

Costs and Challenges of EMP Protection for U.S. Electric Grid

**Presentation of the
Foundation for Resilient Societies
Exeter, New Hampshire**

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Agenda

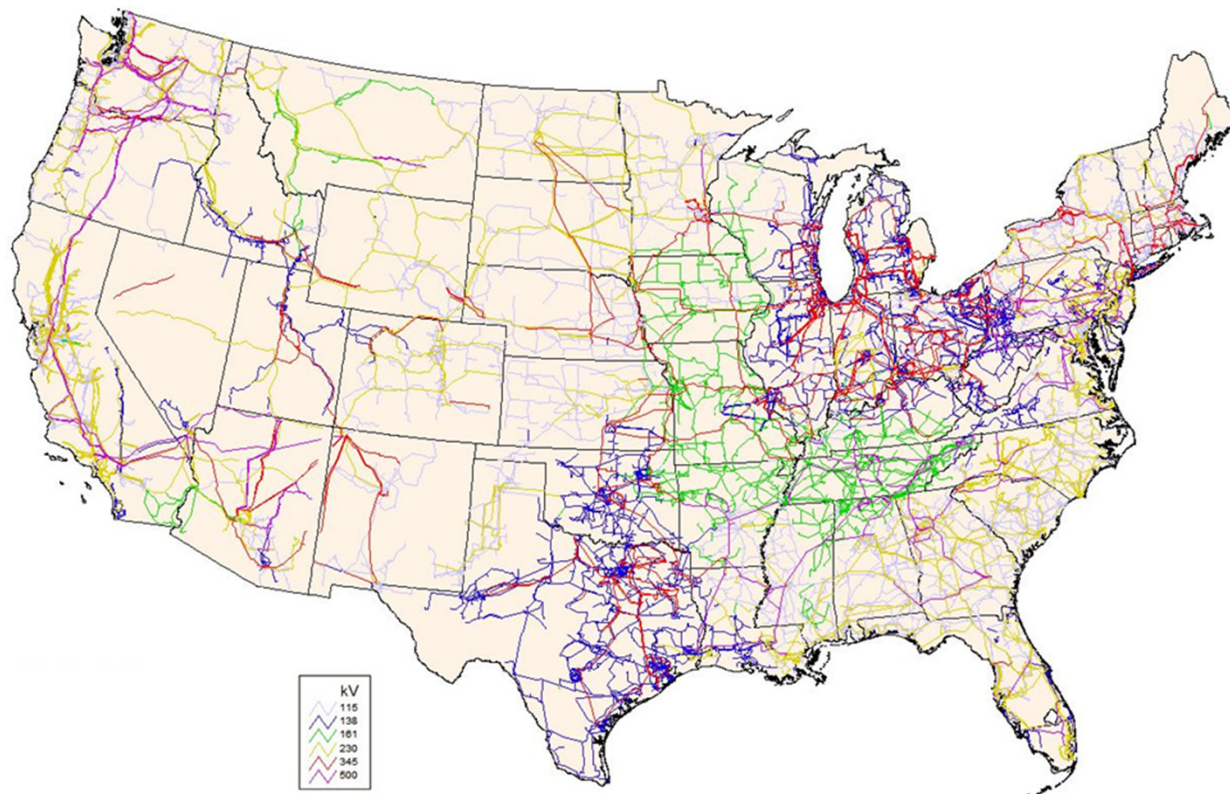
- **Executive Summary**
- **Configuration of electric grid**
- **Types of equipment and counts**
- **EMP protection strategies**
- **Examples of preliminary costs for EMP protection**
- **Importance of prioritization**
- **Summary conclusions**

Executive Summary

- **U.S. electric grid has a great diversity of equipment vulnerable to natural and man-made EMP**
- **Basic EMP protection cost model**
 - **Catalog types of equipment to be protected**
 - **Engineering study of vulnerabilities and protective technologies**
 - **Determine counts by equipment categories**
 - **Multiply per-unit protection costs by equipment counts**
- **Substantial costs make prioritization important**
- **Partial EMP protection is better than no protection**
- **Even partial EMP protection is likely to be a deterrent against EMP attack**

