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Flexibility in Wind Power Interconnection Utilizing Scalable Power Flow Control

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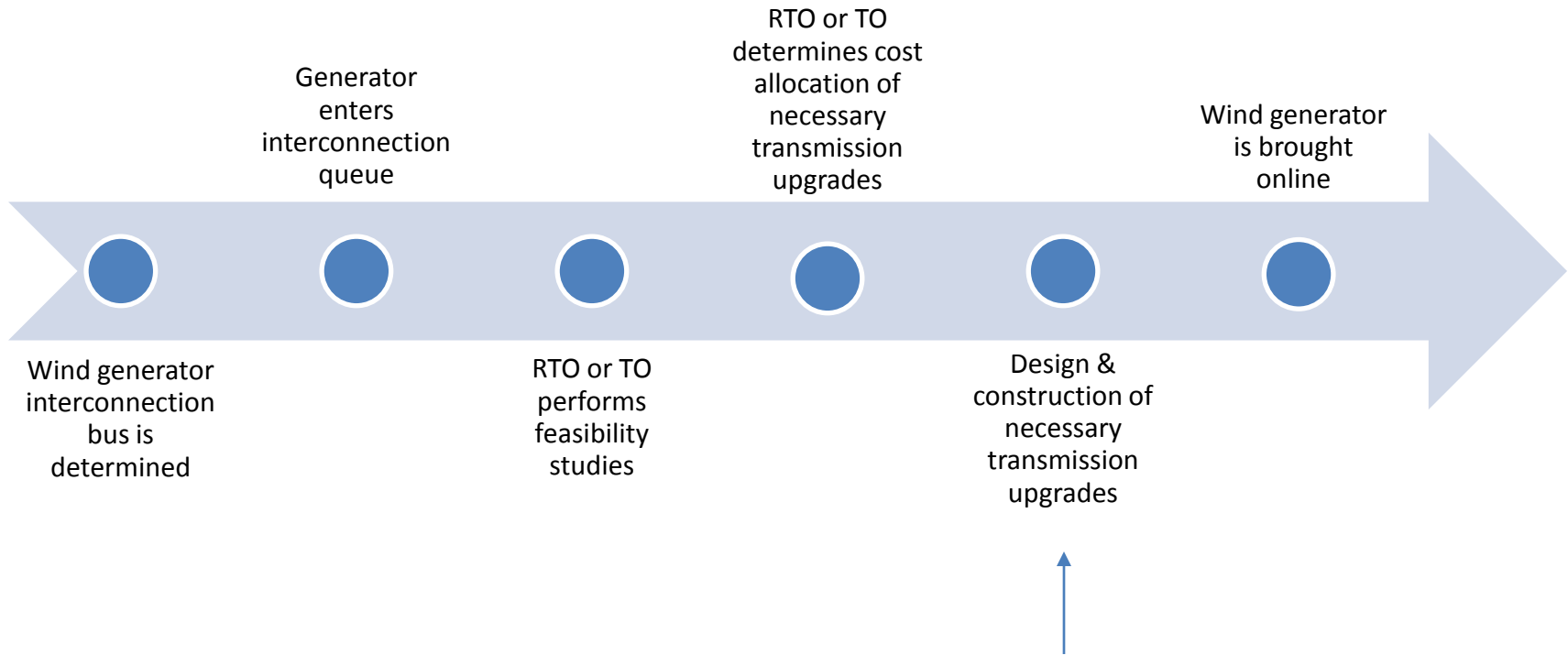
Planning for Uncertainty

- Wind developments have increased rapidly over the last decade, driving billions of dollars worth of transmission projects.
- Interconnection queues suggest this trend will continue for some time, which means additional transmission enhancements will be needed.
- A number of factors are increasing the uncertainty related to transmission planning:
 - Federal production tax credit
 - State renewable portfolio changes
 - EPA Clean Power Plan
 - Commodity price volatility





Interconnection Process



Wind farm developers are responsible for many of these upgrades, which increases the fixed costs of renewable energy projects.



