DYNAMIC LINE RATING FOR CONGESTION RELIEF

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- Dynamic Line Rating technology provider
- Invention of technology 2003 (4 patents, Cigre B2, C2)
- Commercial business since 2010
  - Elia, CREOS, ULg on Board
  - Steady, profitable growth
- 65-lines, 350-sensors, +10 years of operational experience
- Global distributors in +15 countries
- Partnerships with **Cable Monitoring** solution providers
- R&D in extended monitoring services
  - predictive maintenance
  - distribution grid monitoring
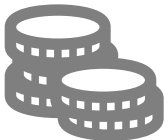
Dynamic line rating for congestion relief

How advanced is Dynamic Line Rating technology?

Where and how is it used?

Benefits to German congestion management
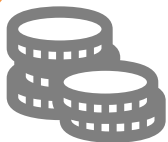
Dynamic line rating for congestion relief
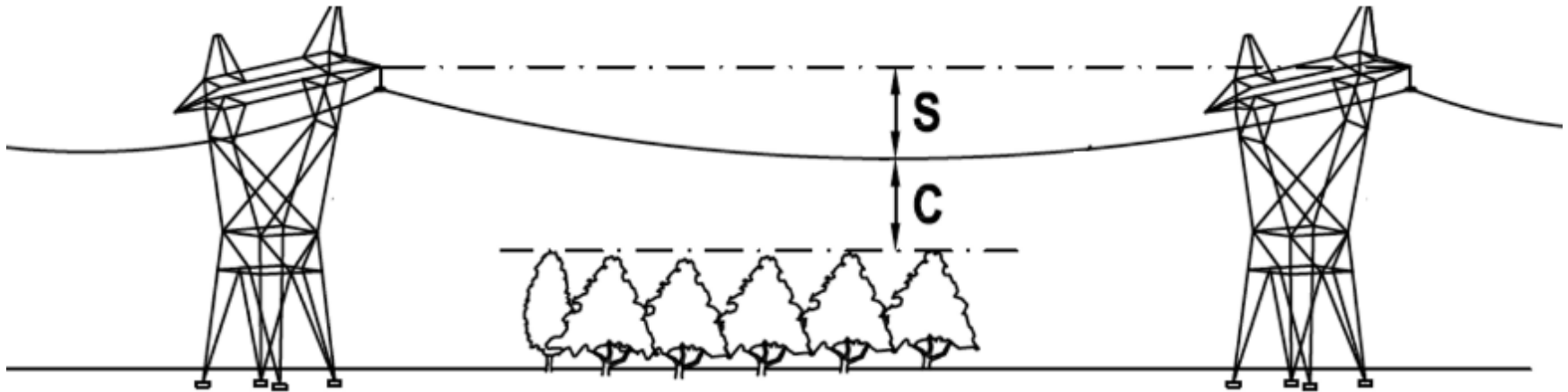
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What is DLR and how does it work?
- Line Sag and conductor temperature -

Security limits:

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

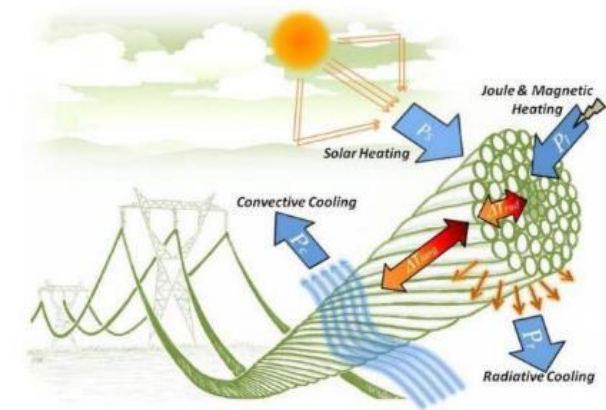**Static vs. Dynamic ratings:**

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** and direction
- Temperature
- Solar irradiation
- Icing on lines