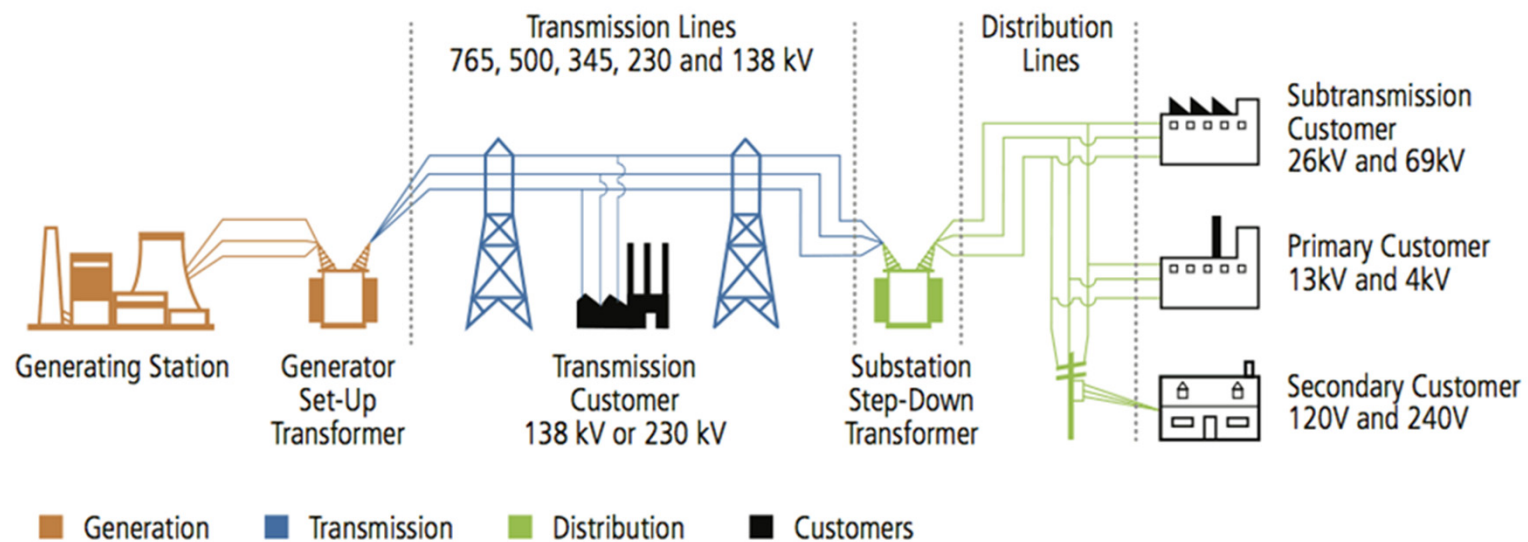
Configuration of Electric Grid

U.S. Electric Transmission System



Graphic credit: Federal Emergency Management Agency

Electric Grid Generation, Transmission, Distribution, and Customers



Graphic Credit: U.S. Department of Energy

Types of Electric Grid Equipment and Counts in Bulk Power System

32,215 Substations



Photo credit: O'Connell Electric Company

15,906 Generation Units



Photo credit: Creative Commons/Rhododendrites

~500 Control Centers



Photo credit: New York State SmartGrid Consortium

EMP Protection Strategies

Neutral Ground Blocking Device



Photo credit: ABB

Spare Circuit Breaker



Photo credit: SML Resources International

Fiber Optic Cabling

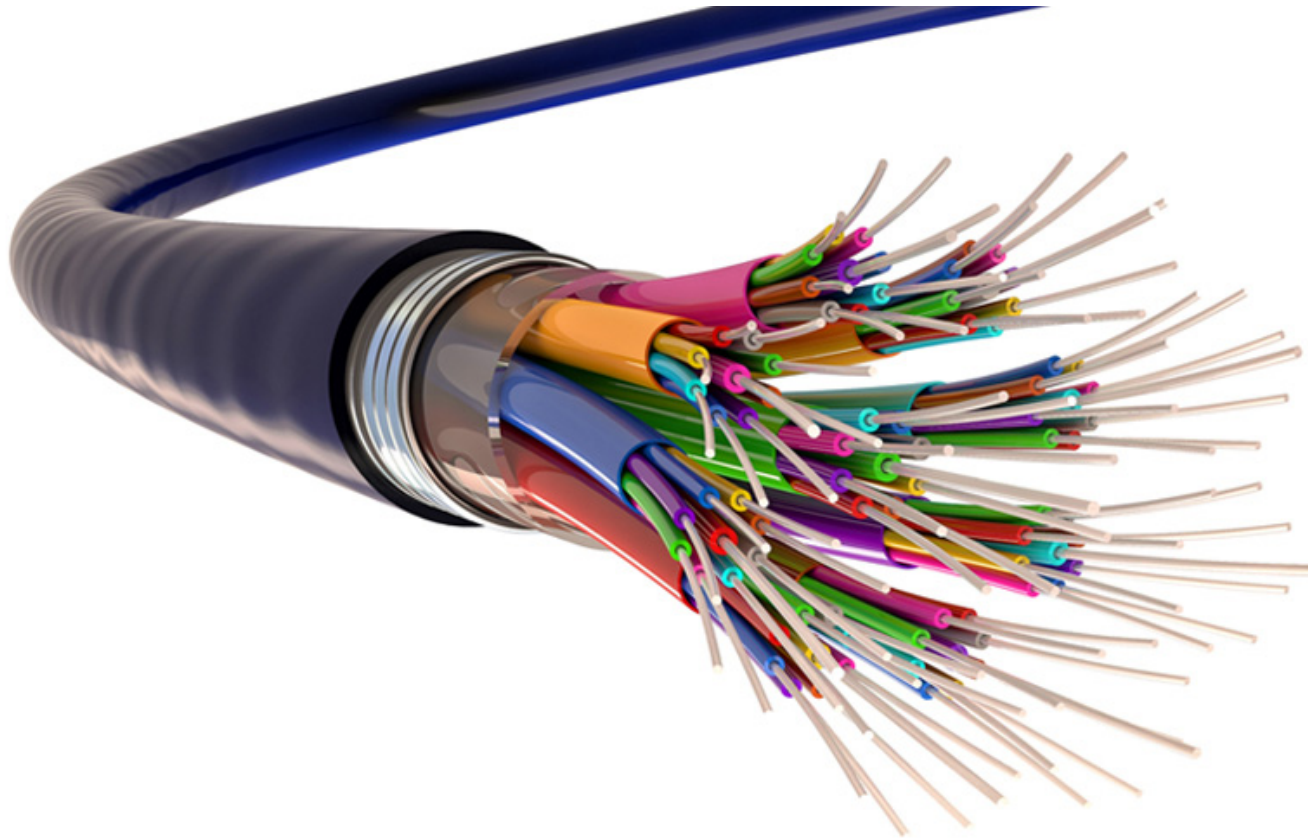


Photo Credit: PeakOptical

Shielded Control Enclosure



Photo credit: ARMAG Corporation

Examples of Preliminary Costs for EMP Protection

Example of Substation Protection Costs

| Substation Name | Item | Protection Basis | Unit Cost (\$M) | Estimated Quantity | Cost (\$M) |
|--------------------|------------------------|------------------|--------------------|-----------------------|----------------|
| Substation 1 | Backup Generator | New Equipment | \$0.10M | 1 | \$0.10M |
| | Circuit Breaker | Spare | \$0.31M | 1 | \$0.31M |
| | Control House | New Equipment | \$1.00M | 1 | \$1.00M |
| | Neutral Ground Blocker | New Equipment | \$0.60M | 2 | \$1.20M |
| | Engineering Study | Overhead | \$1.00M | 1 | \$1.00M |
| Total | | | | | \$3.61M |

Example of Generation Protection Costs

| Generator Name | Technology | Capacity (MW) | Capacity (MVA) | Power Factor | Cost Driver | Unit Cost | Quantity | Cost (\$M) |
|----------------|---------------------|---------------|----------------|--------------|---|-----------|----------|------------|
| Generator 1 | Nuclear - Dual Unit | 1000 | 1176 | 0.85 | Electrical, Instrumentation & Controls Cost (\$/MW) | \$314,000 | 1000 | \$314.00M |
