Bulk Power Risk Analysis: Ranking Infrastructure Elements According to their Risk Significance

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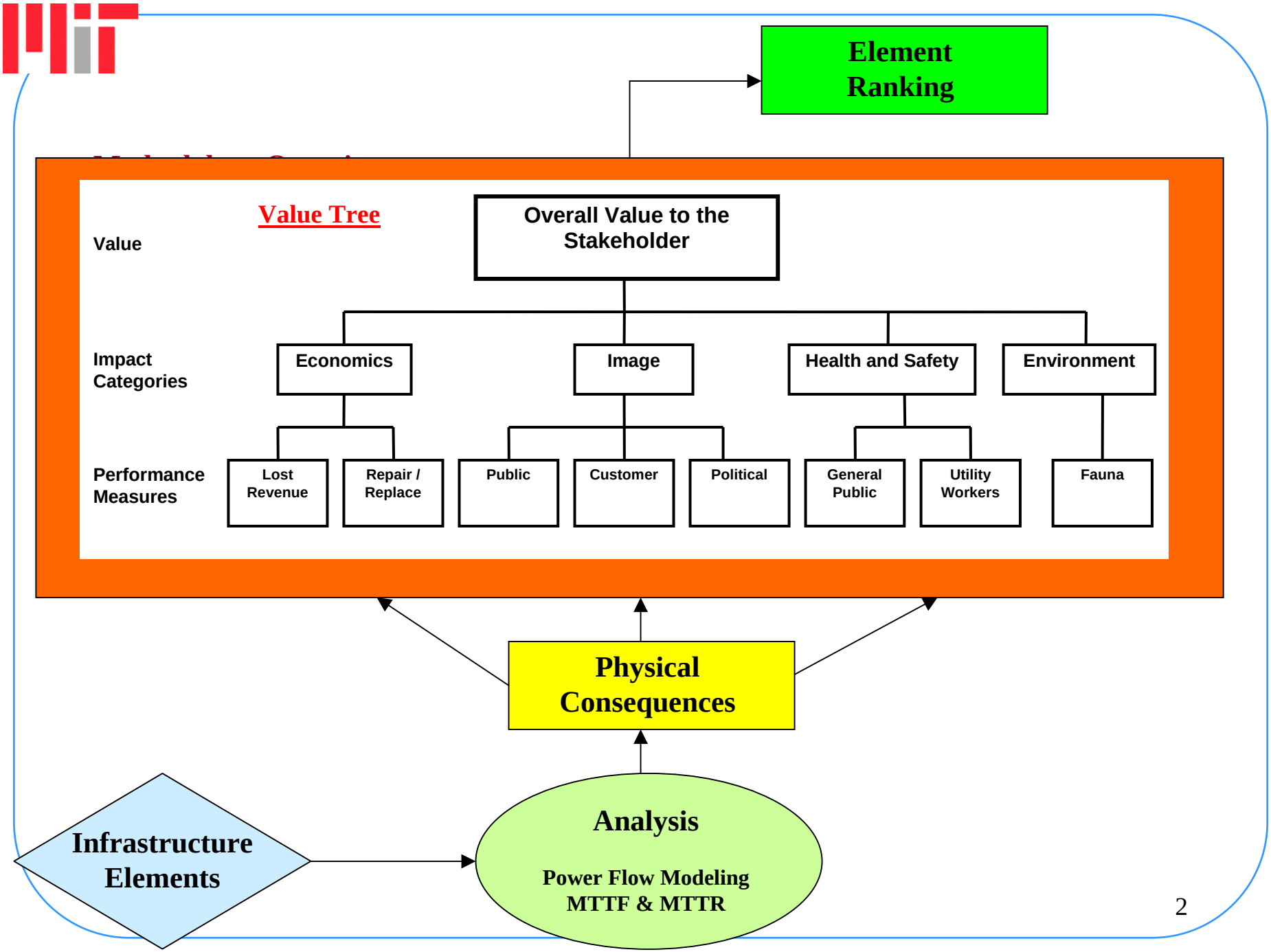
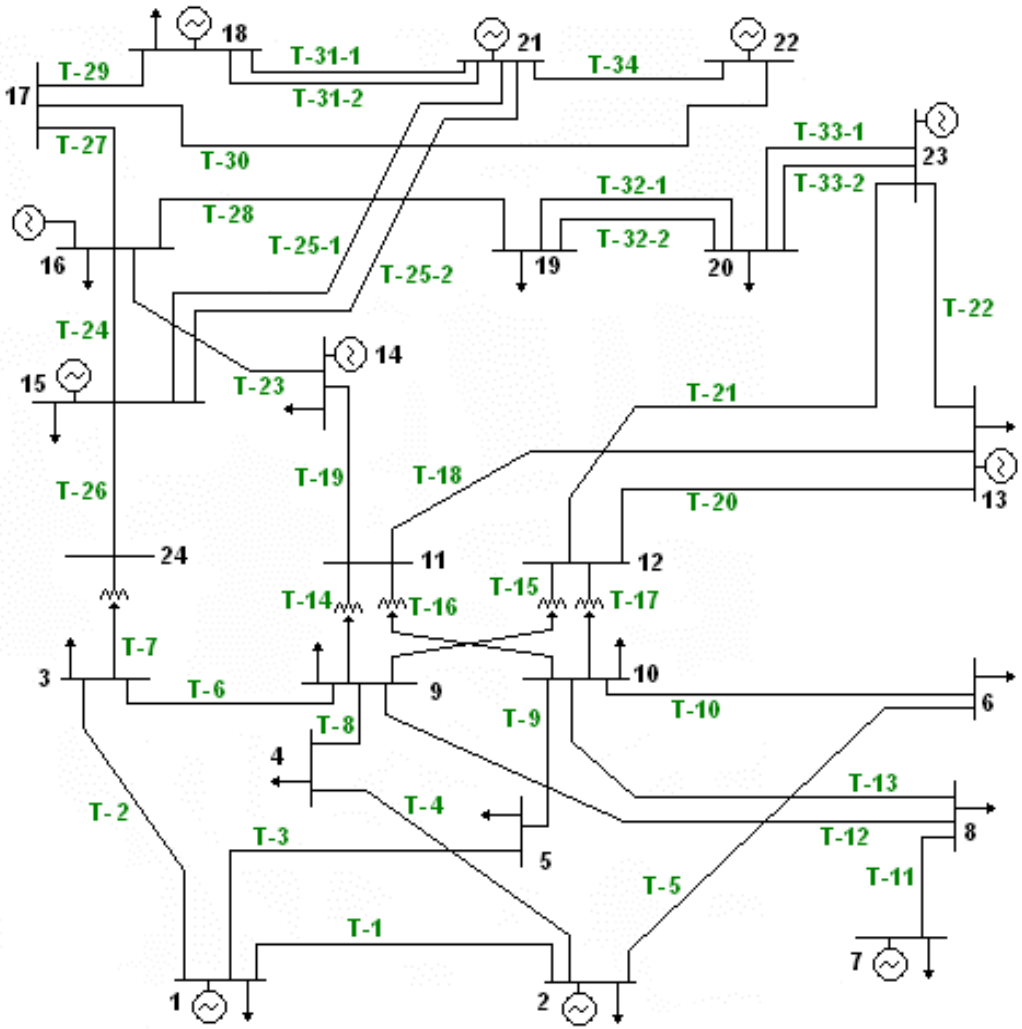
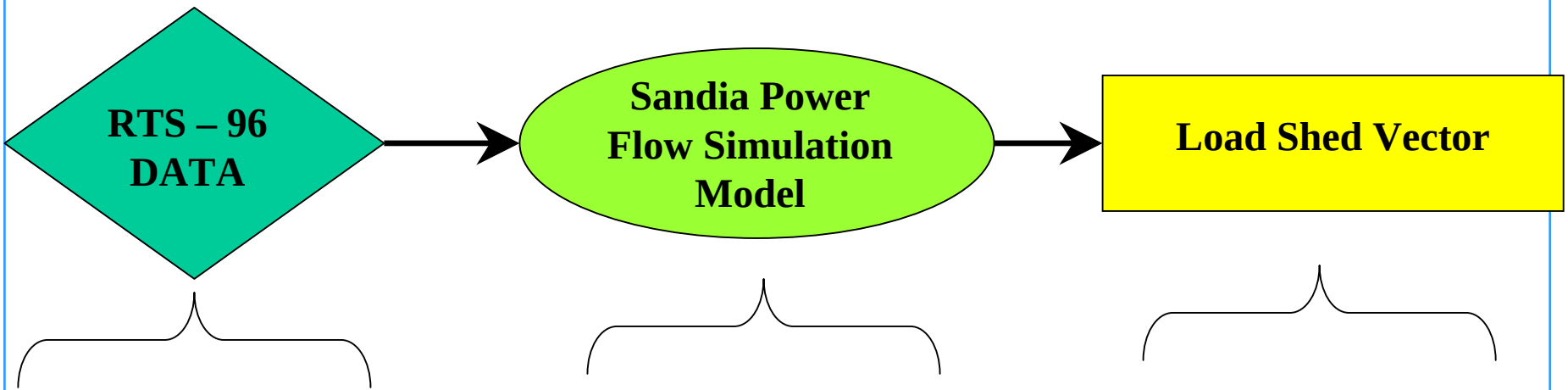