Typical ambient conditions	Drake - thermal rating at 100°C
Wind speed: 0 to 10 m/s	**850 to 2,220 A (260%)**
Wind direction – 20 to 90 degrees	1,630 to 2,220 A (40%)
Air temperature - 0°C to 45 °C	1,140 to 1,400 A (23%)
Solar irradiance – 0 to 1000 w/m²	1,140 to 1,240 A (9%)

2019ISGT0323, Forecasting Dynamic Thermal Line Ratings by D. DOUGLAS, Douglas Power Consulting
http://ieee-isgt.org/panels/panel-details/#track-1-overhead-lines

How advanced is Dynamic Line Rating technology?

- Technique applied in grid control centers over decades already in Europe

- Sensors have been in US market since 1990's already

- Systems are installed with sensors in Europe since 2008, over 10 years of accumulated experience

- Used for Emergency Ratings, Intraday SO, Day-ahead SO planning, Market information, Asset management, starting now in LT planning

- Moving from pilots to tenders in Europe

What is reasonable to expect?
- Sensor-based DLR technology -

- Typically 10-20% average capacity gain
- Complies with reliability standards
- No major changes needed to SO processes
- Real-time and forecast values
- Available in few months
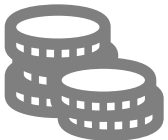- No regulatory barriers

Dynamic line rating for congestion relief

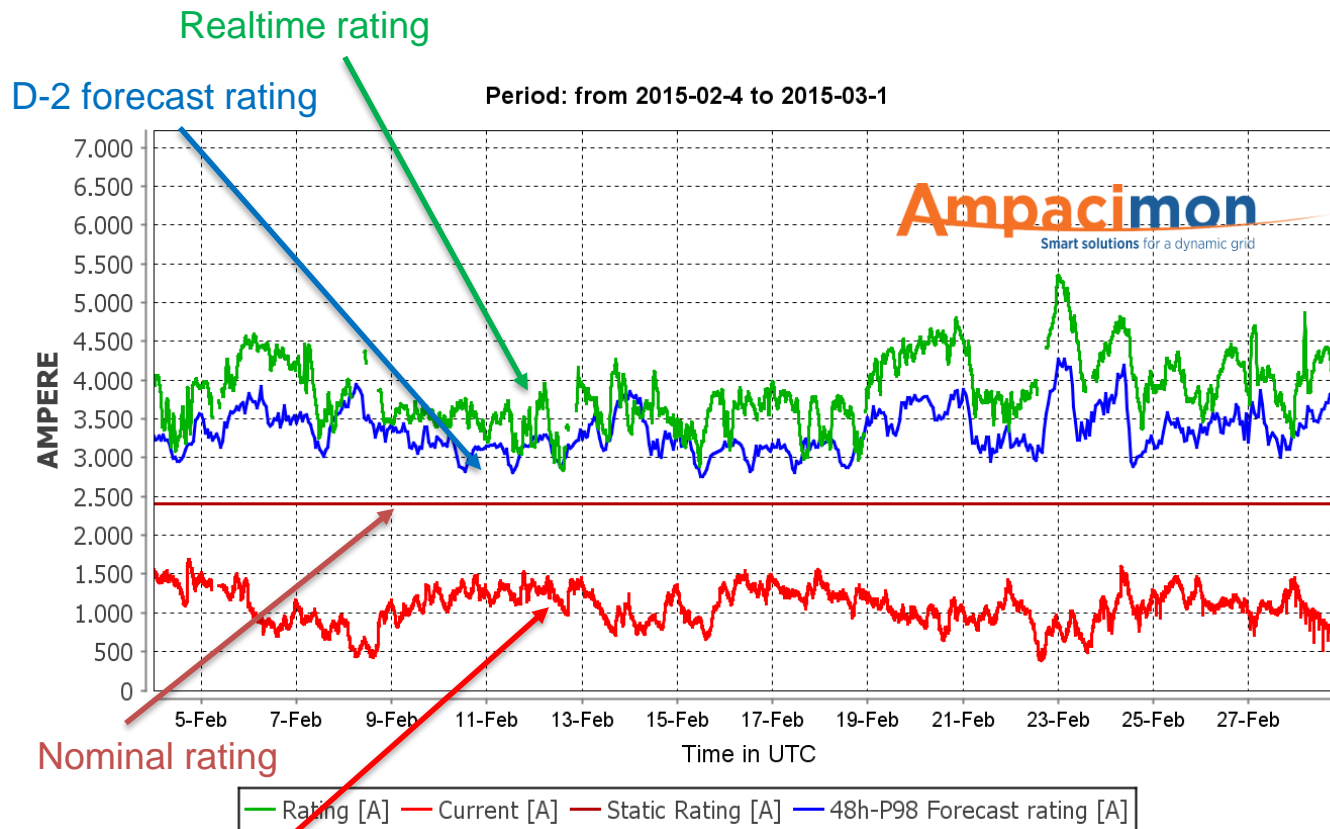How advanced is Dynamic Line Rating technology?