| | | | | | Generator Step-up Transformer (\$/MVA) | \$10,000 | 1176 | (\$11.76M) |
| | | | | | Neutral Ground Blocker (\$/ea.) | \$600,000 | 1 | \$0.60M |
| Total | | | | | | | | \$302.84M |

Examples of Control Room Protection Costs

| Utility Name | Role | Peak Load/ Capacity (MW) | Estimated Protected Area (ft ²) | Cost (\$/ft ²) | Cost (\$M) |
|-----------------|--|-----------------------------|--|-------------------------------|-----------------|
| Control Room 1 | Transmission | 7500 | 6000 | \$590.00 | \$3.54M |
| Subtotal | | | | | \$3.54M |
| Control Room 2 | Generation Dispatch | 1200 | 2400 | \$590.00 | \$1.42M |
| Subtotal | | | | | \$1.42M |
| Control Room 3 | Reliability Coordinator & Transmission | - | 20000 | \$590.00 | \$11.80M |
| Subtotal | | | | | \$11.80M |
| Total | | | | | \$16.76M |

Importance of Prioritization

- **Total EMP protection costs are likely to cause “sticker shock” for policymakers**
- **EMP protection to supply critical facilities with electricity will be a starting point**
 - **Military bases**
 - **Nuclear power plants**
 - **Natural gas pipelines**
 - **Water treatment facilities**
 - **Other critical facilities**
- **Implementation of EMP protection over multiple years will make costs more manageable**

Summary Conclusions

- **Determining categories of grid equipment and their EMP vulnerabilities is a substantial task**
 - Individual engineering studies needed
- **Finding counts of equipment by category is more straightforward**
- **Estimating EMP protection costs by equipment category will be challenging**
- **Pilot programs will provide a better cost basis**
- **Prioritization is essential, across facilities and time**
- **Partial EMP protection will have multiple benefits**
 - Experience in protection techniques
 - Deterrence of adversaries

For More Information

- **Foundation for Resilient Societies is an IRS-approved 501(c)(3) charitable organization with the mission of critical infrastructure protection.**
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