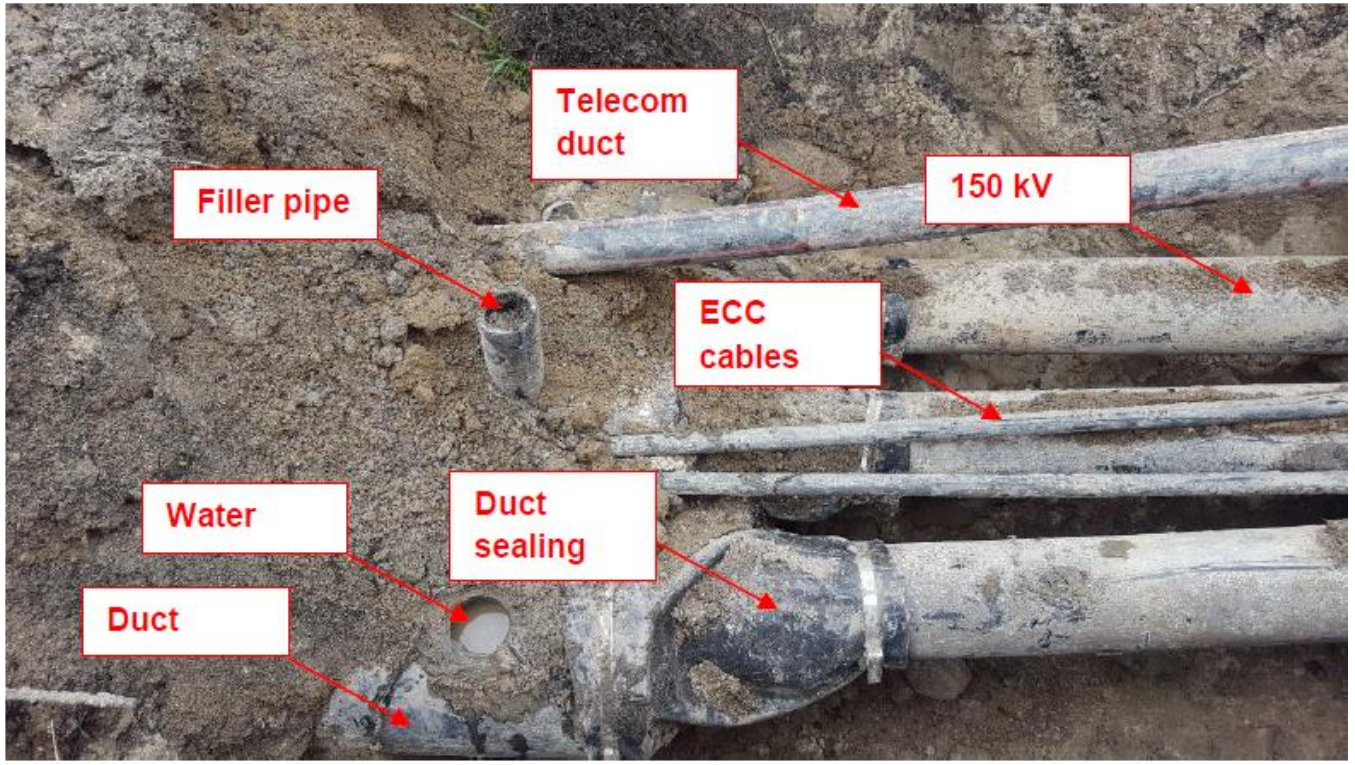
Examples

150 kV connection with one circuit:

