Better utilization of power system infrastructure by using dynamic thermal rating

Dinamik Termal Değerlendirme Yapılarak Güç Sistem Altyapısının Daha İyi Kullanımı

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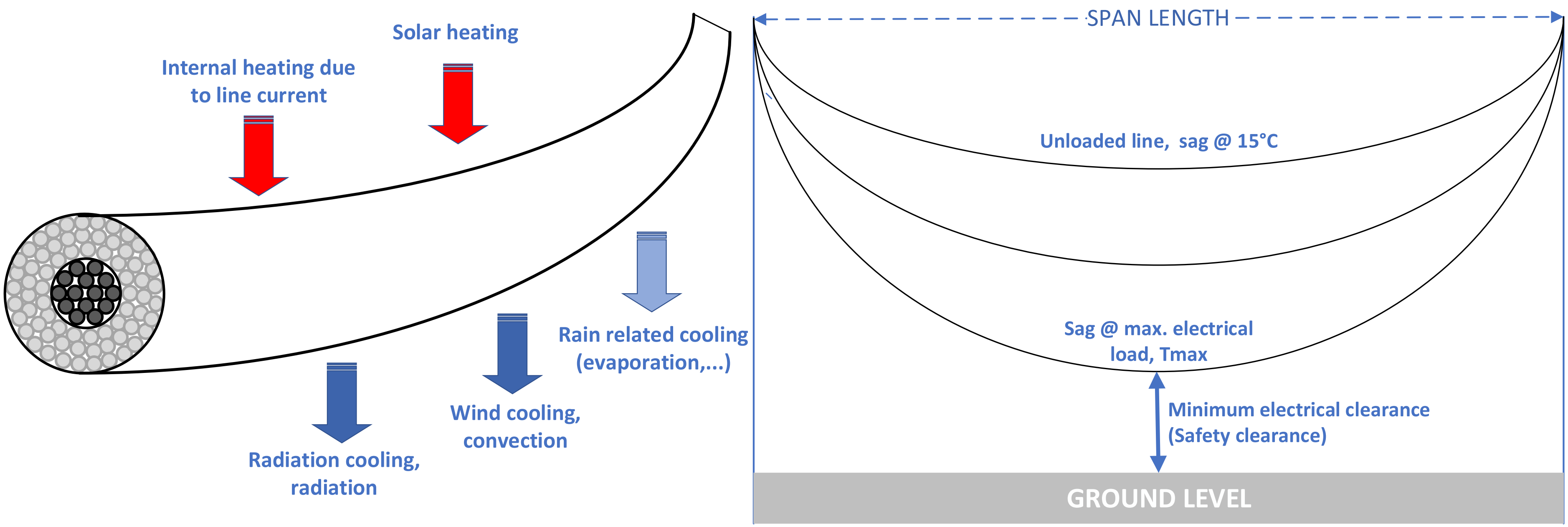
VI. ELEKTRİK TESİSAT ULUSAL KONGRE ve SERGİS, Izmir, October 2019

About EIMV

Name:	**Elektroinštitut Milan Vidmar** Milan Vidmar Electric Power Research Institute
Address:	Hajdrihova 2, SI - 1000 Ljubljana, SLOVENIA, EU
Web:	www.eimv.si
Type:	Research institution
Founders:	Slovenian Academy of Sciences and Arts
Shareholders:	Slovenian Academy of Sciences and Arts (100%)
Number of employees:	100
Date of court registration:	1st of June **1948**
Quality systems:	ISO 9001 (QMS), ISO14001 (EMS), EN ISO/IEC 17020 (Control Body), EN ISO/IEC 17025 (Testing Laboratory)

Prof. dr. Milan Vidmar
1885-1962

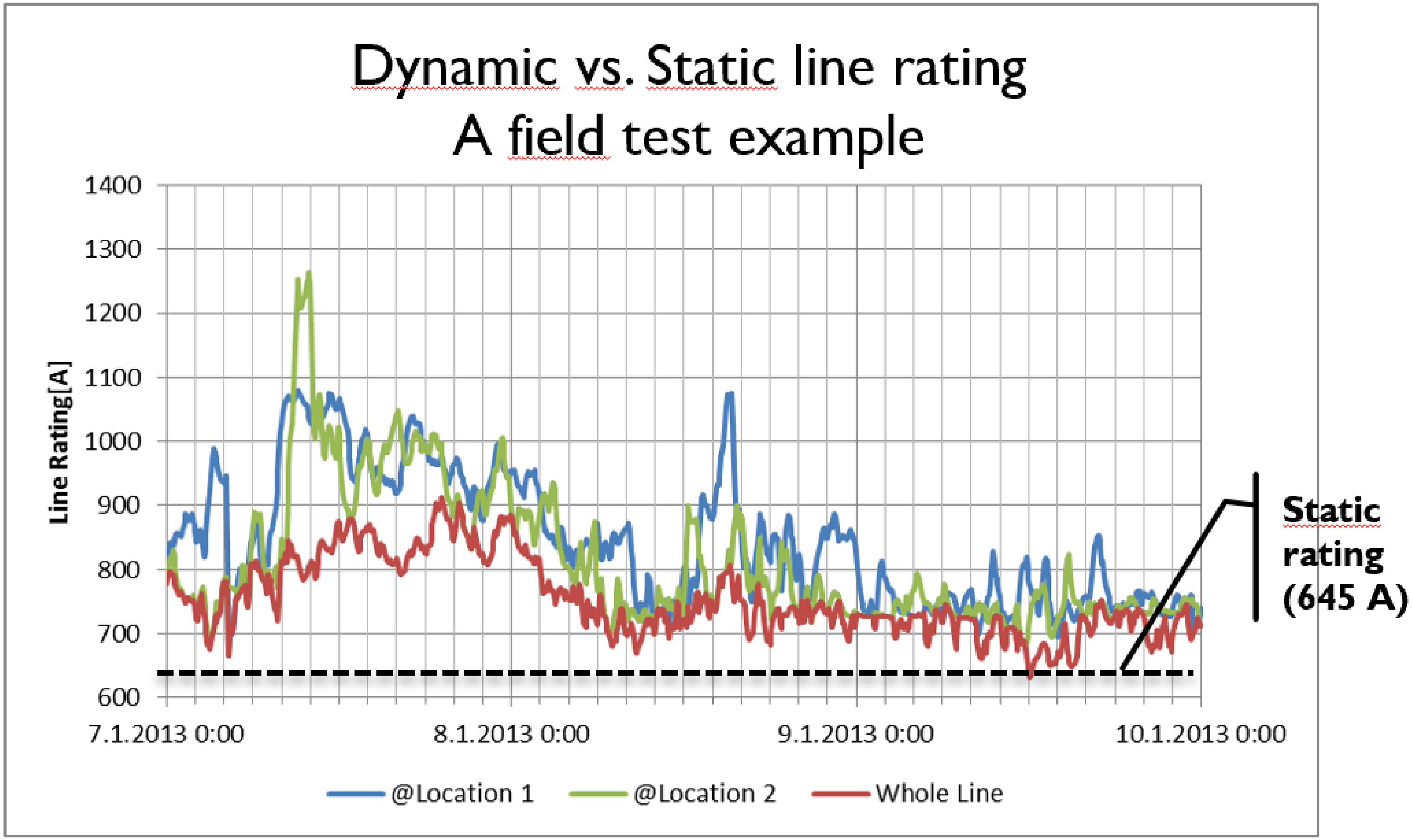
Dynamic Line Rating



Dynamic Thermal Rating covers line rating and also ratings of other equipment, e.g. power transformers, etc.

