TRANSMISSION TOPOLOGY OPTIMIZATION: A SOFTWARE GRID-ENHANCING TECHNOLOGY

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TOPOLOGY OPTIMIZATION ENABLES FLEXIBLE GRID OPERATION

NewGrid topology optimization software quickly *finds* and *evaluates* reliable reconfigurations to reroute flow around congestion ("*Google Maps for the transmission grid*").

  - Fast search time: seconds to minutes.

- Reconfigurations implemented by opening or closing circuit breakers.
  - Analogous to temporarily diverting traffic away from congested roads to make traffic flow smoother.
- Technology supports transmission decision making processes.
  - Utilities already reconfigure the transmission system, based on staff experience, on ad hoc basis.
- Reconfigurations are **reliable** under all specified contingencies and do not radialize load beyond a user-specified value.
- Complements redispatch in congestion management.

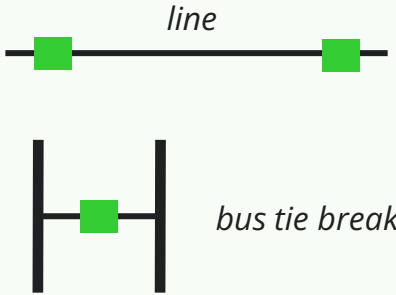
THERE ARE DIFFERENT RECONFIGURATION ACTION TYPES

Optimization routines search for reconfigurations to relieve **one or more simultaneous constraints**, and identify **preventive or corrective solutions**. Reconfiguration actions vary depending on system topology, system conditions and congestion problem characteristics.

Open/close branch

Branch types:

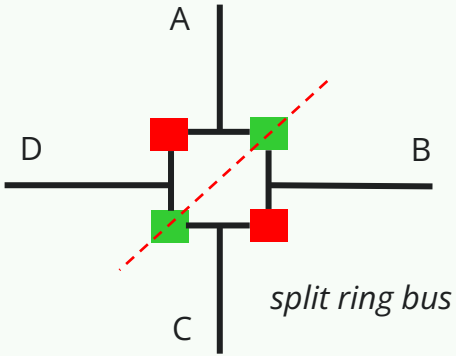
- Lines
- Transformers
- Bus tie breakers
- Reactor by-pass breakers



Bus split/merge

Some substation arrangements allow bus splits:

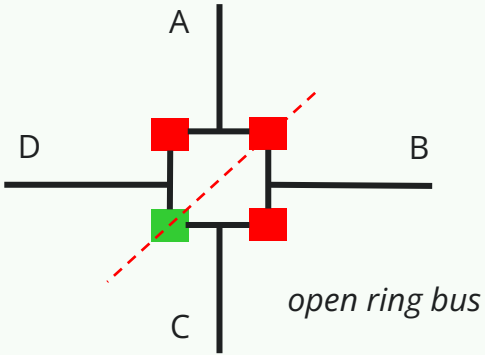
- Ring bus
- Double bus double breaker
- Breaker and a half



Contingency-change

Substation reconfigurations

- Bus normally connected
- Split bus or disconnected element under specific contingency conditions



Closed Circuit Breaker

Open Circuit Breaker

APPLICATIONS

Topology optimization can support business processes across many scales.

Real-time

- **Adapt to emergency system conditions**, increasing grid resilience
- Relieve N-1 flow violations
- Minimize Reliability Unit Commitment (RUC) and manual unit starts for constraint management

Intra-Day

- Unlock capacity from export-constrained areas
- **Minimize congestion costs** in the real-time market
- Reduce renewables curtailments

Day-ahead

- Pre-position the system topology to match expected conditions
- Minimize congestion costs in the day-ahead market
- **Develop Op. Guides** for extreme events that minimize load shedding

Weeks to Months Ahead

- Adjust underlying system topology when new projects are energized
- Allow additional outages to occur reliably and economically in outage scheduling & coordination
- Mitigate the expected congestion impacts of outages