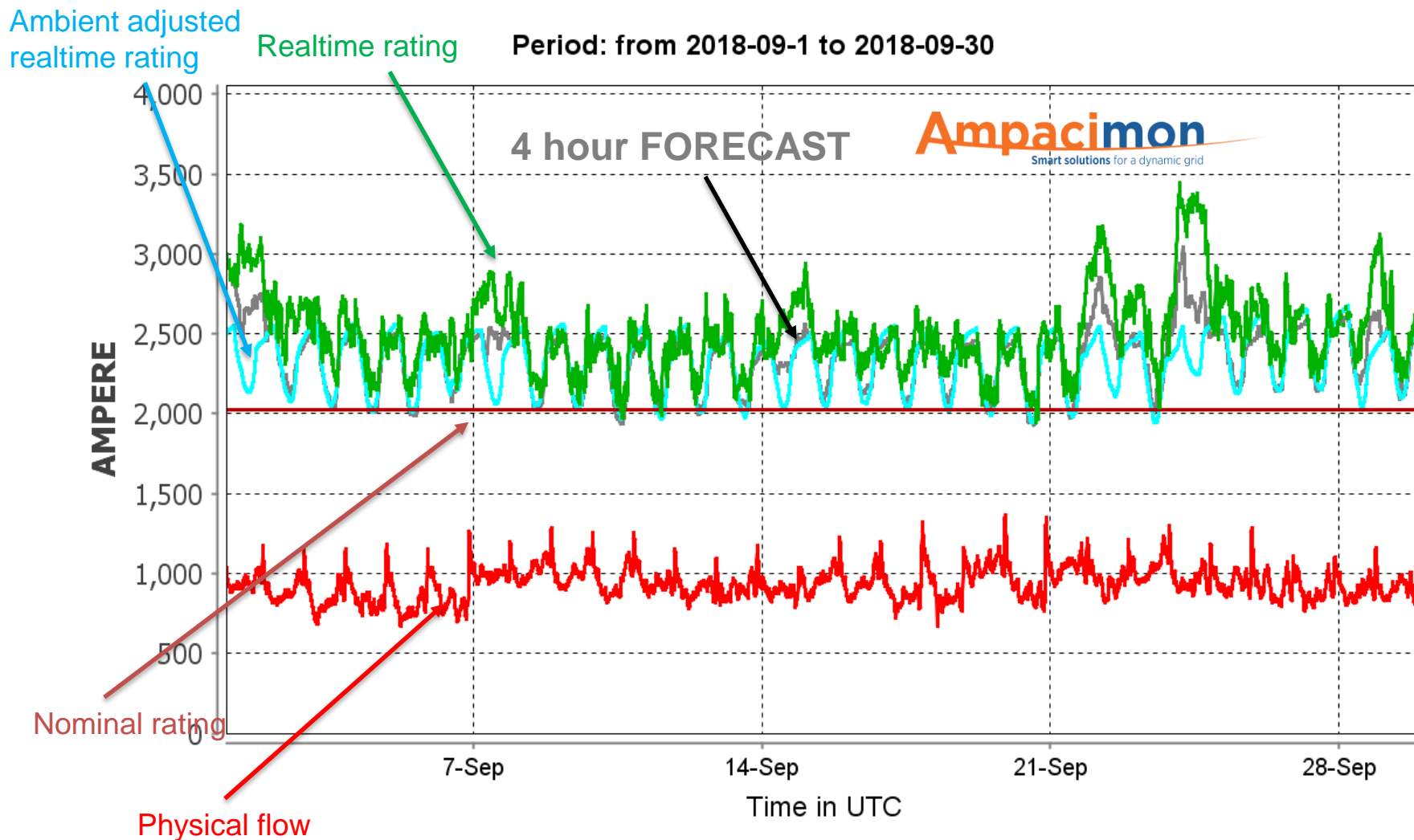Where and how is it used?

