Grid of the Future

Dynamic System Rating

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Challenges due to renewable integration

- Oscillations
- System strength
- Inertia...

leading to stability issues...

Of course solutions are evolving that includes:

- WAMPAC,
- Grid forming invertors
- BESS
- Synchronous condensers with flywheel

On the one hand....

- Capacity constraints

leading to Congestion, Curtailment issues.....

- higher congestion management cost
- thermal stability issues coupled with other stability issue

...Grid enhancing technologies such as DLR, advanced power flow & topology controls....

On the other....

Problem statement (s)

- Integration of more renewables to the grid is limited by the system constraints causing renewable **generation curtailment** (for the developer) . In NA, in CAISO for the year 2019, renewable energy curtailment of wind and solar was 250,000 MWh.
- Similarly, increase in renewables is causing **congestion** (for the utility) on the lines preventing the generation from getting to where it is needed.
- Solutions such as reconductoring or adding lines are both CAPEX intensive and have long permitting and construction timelines. Using alternative solutions such as Dynamic System Rating (DSR) could prove more economical and with quicker impact.

What is needed to solve Congestion & Curtailment issues?

Dynamic System Rating (DSR):

- Use dynamic line rating (**DLR**) and dynamic power rating (**DPR**) to determine the actual throughput of the line in real time.
- Adapting to the variability of generation by adjusting the tap changers of transformers and reactive power compensation devices.
- In doing so, ensure both transformer thermal capacity is monitored using the transformer thermal model and protection settings (thermal) are adapted to protect the devices in the new operating conditions.

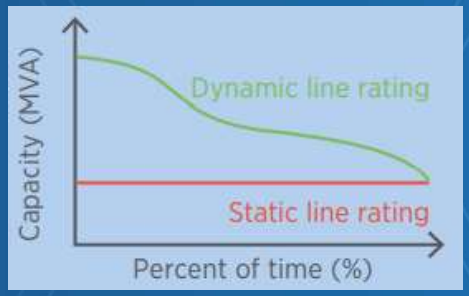
In summary, DSR manages network congestion by enabling temporary overload of assets for "Grid Optimization" **AND** while doing so, considers the overall impact on their health or derating for "Grid Resiliency".

DLR is " 3rd party coverage car-insurance" and DSR is "comprehensive coverage car insurance"

DLR & DPR

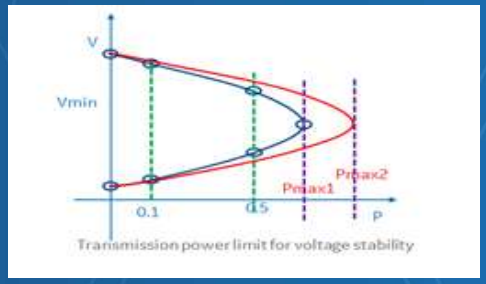
What is DLR? **IRENA's** definition …

DLR refers to the active varying of presumed thermal capacity for overhead power lines in response to environmental and weather conditions. This is done **continually in real time**, based on changes in ambient temperature, wind speed and wind direction, with the aim of minimising grid congestions.

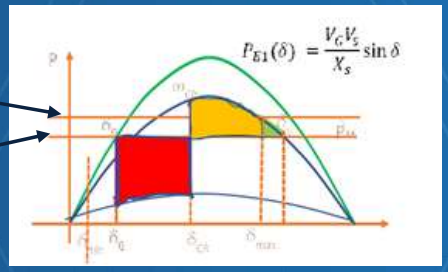


What is DPR?

While ensuring **dynamic ampacity** of the line, it is beneficial to calculate the dynamic **power (active) limit** of the line, not only for reducing the risk of losing stability, but for increasing the transmission capacity within the stability margins, without losing angular and voltage stability.



Dynamic power (active) limits adjusted to maintain equal areas between red (acceleration) and orange (de-acceleration) zones.