Element Ranking
Value Tree
Value
Overall Value to the Stakeholder
Impact Categories
Economics
Image
Health and Safety
Environment
Performance Measures
Lost Revenue
Repair / Replace
Public
Customer
Political
General Public
Utility Workers
Fauna
Physical Consequences
Infrastructure Elements
Analysis
Power Flow Modeling
MTTF & MTTR

IEEE RTS-96 Network



- 24 buses
- 10 Generation Sites
- 17 Load Sites
- 38 Transmission Lines
- Customer Groups
  - Residential
  - Commercial
  - Small – Medium Industrial
  - Large Industrial

Infrastructure Analysis



Load Data
Generation Data
Line Data
Repair Times
Failure Rates

AC load flow model determines the effects a failed component has on the system.

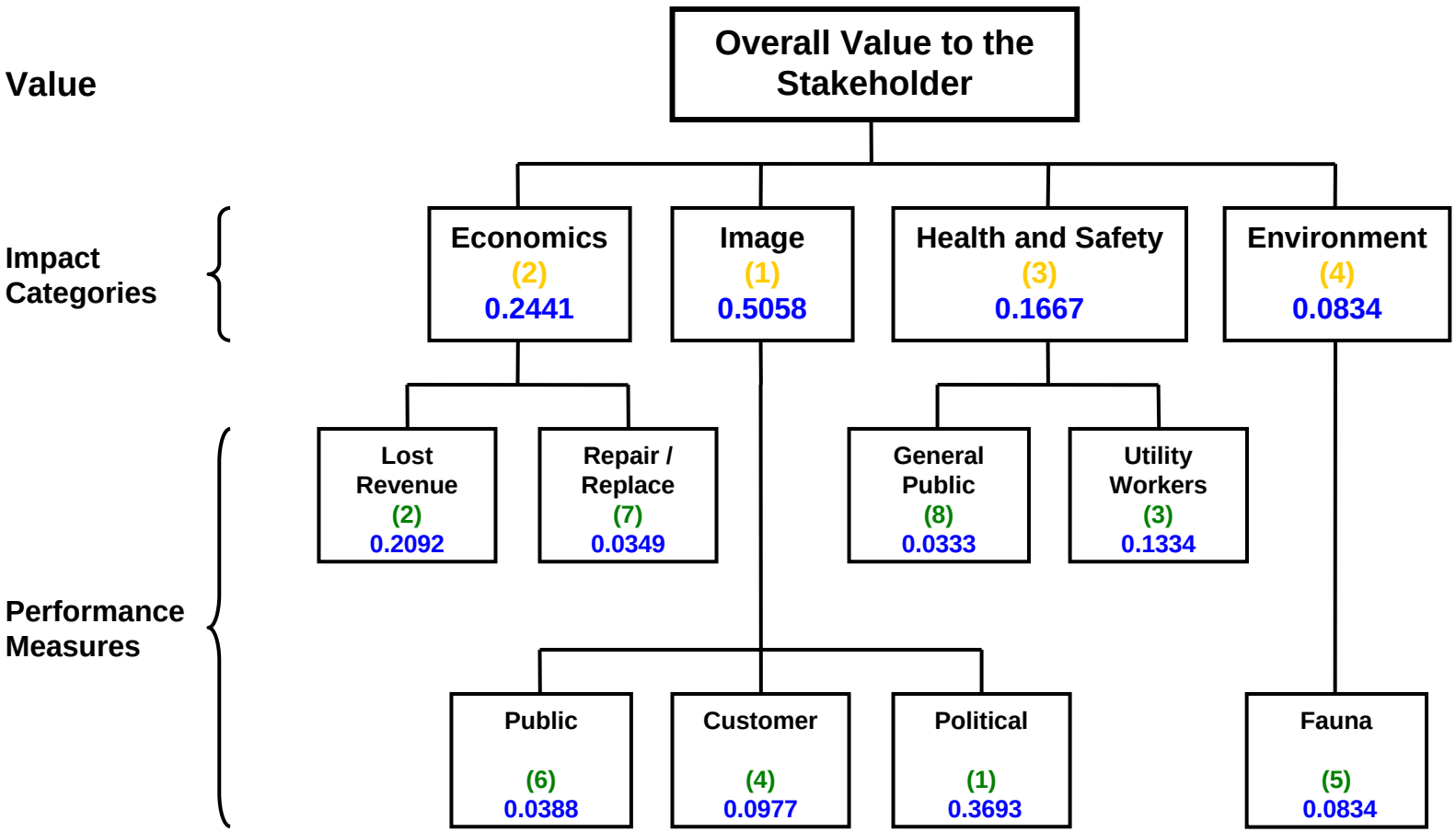
Used to determine the physical consequences that serve as input into the risk assessment methodology.