Dynamic Line Rating is usually the most difficult to implement.

Dynamic Line Rating



Operator's point of view

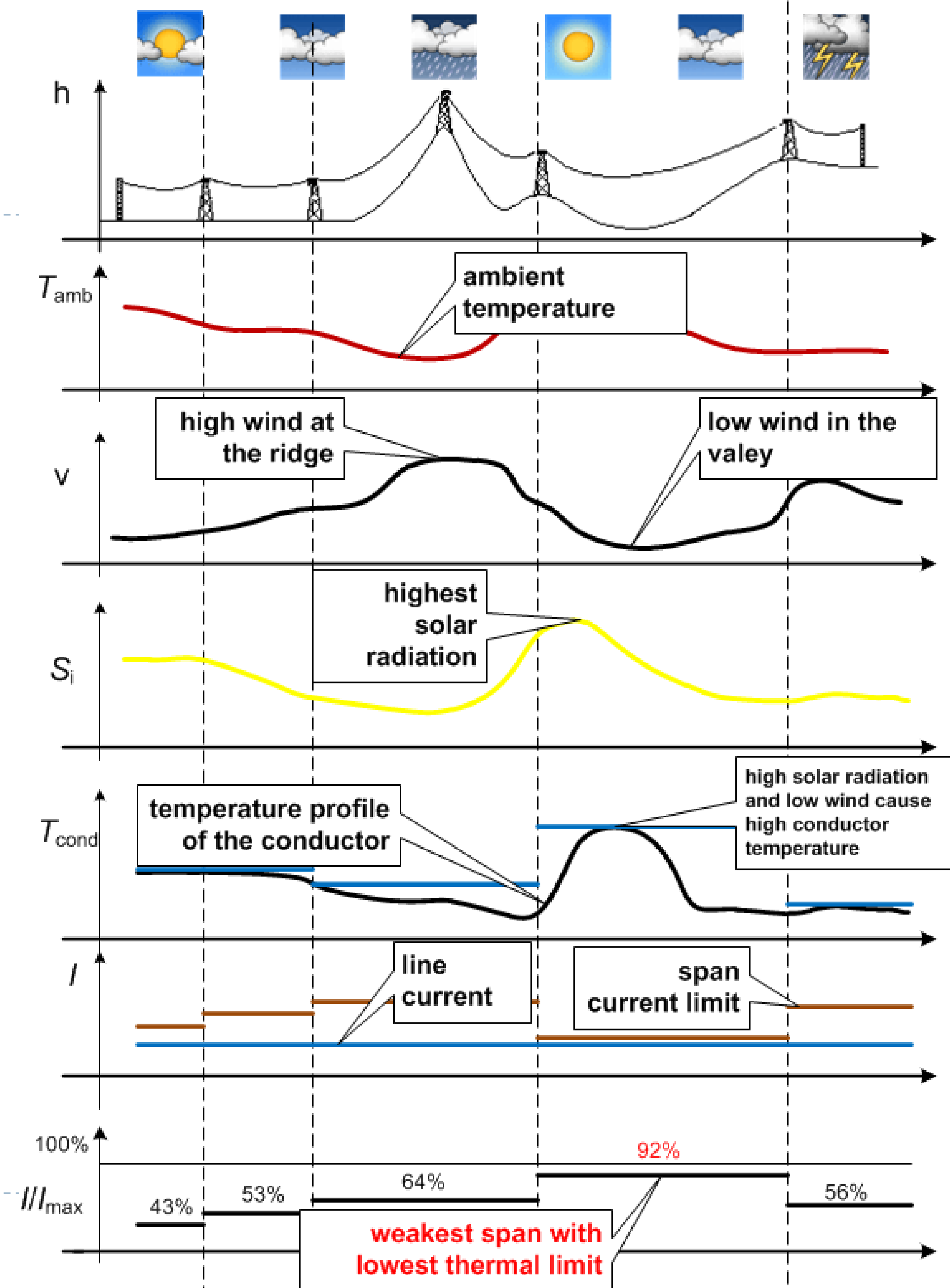
Increasing the transmission capacity of the overhead lines from the operator's point of view is related to:

- Thermal limits - ampacities (dynamic raitings)
- Permissible operating time in case of overcurrent
- Taking into the account also N-1 situation
- Alerts on extreme weather conditions along the line (strong wind, high/low temperatures, lightning, icing,…)

DLR

Weather conditions along the line vary all the time, which means that „bottle neck“ span changes location.