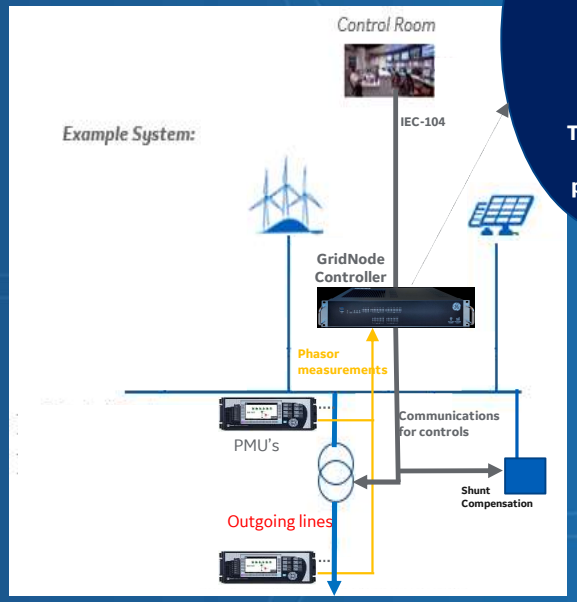


GE Solution

(1) Use Dynamic Line Rating (DLR) technology to calculate the maximum **CURRENT rating** in real time and Dynamic Power Rating (DPR) to calculate the maximum **POWER rating** of the line at a given time (short duration).

(2) Based on the above information further increase the capacity of the line throughput by **controlling** the transformer tap changers and reactive VAR compensation devices, whilst ensuring transformer thermal and power capacity are **monitored** using the transformer thermal model and adaptive protection.

(3) **Adaptive thermal protection** to monitor and protect the devices employed in the line in real time.



GridNode: DSR

DLR

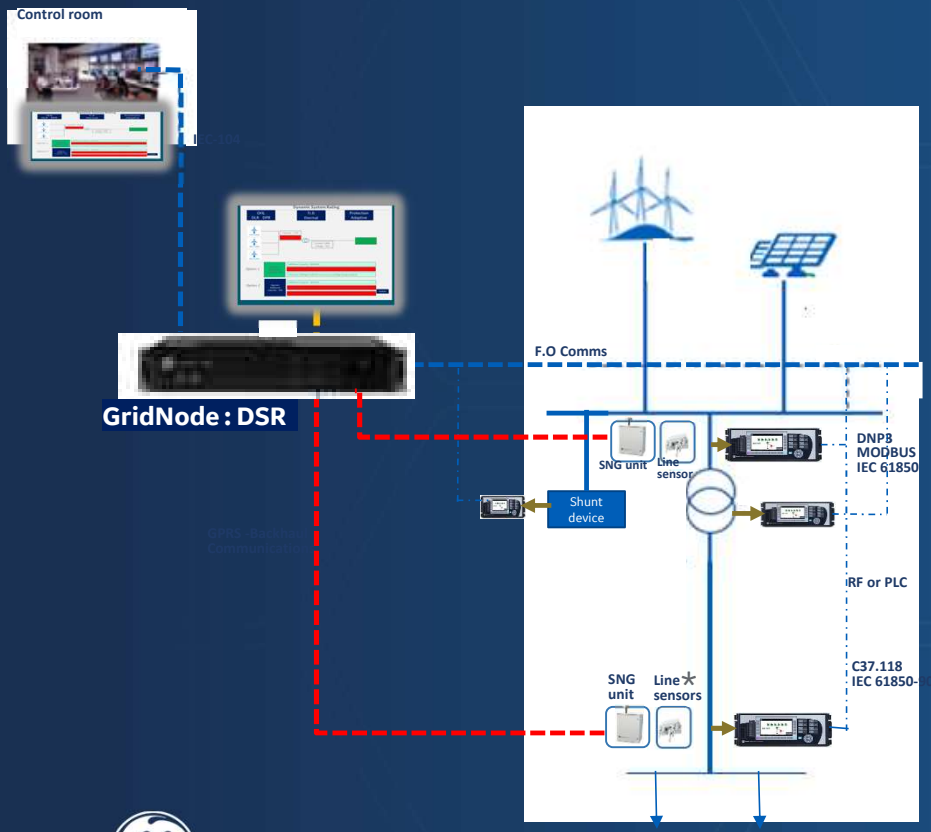
Imax, Pmax

Tx. Thermal Adaptive protection

- Fast Controller actions

Renewable integration to Grid

DSR – How does the solution work?



INPUTS

- Line parameters
- Power flow
- Weather condition
- Tx. Tap changer position.
- Reactive compensation device settings

GridNode : DSR

DLR (I_{max})
DPR (P_{max})

OUTPUTS

- Farm power ref
- Line rating : Imax, Pmax
- Controller settings
- Protection settings

More communication options:
(1) Remote PMU communicating via switch at the remote end. Communication between switches (local and remote) is RF or PLC .
From local switch to GridNode direct F.O connection.