- **The physical consequence of a scenario is the combination of outage duration along with the number of customers affected in each customer group.**

Stakeholders

Stakeholder	Organization
S-1	Management Division
S-2	Transmission Department
S-3	Transmission Department
S-4	Management Division
S-5	Transmission Department

Value Tree with Weights (Stakeholder S-1)



Prioritization Methodology

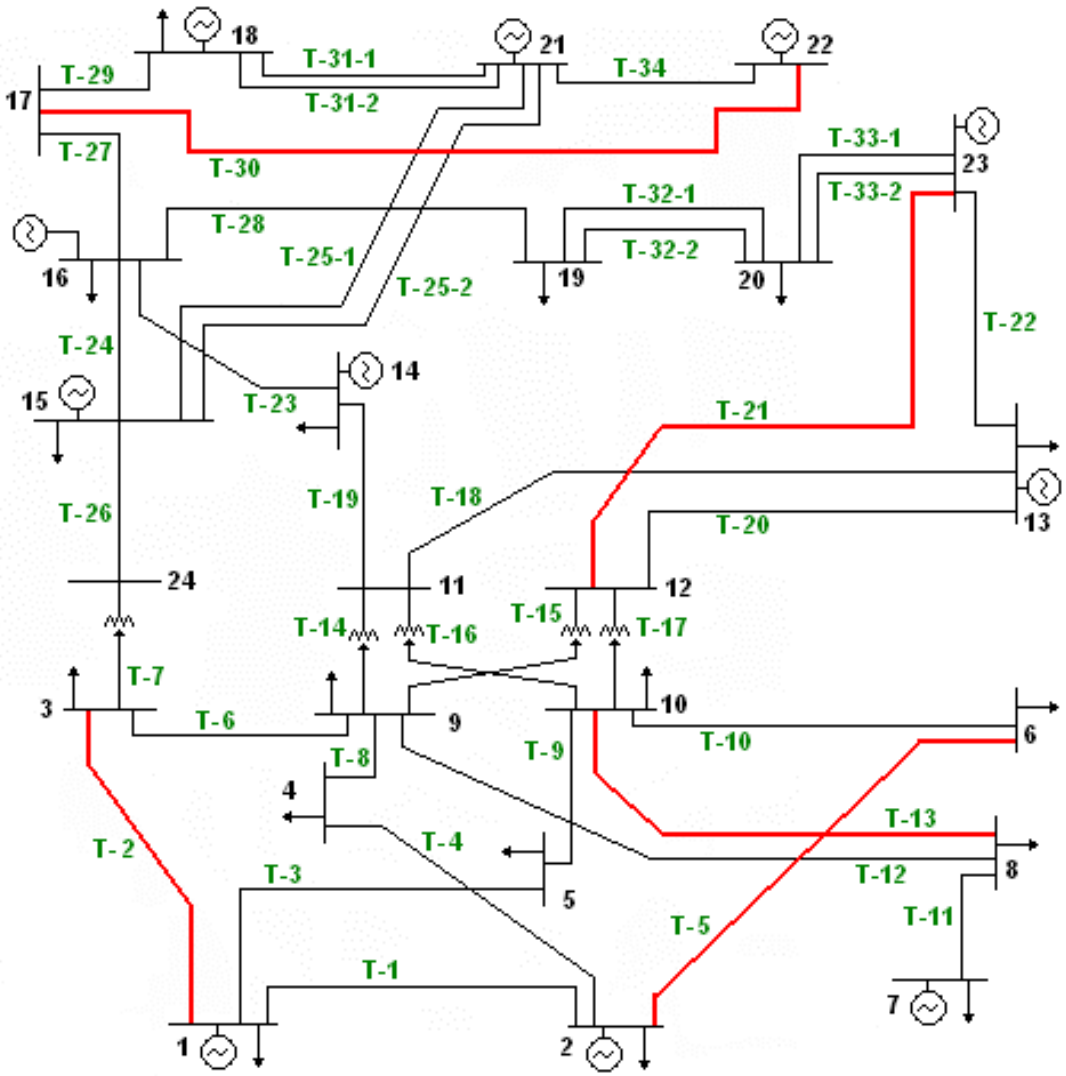
- **Performance Index (expected disutility)**