Benefits to German congestion management

Reliable and accurate increase of forecast grid capacity
- data provided by our sensors -

Realtime rating

D-2 forecast rating

Period: from 2015-02-4 to 2015-03-1

Nominal rating

Physical flow

Rating [A] — Current [A] — Static Rating [A] — 48h-P98 Forecast rating [A]

Time in UTC

- ➢ 98 % confidence (adjustable) RT>forecast
- ➢ Sag Monitoring guarantees clearance respect 100% of the time
- ➢ + 20% more capacity on average for real-time rating
- ➢ + 10% more capacity on average with D-2 forecast rating
- ➢ Extra capacity for congestion relief and market!

4 hour ahead forecast gives more gain than real-time ambient adjusted rating

Ambient adjusted realtime rating

Realtime rating

4 hour FORECAST

Period: from 2018-09-1 to 2018-09-30

Nominal rating

Physical flow

Support integration of data stream with system operation processes and workflows
## - we work together on -

1. Grid hot-spot analysis
2. Deployment on grid
3. SCADA integration
4. Realtime operation using emergency ratings and 1-hour ahead forecasts

5. Intraday operation using short-term forecast up to 4 hours
6. Day-ahead grid and market operation planning using forecast up to 2 days-ahead

APPROVED

Belgium benefits from reliable capacity increase for congestion relief in intraday and day ahead

- DLR maximize import capacity on all critical cross-border lines.

- Critical internal lines are also equipped with DLR sensors.

- Two days ahead capacity forecast offers additional exchange volume to the market.

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 € (Elia)
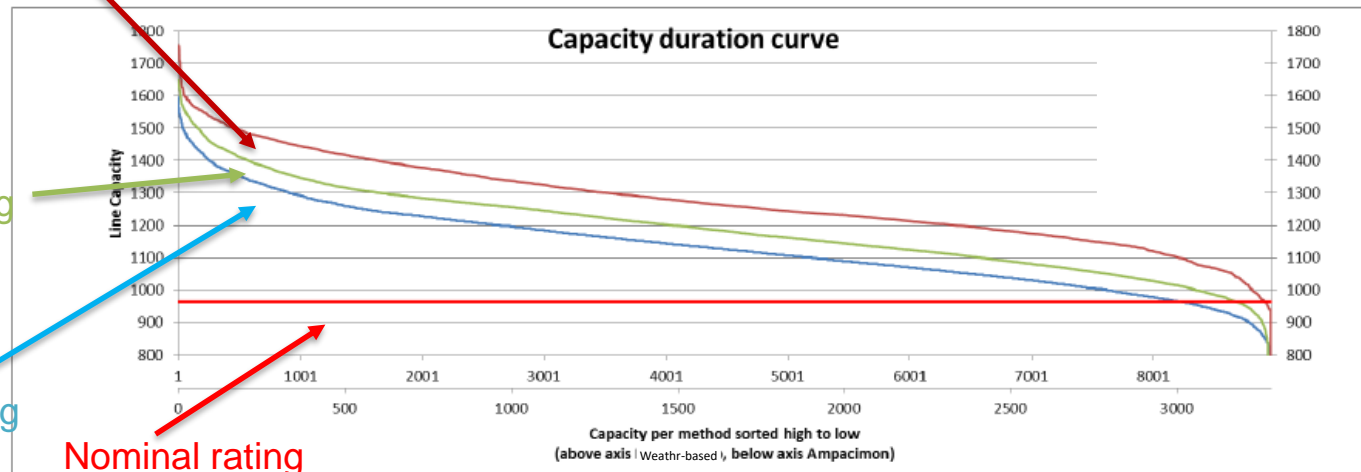