Impact of Transmission Constraints

- Many reliability constraints must be resolved before a wind farm is initially brought online.
- The cost and time to address some constraints can derail wind projects altogether.
- Existing wind farms may be subject to curtailment at certain times due to transmission congestion or reliability issues.
- Eliminating congestion with conventional transmission solutions may prove too costly



The risk of stranded assets makes it difficult to eliminate some congestion

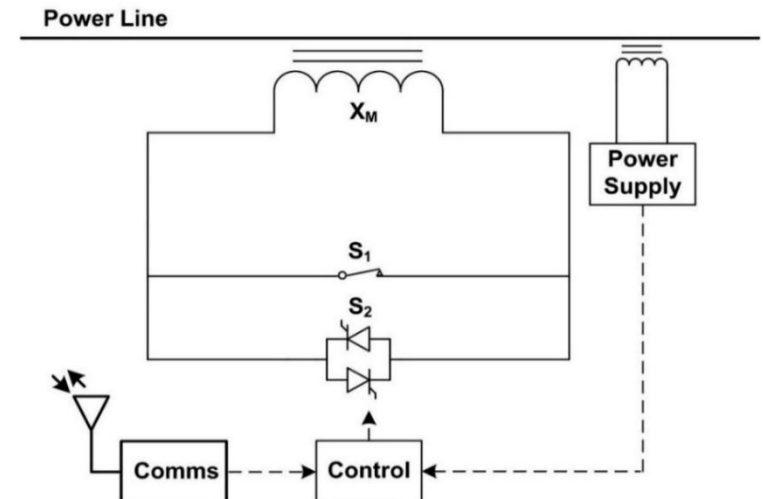


Overview of Modular Power Flow Control

- **Rapidly deployable and re-deployable**
The modular power flow control devices are modular and mount directly onto the conductor
- **Increases or decreases line impedance**
to divert current from lines nearing overload to parallel paths that are underutilized
- **Embedded sensing technology**
allows monitoring of transmission line in real-time
- **Reliable and resilient**
line-fault tolerant (self-protecting), overload tolerant, lightning tolerant



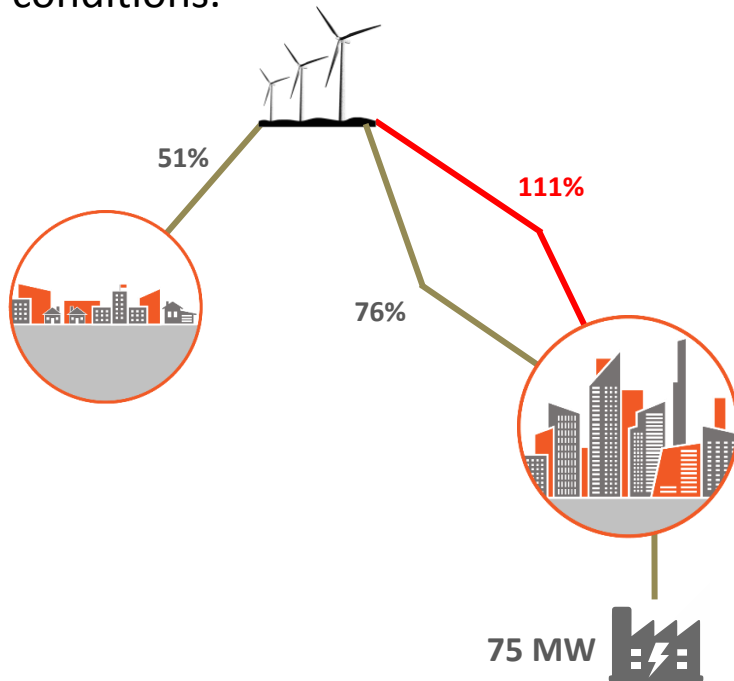
The PowerLine Guardian (formerly known as the Distributed Series Reactor or DSR) injects magnetizing inductance to increase line impedance and “push” power to parallel lines.