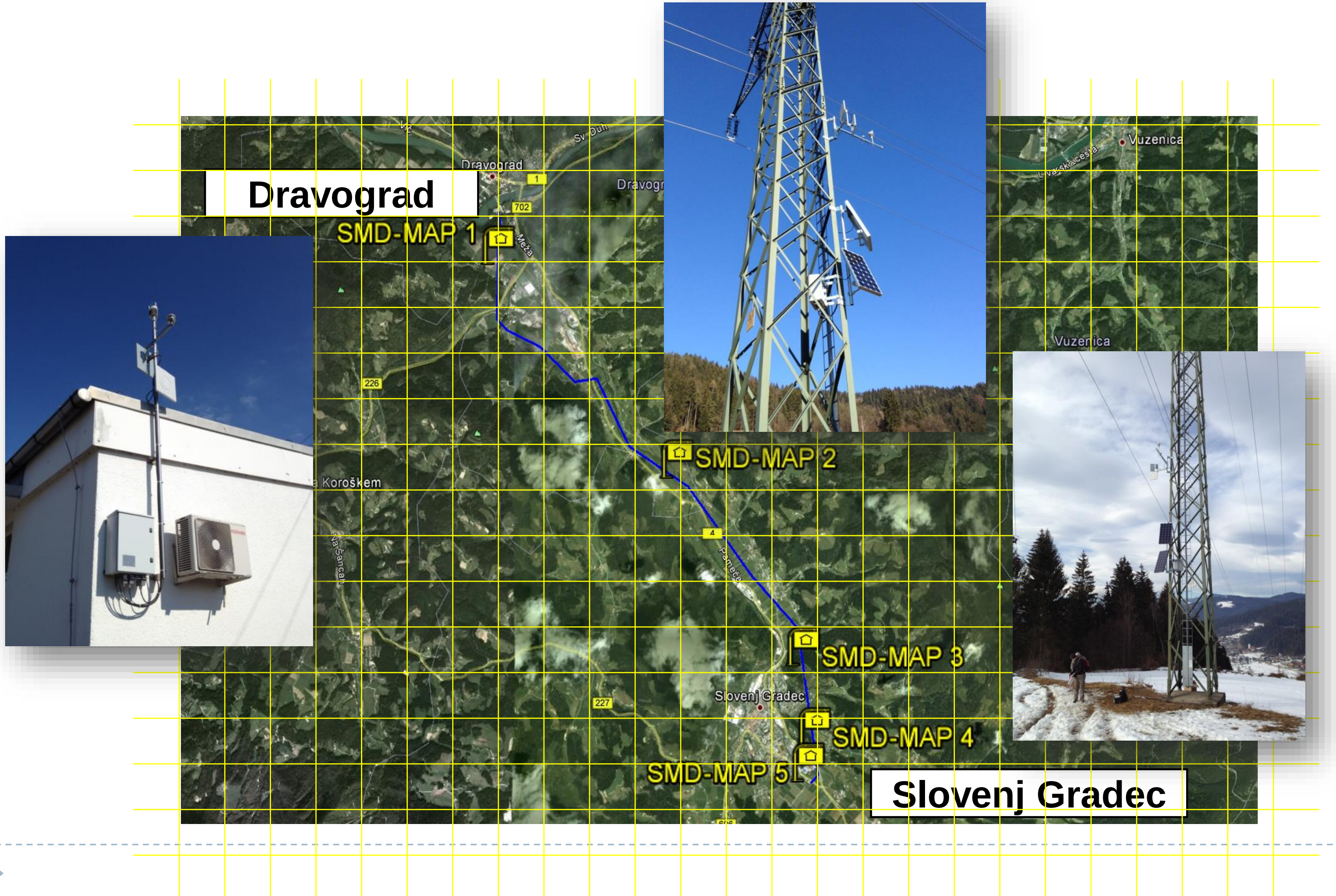
DLR calculation shall be performed per span!



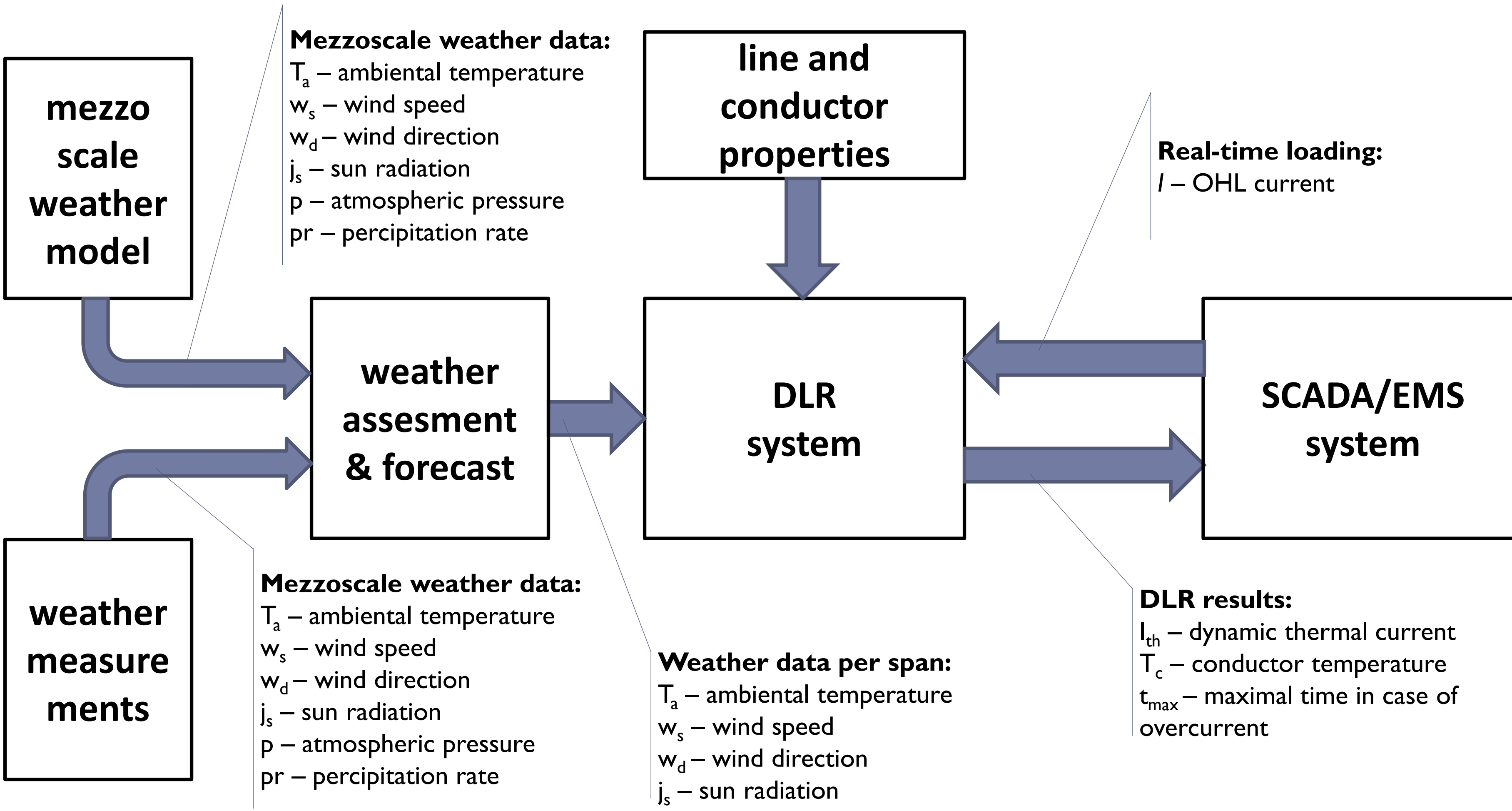
Meteorological models – an example

Weather variables are determined for the fixed geographical resolution grid 500 ×500m from results **of the mesoscale meteorological model** by using the **microscale** weather model, which also takes into account the orography of the terrain and some weather measurements (if available).