INTERNATIONAL NETWORK 380-220-150kV
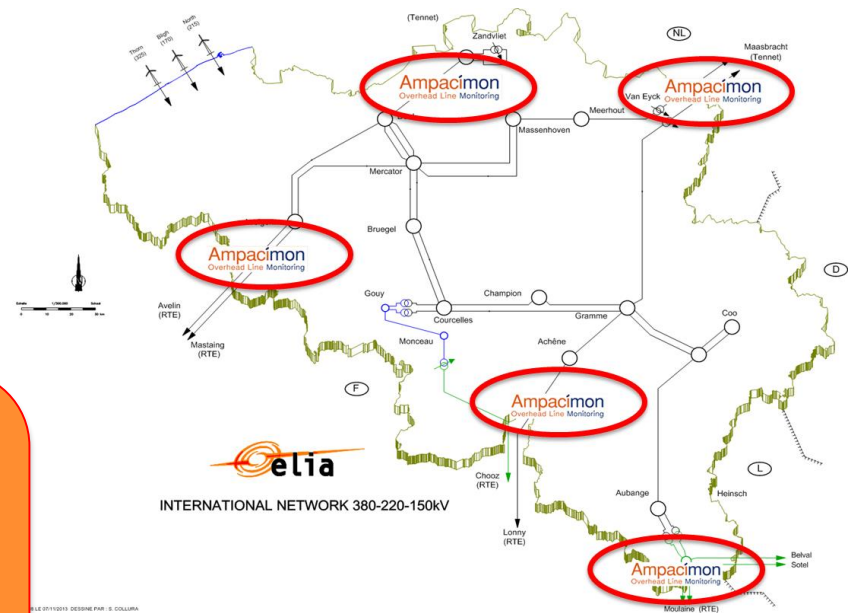
TSO uses two DLR technologies for ensuring best possible capacity gain
- our sensor & weather-based -

Our sensor rating

Weather-based rating

Adjusted weather-based rating

Nominal rating

Capacity duration curve

Capacity per method sorted high to low
(above axis | Weathr-based |, below axis Ampacimon)

- Additional capacity:
  - Ampacimon: 99% of the time

  Weather-based : 90% of the time
- Additional 10% capacity
  - Ampacimon: 95% of the time

  Weather-based : 70% of the time

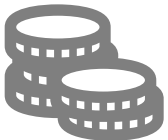| Percentile	Summer	Winter	Weathr-based		Ampacimon
			reduction	full	
	A	A	A	A	A
99	965	1140	873	922	979
95	965	1140	938	987	1067
90	965	1140	974	1025	1113
85	965	1140	1000	1052	1146
80	965	1140	1022	1075	1168
75	965	1140	1041	1094	1187
70	965	1140	1060	1115	1204
65	965	1140	1077	1132	1219
60	965	1140	1093	1149	1234
55	965	1140	1109	1166	1246

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Benefits to German congestion management