Long-Term

- Optimize transmission expansion portfolio
- Maximize the benefit-to-cost ratio of new projects

TECHNOLOGY APPLICATIONS AND SYSTEM INTEGRATION

Simplest

Highest benefits

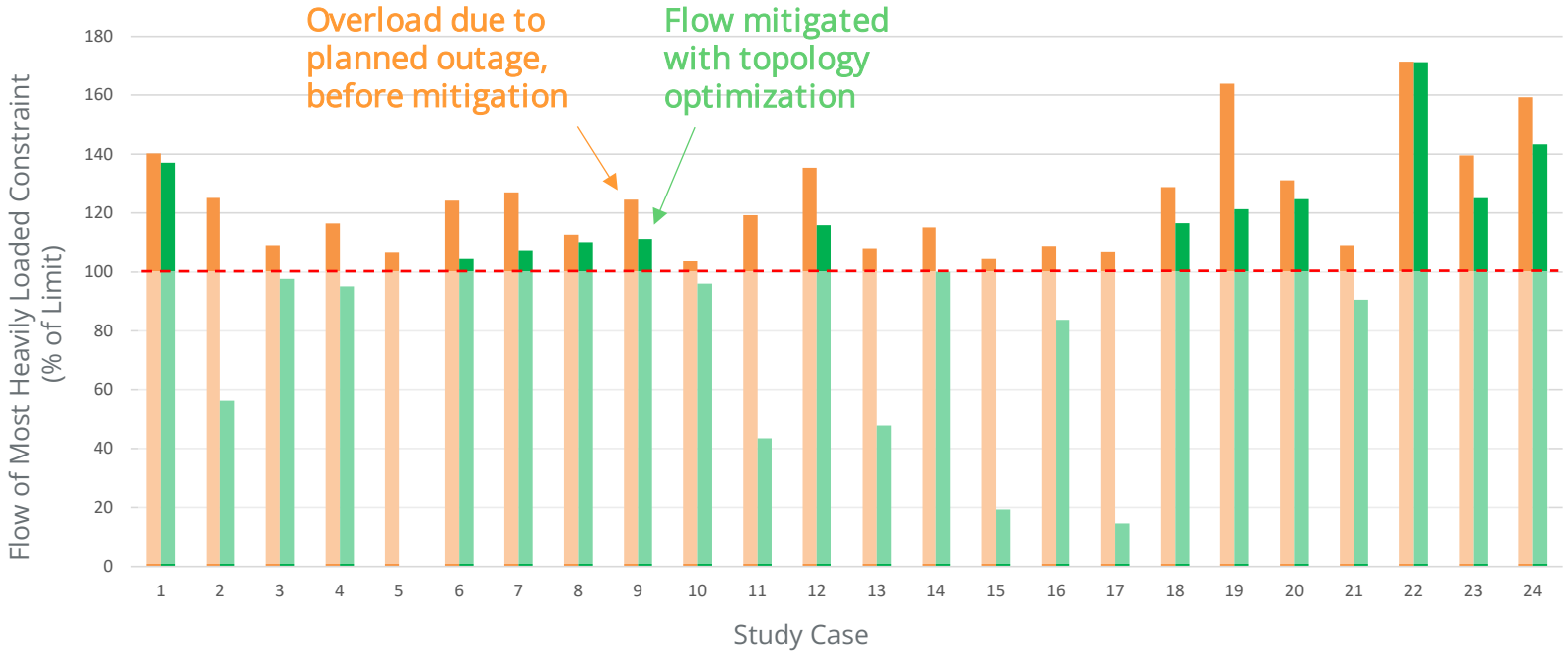
Processes	Technology User	Applications	System Integration	Timeframe
Reconfiguration Request Process	**Market Participants** (SOs, RCs and TOPs have the software needed to evaluate requests)	mitigation of major expected constraints	none	days / weeks / months ahead
Planning and Operations Planning Support	**System Operator (SO), Reliability Coord. (RC), Transmission Op. (TOP)**	operating/mitigation plan development, outage scheduling support, optimize transmission expansion	none to minimal (offline advisory tool)	days / weeks / months ahead
Real-Time Operations Support	**SO, RC, TOP**	reconfigurations tailored to address real-time conditions: mitigate overloads, release stranded generation	Energy Management System (EMS)	days ahead to real time
Market Clearing w/ Optimized Topology	**Market Operator**	continuous optimization of topology as conditions evolve to mitigate cost of congestion management	EMS and Market Management System (MMS)	days ahead to real time