Enhancing observability of the weather conditions => enhancing the model results

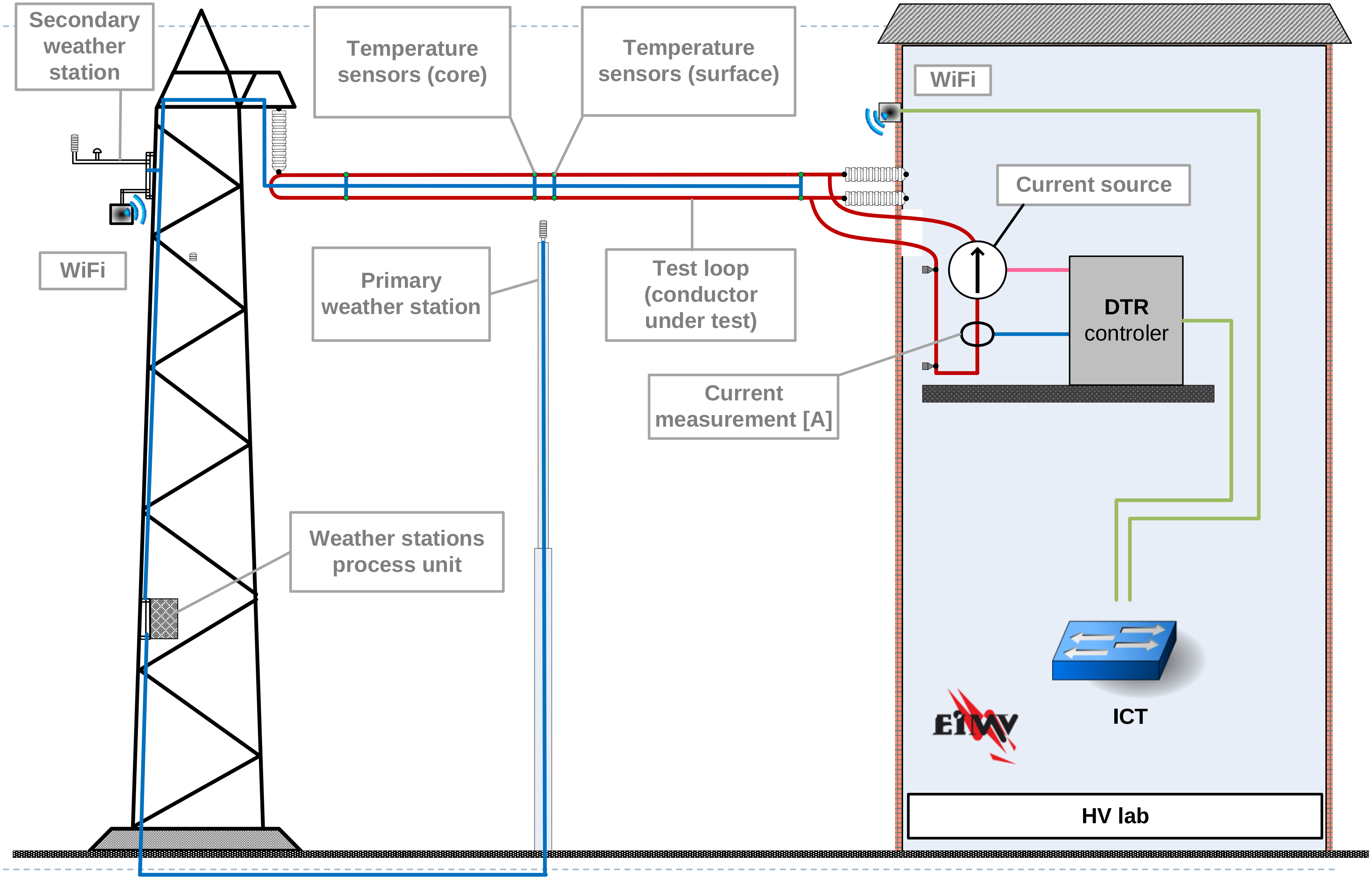


Basic structure of the DLR system

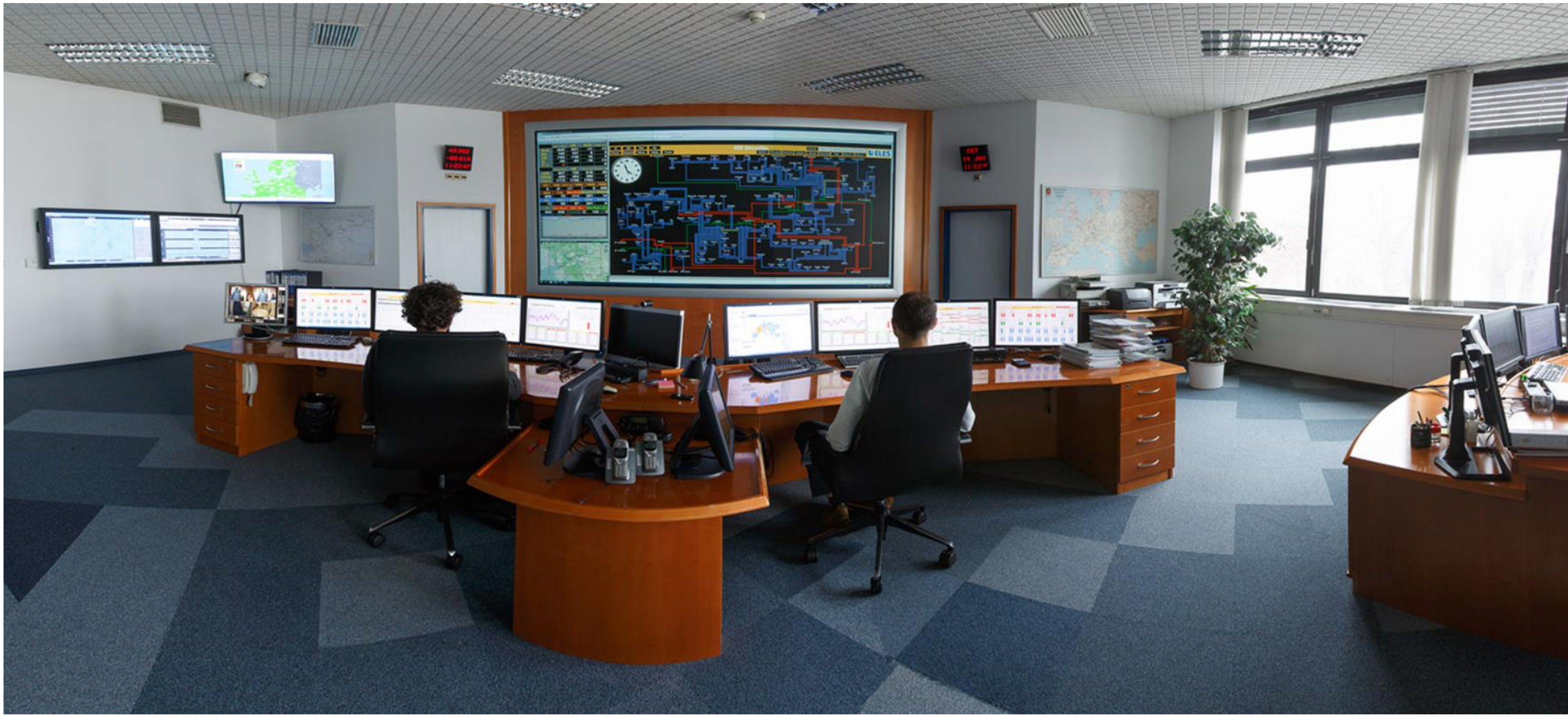


A reference testing site for DLR uncertainty evaluation

Scheme of the test site