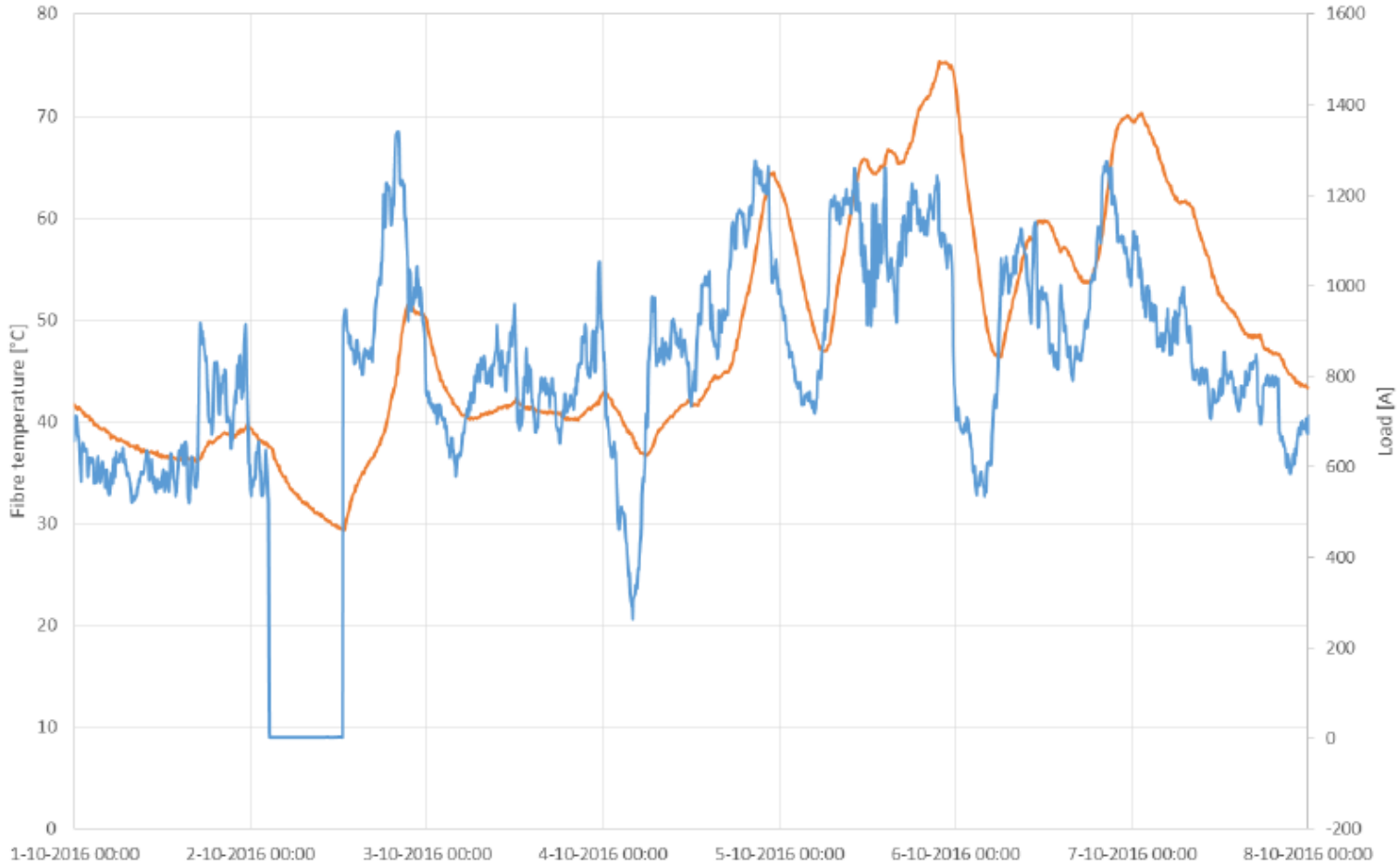
- Hotspot due to air filled duct
- Induced currents increased losses

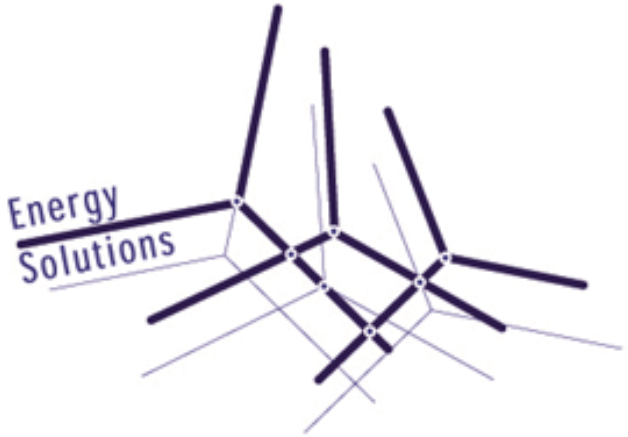
Examples


Filler pipe
150 kV cable
Bentonite
Sand


Telecom duct
Filler pipe
150 kV
ECC cables
Water
Duct sealing
Duct

Examples

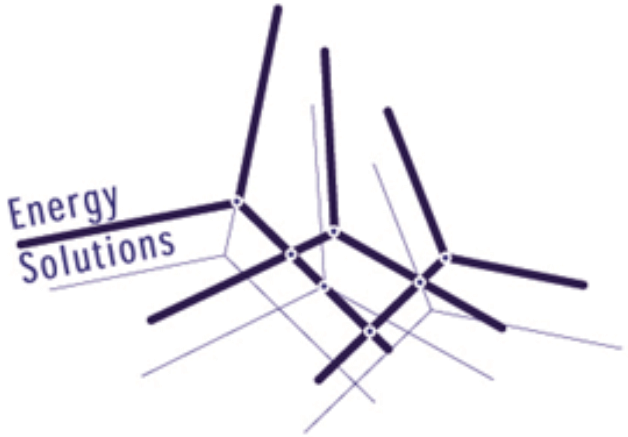

Fibre temperature [°C]
Load [A]
80
70
60
50
40
30
20
10
0
1600
1400
1200
1000
800
600
400
200
0
-200
1-10-2016 00:00
2-10-2016 00:00
3-10-2016 00:00
4-10-2016 00:00
5-10-2016 00:00
6-10-2016 00:00
7-10-2016 00:00
8-10-2016 00:00



Conclusions

Benefits of using DCR/RTTR with cables:

- More optimal use of transport capacity of cable connections
- Preventing cable failures due to overheating
- Postpone or reconsider new investments



End of presentation