*** Location of line sensors will be decided based on the topology of the region**

ENTSO-E's recommendation based on analysis of different DLR technologies

11. It should be noted also that under certain conditions the DLR may push the thermal loading beyond the stability limit (in particular transient, voltage or small signal stability) or introduce too high reactive power losses for which the necessary reactive compensation may not be available. These issues have to be carefully considered before the additional loadability is made available.
12. Compared to the current rigid approach DLR may allow an increase in loading but we have to reserve a margin for the uncertainties associated with the applied method. An accurate assessment of this margin requires detailed analysis based on pilot installations over long time periods.

NEED FOR DSR

👉 All 12 recommendations can be studied under:

https://eepublicdownloads.entsoe.eu/clean-documents/SOC%20documents/Regional_Groups_Continental_Europe/Dynamic_Line_Rating_V6.pdf

Who are the targets customers

1) Transmission, sub-transmission utilities
2) Primary distribution utilities
3) Independent Power Producers
4) Independent system operators

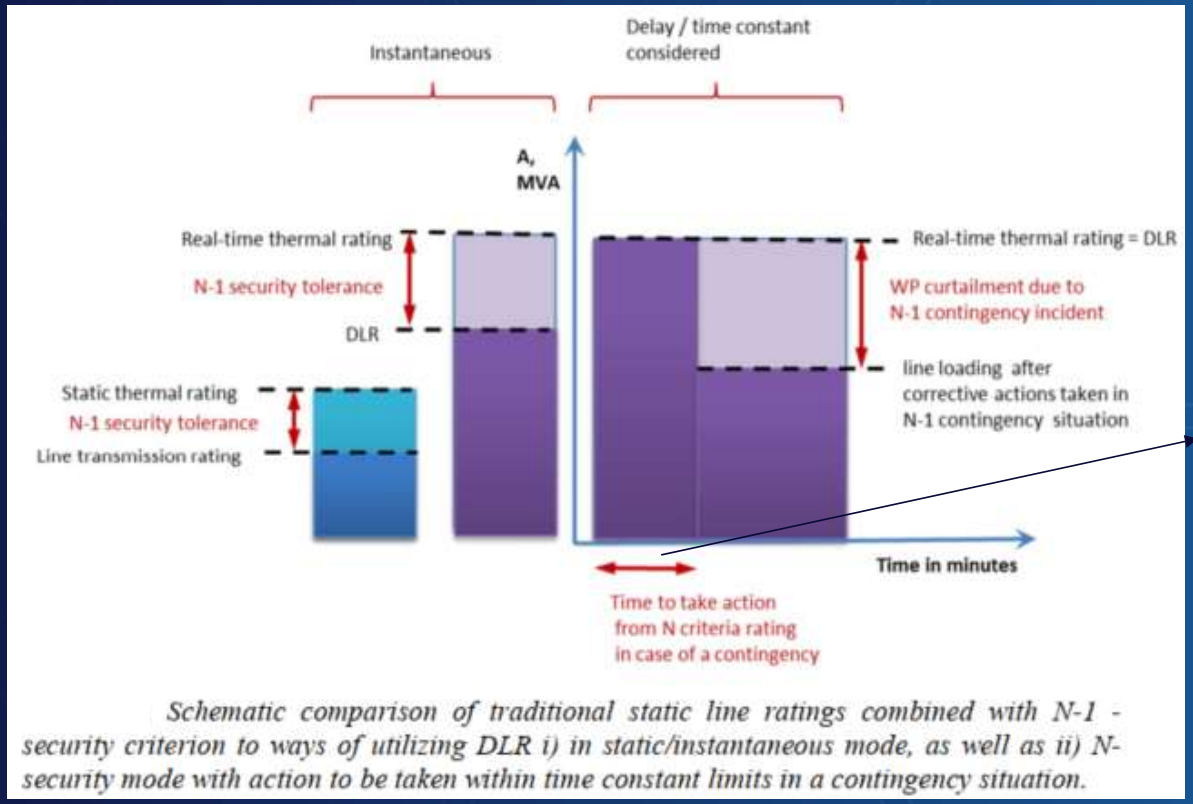
Applicable Use Cases

1) Py. Dist., Sub-Tx, Tx Utility connection with Ren
2) Developer connection with Utility
3) General, congested lines across Py. Dist., sub-Tx, Tx lines

Possible Stakeholder (s)

- GA
  - GridNode : DSR + thermal model + Controls
  - relays (Adaptive protection)
- Power Transformer thermal model

(WAMPAC/ SIPS) + DSR



Schematic comparison of traditional static line ratings combined with N-1 - security criterion to ways of utilizing DLR i) in static/instantaneous mode, as well as ii) N-security mode with action to be taken within time constant limits in a contingency situation.

Natively termed
"Grid of the future"