Abbildung 42: Dauer von strombedingten Redispatch Einzelüberlastungsmaßnahmen auf den am stärksten betroffenen Netzelementen im Gesamtjahr 2017 gemäß Meldungen der ÜNB

Cost +1 Billion EUR in 2017 and 2018

BNetzA Monitroing Report lists for 2017

- 38 most congested lines
- Quantities
  - Total 6 150 GWh per direction (for the 38 lines)
  - For all lines 18 456 GWh
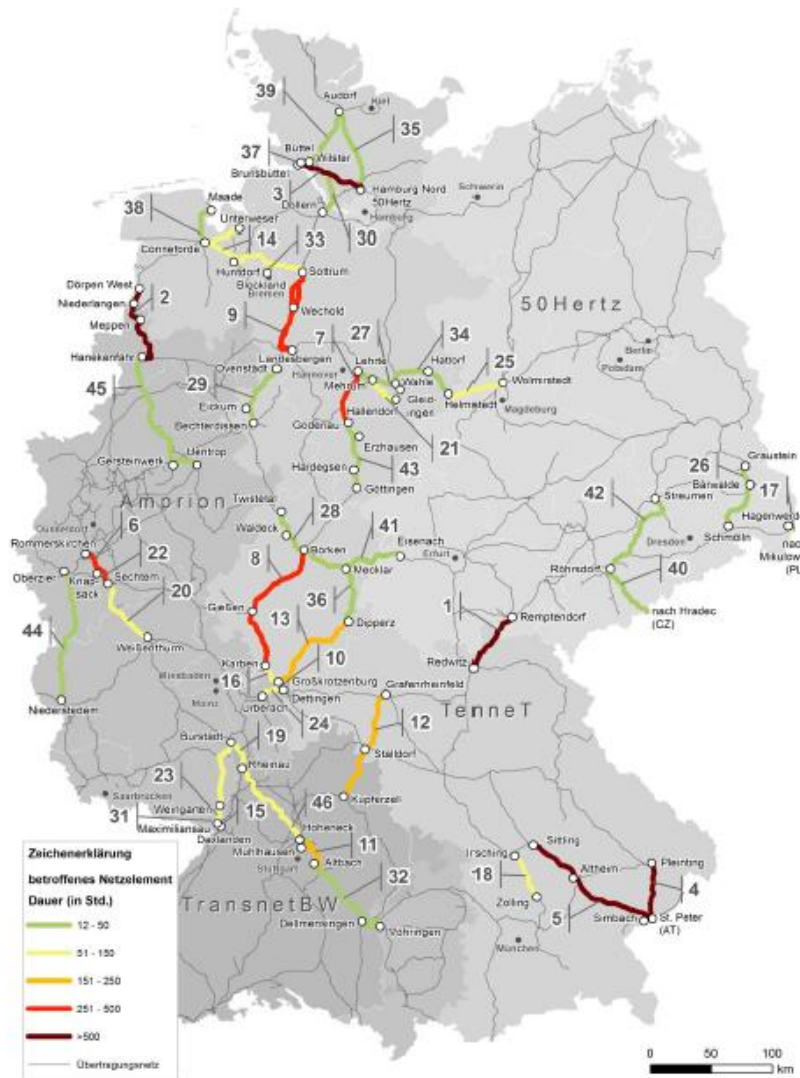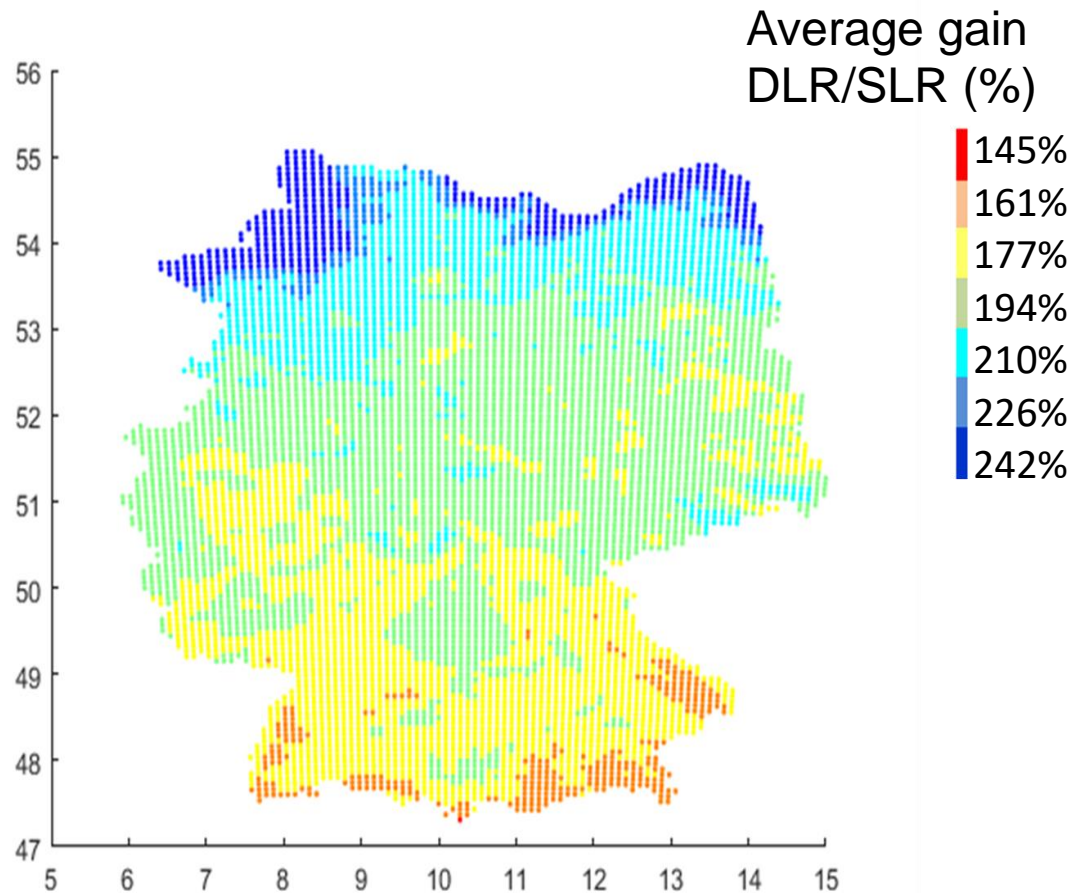- Location on map (more than 38 lines)