$$\overline{PI}_j = \sum_i^{K_{pm}} w_i \overline{d}_{ij}$$

$\overline{PI}_j$	**expected performance index for vulnerability *j***
w_i	**weight of the performance measure *I***
$\overline{d}_{ij}$	**expected disutility of performance measure *i* for vulnerability *j***
K_{pm}	**number of performance measures**

- **For random failures, expected values will be calculated.**
- **For malevolent acts, they will not.**

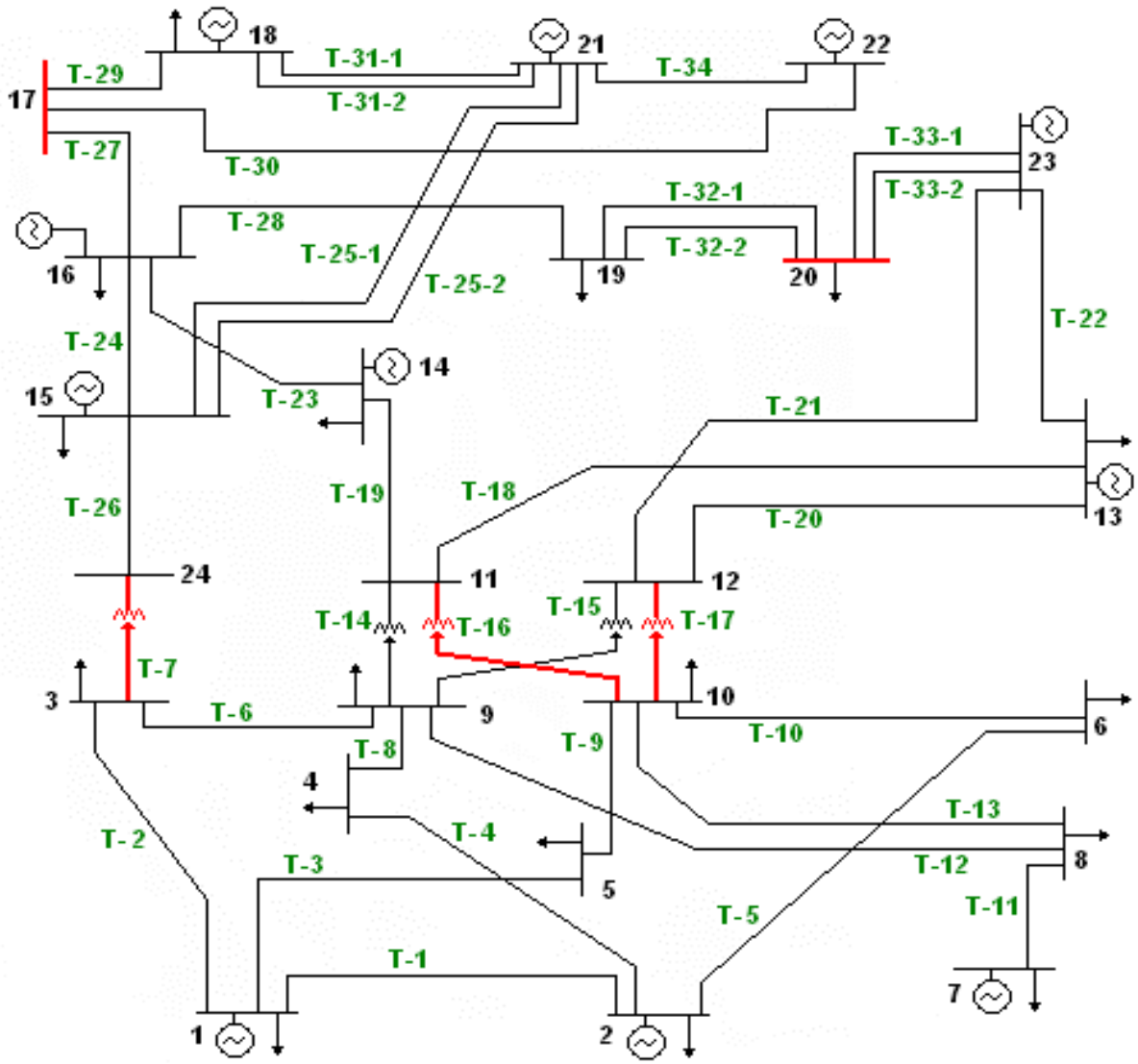
Results (S-1)
(random failures)



Vulnerability / Risk Categories

Category	Description
I (Red)	**This category represents a severe vulnerability in the infrastructure. It is reserved for the most critical locations that are highly susceptible to attack. Red vulnerabilities may require the most immediate attention.**
II (Orange)	**This category represents the second priority for counter-terrorism efforts. These locations are generally moderately to extremely valuable and moderately to extremely susceptible.**
III (Yellow)	**This category represents the third priority for counter terrorism efforts. These locations are normally less vulnerable because they are either less susceptible or less valuable than the terrorist desires.**
IV (Blue)	**This category represents the fourth priority for counter terrorism efforts.**
V (Green)	**This is the final category for action. It gathers all locations not included in the more severe cases, typically those that are low (and below) on the susceptibility scale and low (and below) on the value scale. It is recognized that constrained fiscal resources are likely to limit efforts in this category, but it should not be ignored.**

Results (S-1)
(malevolent acts)



Insights (S-1)

- **Transmission lines appear as the top ranked components with respect to both random failures and malevolent acts. This is due to the usually more wide-spread consequences resulting from failures of transmission lines. Their high level of susceptibility is also a key factor.**

- **Due to their lower Forced Outage Rates and low susceptibility levels, generators are not present in the higher levels of the expected disutility and vulnerability rankings. They are all placed within the Blue or Yellow vulnerability categories.**

- **Buses do not appear in the upper rankings of random failures because of their very low failure frequencies.**

- **Buses appear in the vulnerability rankings as Orange vulnerabilities and below because of their large consequences and moderate susceptibility.**

Conclusions

- **All stakeholders share T-7, T-16, and T-17 within their top five components for vulnerability rankings. All but S-2 complete their top five vulnerabilities with B-17 and B-20.**

- ***Lost Revenue* and *Customer Image* remain the dominant factors determining a failure scenario's value even for the stakeholders that ranked Health & Safety as the #1 impact.**

- **All stakeholders share the top 10 components for random failure events with very few differences in the component ordering. This is due to transmission lines having both relatively short durations and higher failure frequencies.**