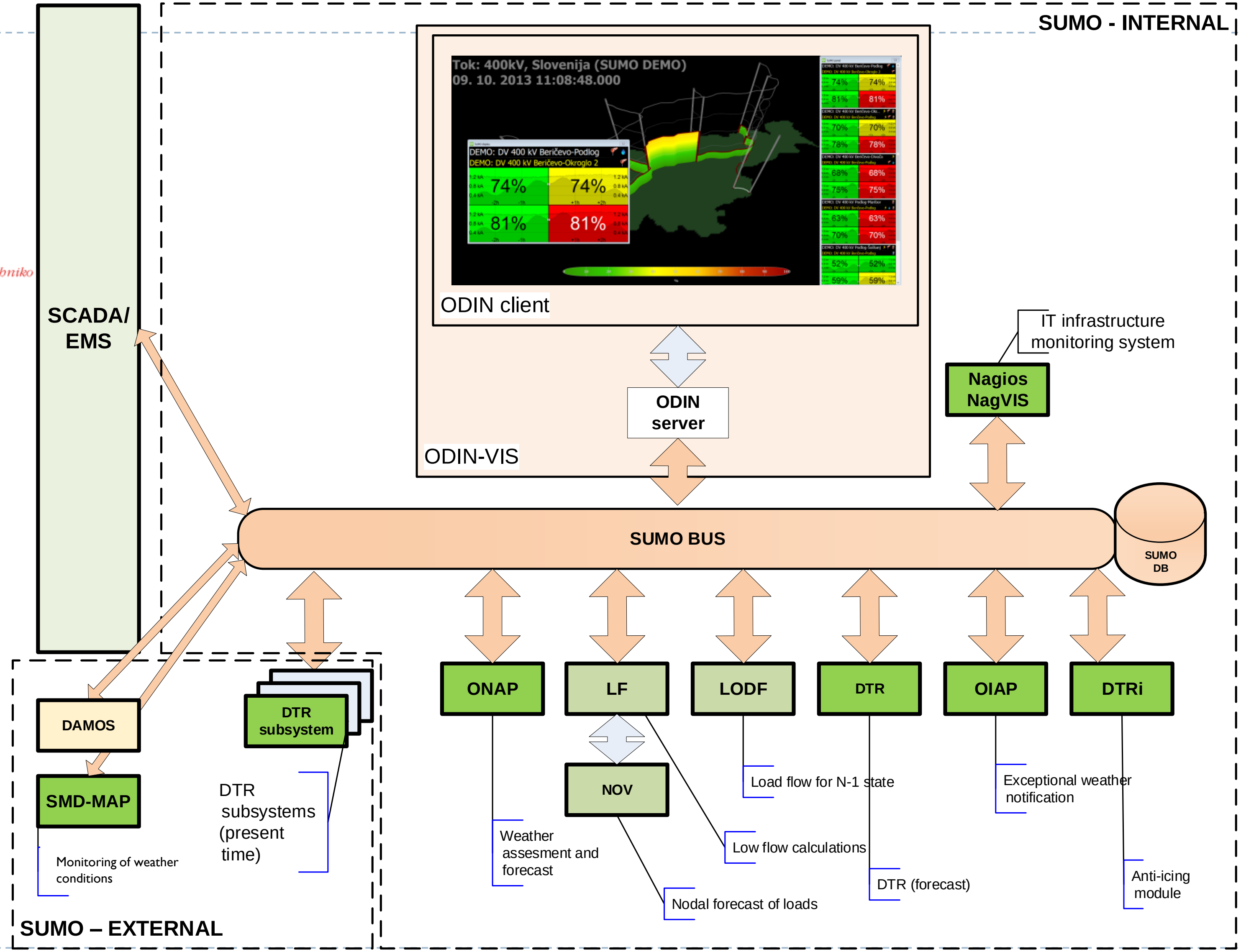


Implementation at the Slovenian TSO ELES

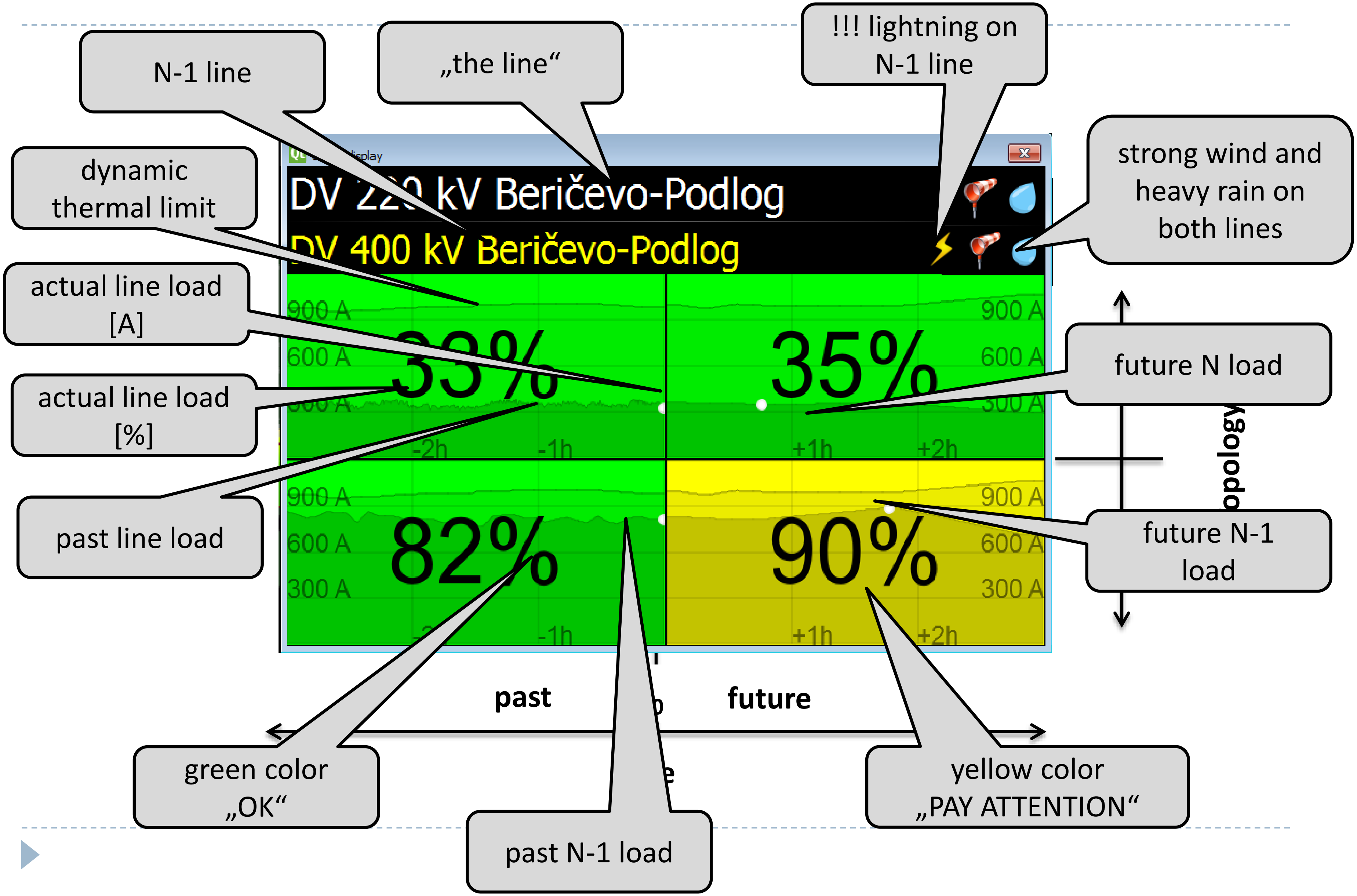


As of December 2013 the system had been trial running with 4 power lines. In December 2015 additional 17 power lines and one phase shift transformer were added. Since 2017 the system has