DLR potential in Germany is known
- heat map for 380kV network -

- DLR can benefit congestion in all regions

- This map is based on 2012 weather model (7x7km) data!

- Local conditions not taken into account but gives broad overview

Average gain DLR/SLR (%)

145%	
161%	
177%	
194%	
210%	
226%	
242%	

Master Thesis by Fahad Mansoor @Univ Magdeburg: Analysis of DLR as part of the planning process for optimization of German transmission grid

TSO can avoid already with fraction of cost

Estimation exercise:

- Congestion map + ampacity gain map gives rough estimation of line length and average gain

- For each hour of congestion on the line (GWh/year ÷ h/year), how much could be avoided with average gain

- Sum all hours of avoided redispatch down energy (for the listed 38 lines) ~6TWh

- Apply unit cost of redispatch: ~21kEUR per GWh

- ~ 10 Million EUR to equip the listed 38 lines

- ~ 65% of redispatch could have been avoided

- In order of 250 Million EUR could have been saved with our DLR

IMPORTANT! Find optimal cost with combination of alternatives, DLR with grid operators' power flow control actions, localized flexibility markets, Netzbooster etc

Further trainings

ENTSOE webinar on DLR (20th March 2019)

https://www.entsoe.eu/events/2019/03/20/smart-grid-world-of-innovations-dynamic-line-rating-webinar/

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