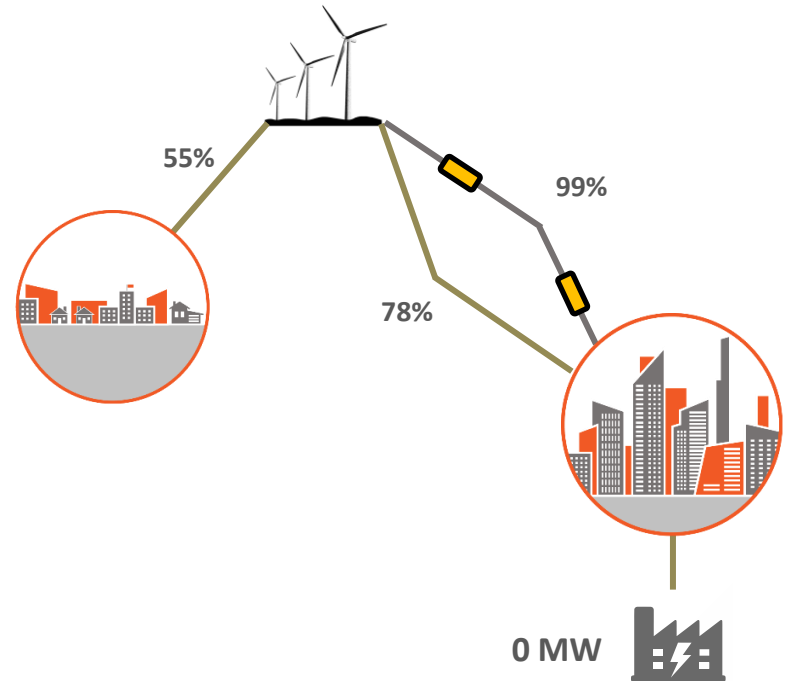


Example Study

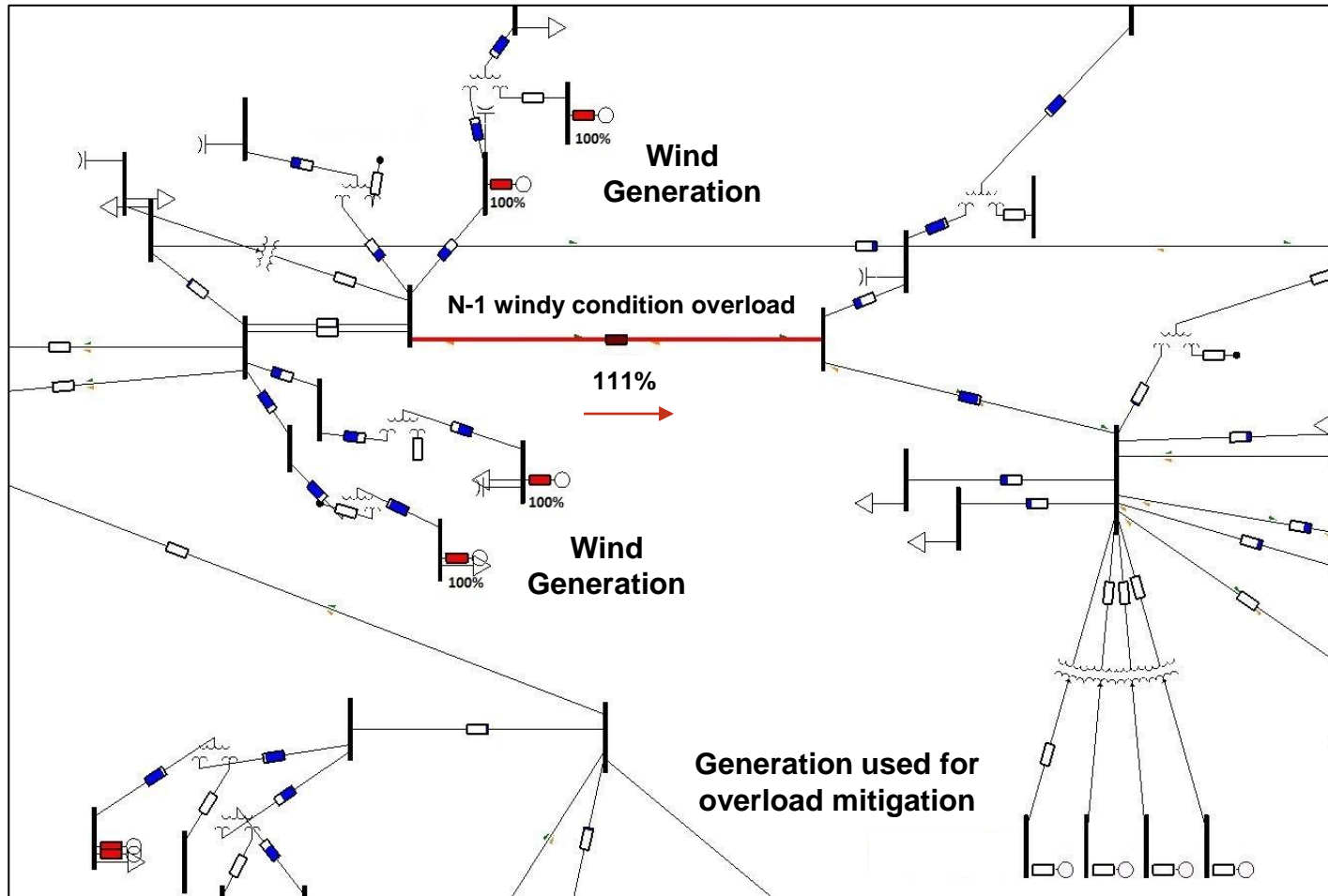
A utility was **spending an incremental \$10 M per year** to redispatch expensive generation under windy conditions to avoid curtailment and prevent overloads on its 138 kV network under N-0 conditions.