ISO NEW ENGLAND PARTNERSHIP WITH NEWGRID

- ISO-NE has partnered with NewGrid, supported by MassCEC, to:
  - Reduce congestion in the ISO New England footprint through application of transmission switching solutions to obtain more efficient market outcomes.
  - Improve reliability by systematically running topology optimization software to identify switching solutions. Previously, these were found through experience of analyzing old outage combinations and are typically documented in procedures.
  - Cross-check previously identified switching solutions against NewGrid Router outputs and identify new ones.
- The following slides illustrate some results of ISO-NE's use of NewGrid Router in outage coordination support.
  - The study cases used with NewGrid Router have high flows or overloads on key constraints when planned outages are modeled. ISO-NE staff used NewGrid Router to identify reconfigurations that mitigate the high constraint flows.
  - ISO-NE staff recorded if a solution was *promising* given the specifics of the study.
  - Mitigated flow on most limiting transmission constraints by 31% on average.

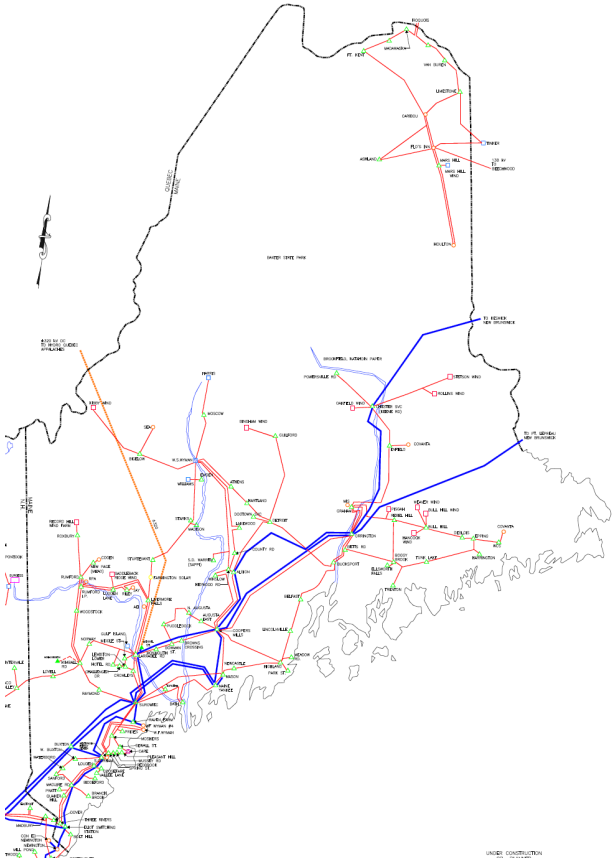
REDUCED CRITICAL CONSTRAINT FLOW BY 31% ON AVERAGE

Topology optimization **reduced by 31% on average the most heavily loaded constraint flows** due to planned outages (before mitigation by ISO-NE staff), over all cases with promising solutions, and **resolved the need for flow mitigation in 12 out of 24 cases**.



EXAMPLE OF A SOLUTION IDENTIFIED BY NEWGRID ROUTER

- During an outage scenario of a 345kV line in the Maine area, loss of two additional major paths showed overloads.
- NewGrid Router offered reconfiguration options to off-load the most limiting path.
- Out-of-merit unit commitment needs were reduced in the outage scenario study.
- The options NewGrid Router offered have been used in subsequent outage scenarios.