been in full operational mode. Currently the dynamic thermal limits are calculated for 29 OHL, one phase-shift and two power transformers.

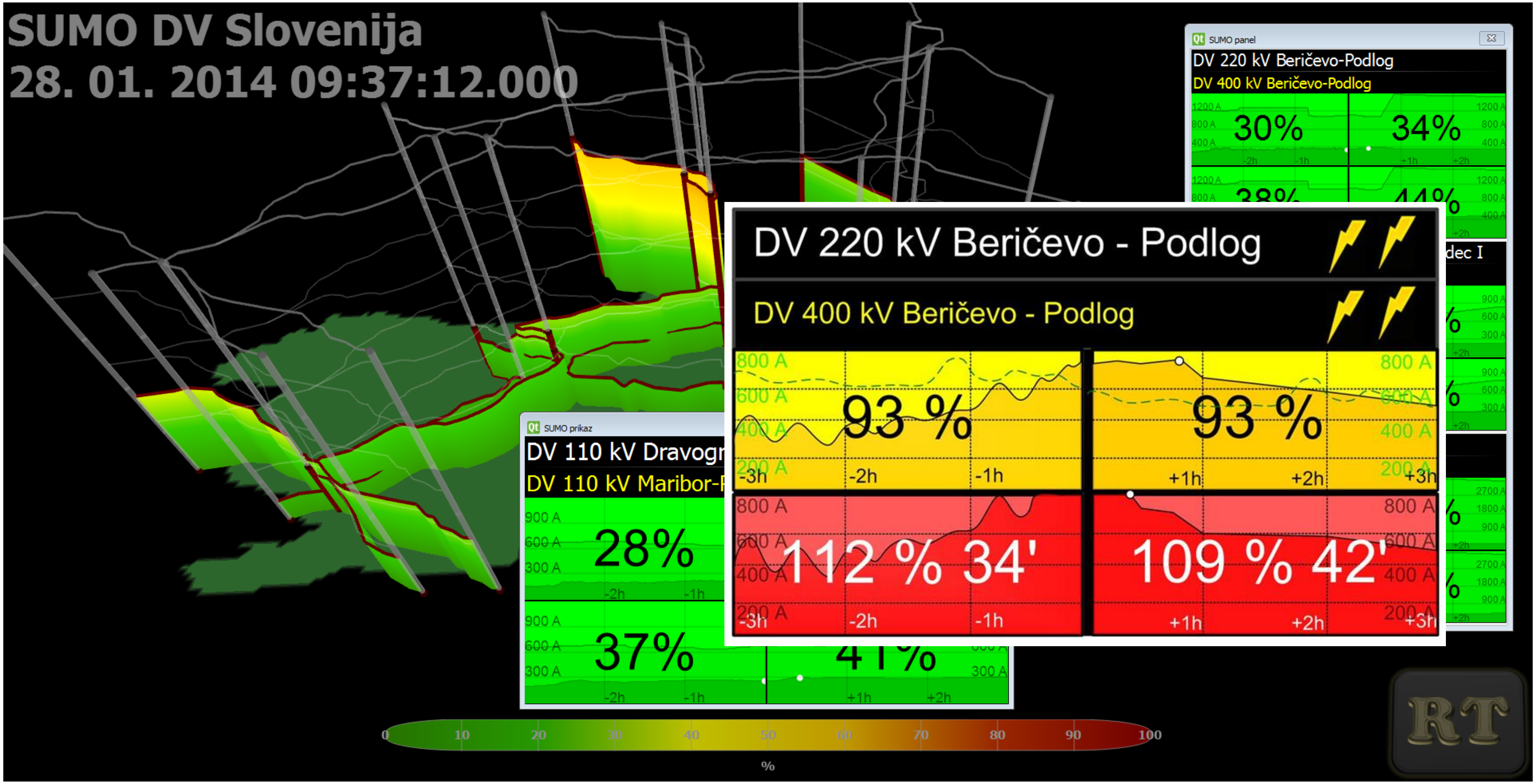
System architecture @ Slovenian TSO ELES



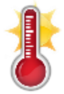
4 quadrants visualization (DLR)