Power flow control can provide a solution that completely eliminates the overload and the need to run expensive generation. The Smart Wires system provides additional headroom for future wind development.

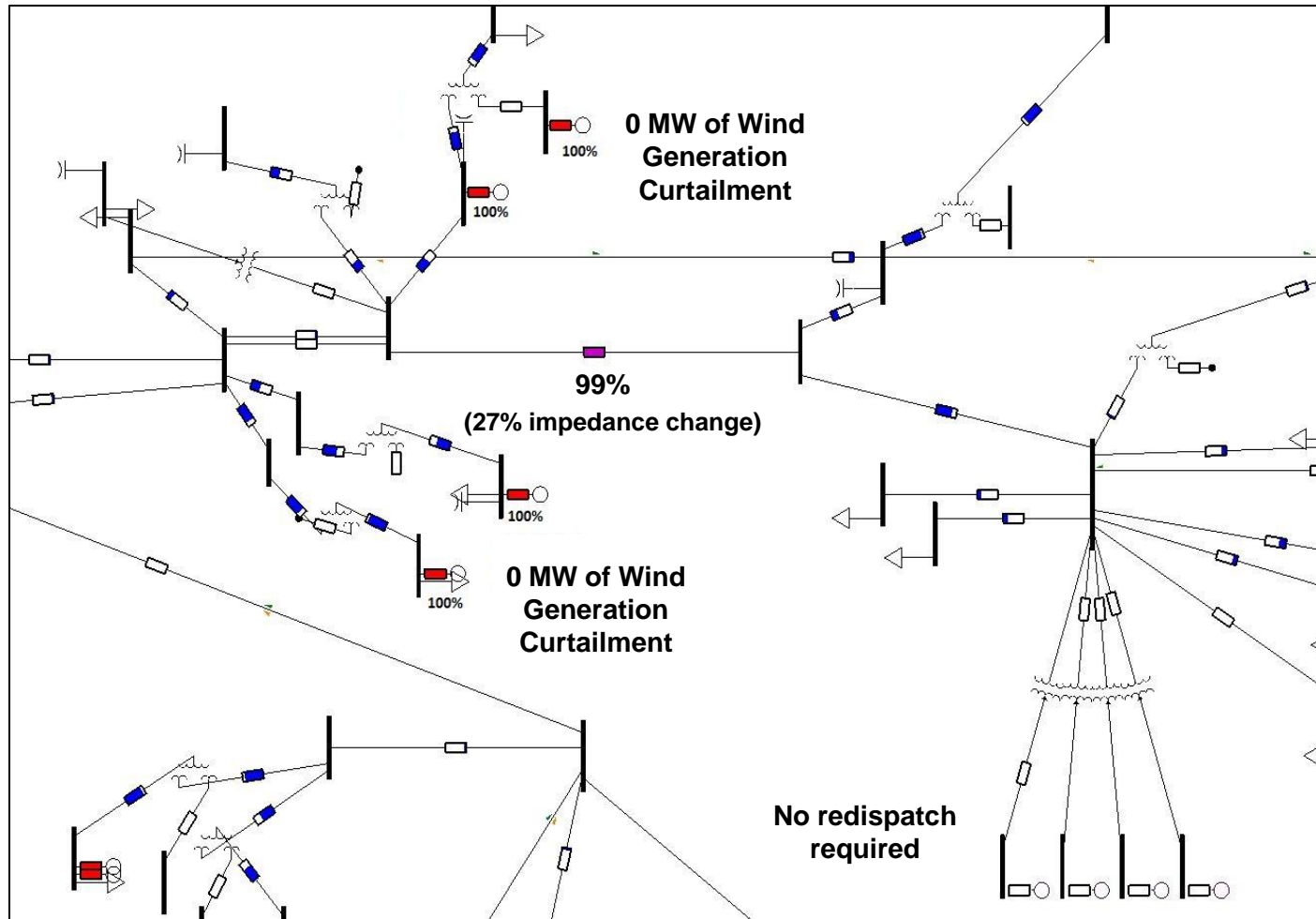


Example Study



The constrained line overloads for N-0 and N-1 conditions on windy days

Example Study

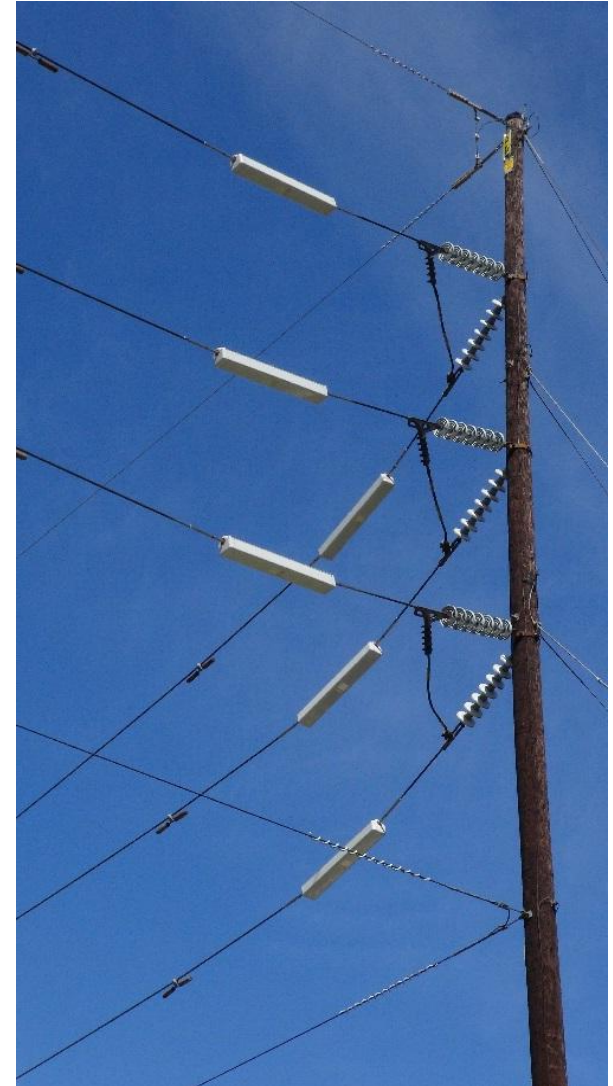


Installing power flow control devices on one line eliminates the overload

Study Results

The deployment of power flow control on the constrained line:

- Completely eliminates the N-0 overload.
- Completely eliminates the N-1 overload.
- Eliminates the need to dispatch the fossil fuel plant.
- Allows for an additional 425 MW of wind generation by adding power flow incrementally.
 - Cost responsibility can be assigned to new wind generators incrementally
 - Devices can be moved in the future based on system need.





Questions?