Map source: New England Geographic Transmission Map through 2033.

CONCLUDING REMARKS

- ISO-NE staff has successfully used NewGrid Router at scale for an extended period of time to demonstrate its potential value in support of Outage Coordination processes.
  - Mitigated flow on most limiting transmission constraints by 31% on average.
- NewGrid Router showed a strong potential to improve outage coordination processes.
- Implications once topology optimization system is fully implemented:
  - Reduce congestion in the ISO-NE footprint to obtain a more efficient market outcome.
  - Allow more maintenance, repair, and construction work to be performed.
  - Improve reliability by systematically running software to identify reconfiguration solutions.
    - Without the software support, these were found through experience.
  - Enable cross-checking previously identified reconfigurations against those from NewGrid Router and identifying new ones.
- ISO-NE and NewGrid continue to partner to support Outage Coordination processes.

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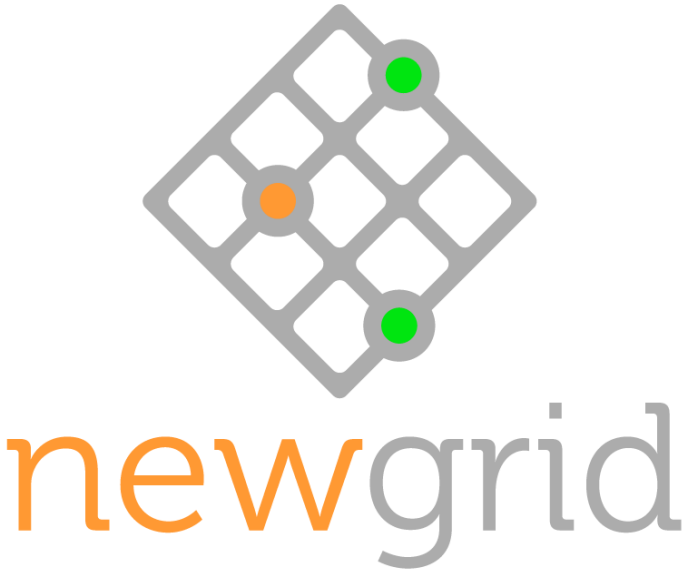

http://www.newgridinc.com

RELIABLE RECONFIGURATIONS

The reconfigurations are **reliable under all specified contingencies** (e.g., do not introduce new problems, and are consistent with mitigating the ongoing risks in operations) and **do not radialize load** beyond a user-specified value. They can be validated for transient and/or voltage stability performance as needed using existing software tools.

NEWGRID ROUTER

OPTIMIZATION

TOPOLOGY OPTIMIZATION

OUTPUTS

- Reconfiguration candidate
- Dispatch and commitment
- Marginal costs

RELIABILITY

CONTINGENCY AND CONNECTIVITY EVALUATION

OUTPUTS

- Feasible/infeasible reconfiguration
- Constraints to ensure feasibility of the optimization outcome

ISO NEW ENGLAND OUTAGE COORDINATION PROCESSES

- ISO-NE staff perform engineering analyses conducted on study power flow cases to
  - Determine the viability of major requested planned transmission and generation outages.
  - Develop solutions to mitigate outage impacts, if needed.
- ISO-NE Operating Procedure 19 (Transmission Operations) has steps for identifying and correcting reliability concerns; possible steps include committing out-of-merit generation and reconfiguration of the transmission system.
- After finding a solution, ISO-NE Outage Coordination verifies the solution will work over the duration of the outage under a variety of dispatch conditions.
- ISO-NE coordinates with the Transmission Owner to verify no adverse system impact to their customers/metrics/criteria.
- ISO-NE determines the system-wide congestion savings based on repositioning of outages, which is reported annually in the ISO-NE Transmission Equipment Outage Coordination report.