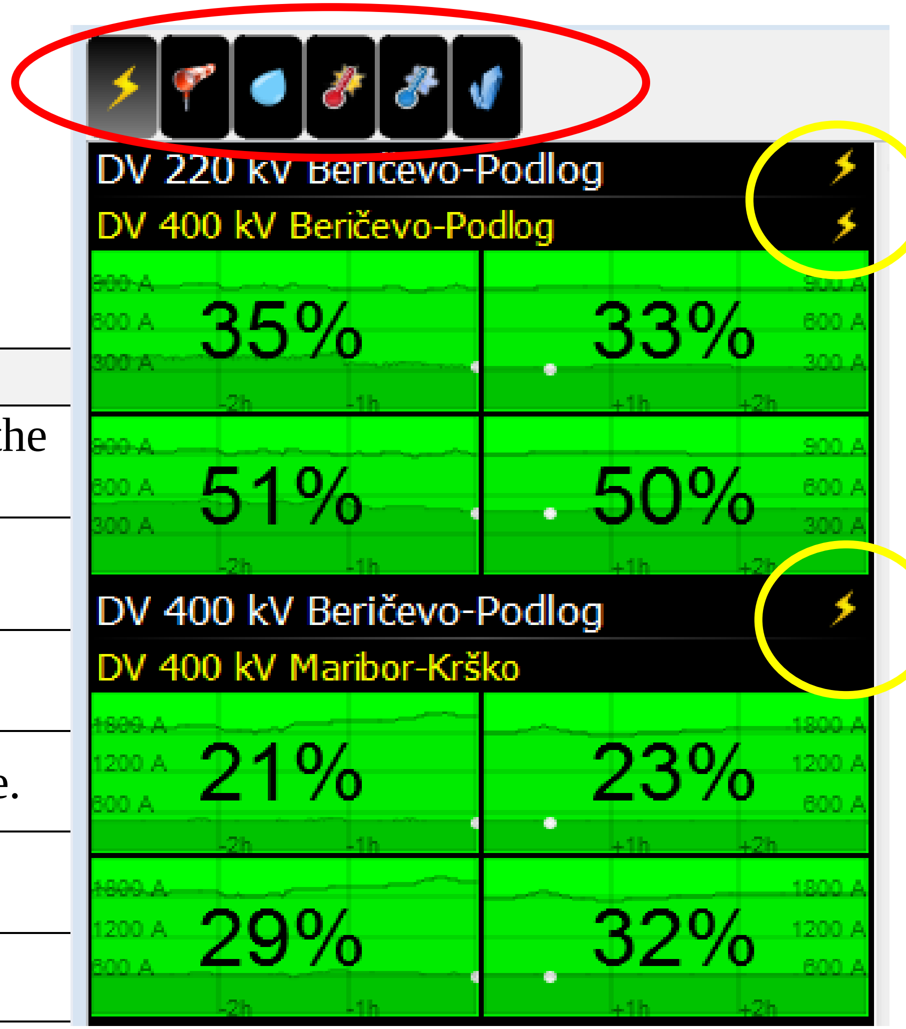


Visualisation application ODIN-VIS



Alerts on extreme weather conditions

Symbol	*Meaning*
	Thunderstorm – lightning activity on the route.
	High wind speed on the route (gale or storm)
	High air temperatures on the route.
	Low temperatures or frost on the route.
	Heavy rain on the route.
	Danger of glaze ice.



SCADA integration
ABB Network Manager‘s HMI

Notranji DV

Meje prekoračitev 400 kV DV

DV	$I_{th-stat}$ [A]	I_{th-din} [A]	I_{th-obr} [A]	Meja OCV [A]	Meja RCV [A]
BER4DIV	1920	2017,8	1920,0	1824	1728
BER4POD	1920	2055,9	1920,0	1824	1728
DIV4PST	1732	2709,9	1732,0	1645	1559

Meje prekoračitev 220 kV DV

DV	$I_{th-stat}$ [A]	I_{th-din} [A]	I_{th-obr} [A]	Meja OCV [A]	Meja RCV [A]
BER2KLE	960	1032,3	960,0	912	864
BER2POD	960	1027,9	960,0	912	864
KLE2DIV	960	1135,6	1135,6	1079	1022
SOS2POD	960	1040,4	960,0	912	864

Meje prekoračitev 110 kV DV

DV	$I_{th-stat}$ [A]	I_{th-din} [A]	I_{th-obr} [A]	Meja OCV [A]
AJD1DIV1	1200	1381,7	1200,0	1100
AJD1DIV2	1200	1381,7	1200,0	1100
AJD1IDR	645	745,2	645,0	600
AVC1GOR1	645	658,1	645,0	600
AVC1GOR2	645	658,1	645,0	600
BER1DOM	645	621,5	645,0	600
CER1IDR	645	1162,0	645,0	600
DIV1PIV	340	465,5	450,0	419
GOR1AJD	1200	1128,3	1200,0	1100
GOR1PLA	645	743,0	645,0	600
HED1SLG	645	746,0	645,0	600
PIV1ILB	340	365,8	365,8	340

Figure 3: The results: operational thermal rating and limit values

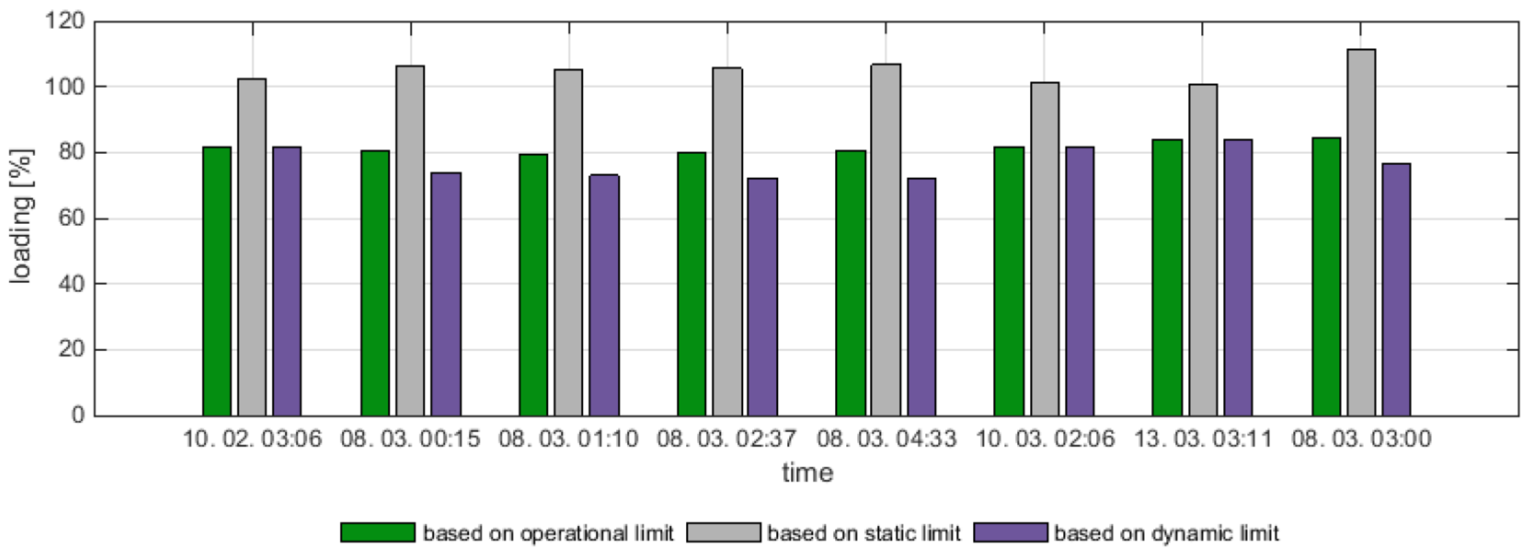
Mednarodni 220 kV DV

Št.	Uporabi SUMO DTR	Upoštevaj partnerja	DV	P [MW] / I [A]	I_{th-obr} [A]	I/I_{th-obr} [%]	TSO	Stanje DTR	$I_{th-stat}$ [A]	I_{th-din} [A]	Maks. čas preob. [min]	Temp. vod. [°C]	Upošteva lim. part.
3	VKL	VKL	OBE2POD	-163	1065,3	37	ELES	✓	920	1065,3	∞	26,9	✓
				396			APG	✓	920	1115,7	---	---	✓

Figure 5: Control of the devices

Experience from RT operation – an example

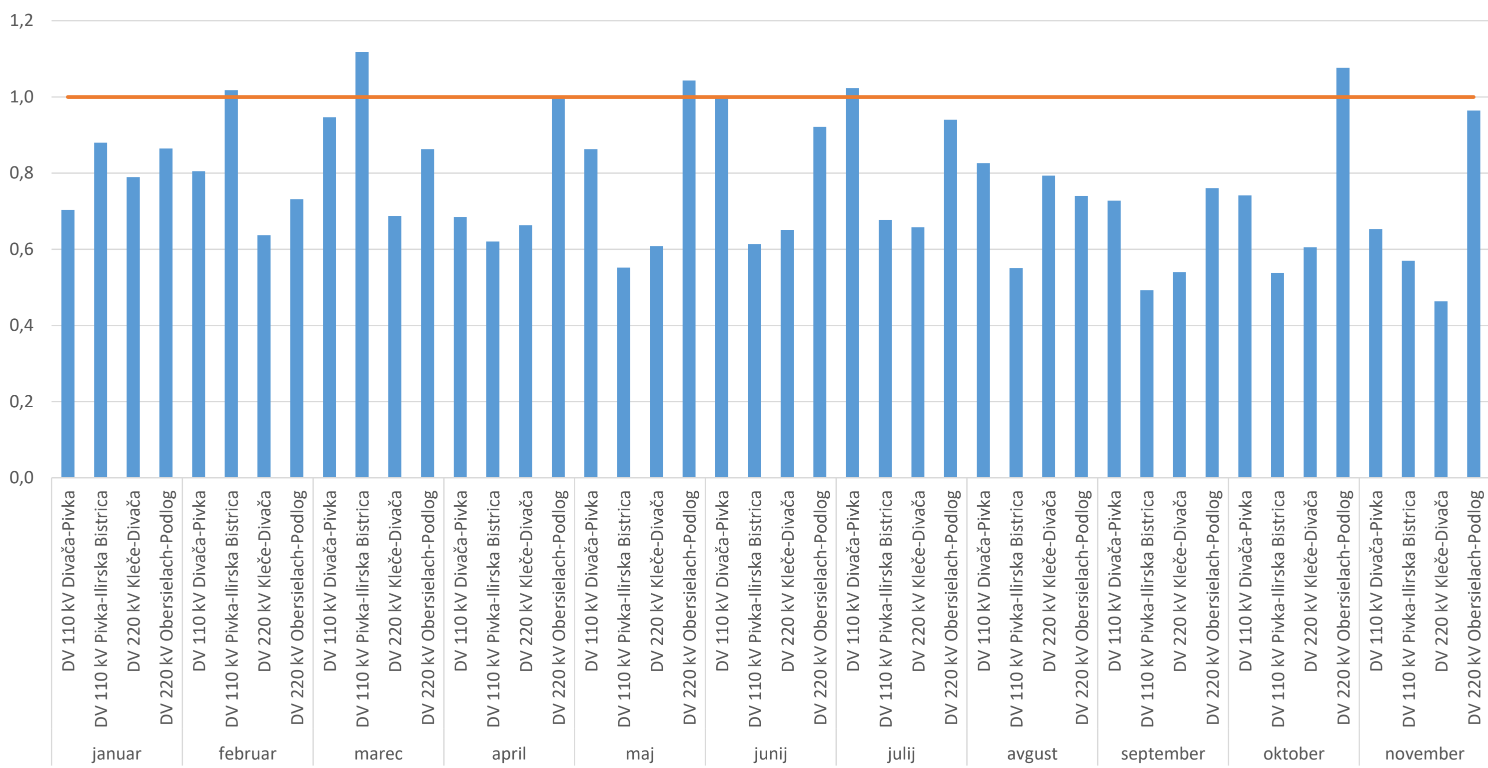
- Outage of a 400/110 kV power transformer in Divača substation → increased loadings in south Primorska region
- Countermeasures:
  - Usage of the DLR system
  - Adaptation of protection systems
  - Conductor temperature measurement device installation (OTLM)
- Result: increased transmission capacity → prevention of seven overloadings (up to 113 %)



Ref. [3]

Experience from RT operation (2017)

- Prevention of overloadings in several N-1 occasions and at the N topology as well



References

- [1] M. Maksić, V. Djurica, A. Souvent, J. Slak, M. Depolli, and G. Kosec, '**Cooling of overhead power lines due to the natural convection**', *Int. J. Electr. Power Energy Syst.*, no. 113, p. str. 333-343, 2019.
- [2] G. Kosec, M. Maksić, and V. Djurica, '**Dynamic thermal rating of power lines : model and measurements in rainy conditions**', *Int. J. Electr. Power Energy Syst.*, vol. 91, p. str. 222-229, 2017.
- [3] Š. Vidrih, J. Kosmač, T. Tomšič, A. Donko, and A. Matko, '**Operational Experiences with the Dynamic Thermal Rating System**'. CIGRE SEERC Kijev 2018, Jun-2018.
- [4] G. Lakota, J. Kosmač, J. Kostevc, A. Souvent, and T. Fatur, '**Real-time and short-term forecast assessment of power grid operating limits - SUMO**', presented at the Actual trends in development of Power System Relay Protection and Automation, Sochi (Russia), 2015.
- [5] J. Kosmač, G. Kosec, B. Vertačnik, and N. Zima, '**Resilience improvement attempts after severe icing storm**', presented at the Energy transition and innovations in electricity sector, 2018, p. 13 str.
- [6] A. Souvent, J. Kosmač, M. Pantoš, R. Vončina, and M. Maksić, '**SUMO - a system for real-time assessment and short-term forecast of operational limits in the Slovenian transmission network**', presented at the CIGRE SEERC Portoroz 2016, 2016, p. 10 str.

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