

# Flexible AC Transmission Systems (FACTS) and Power Systems Security – A Valuation Framework

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# Motivation



- Aging power system infrastructure
- Increased electricity demand and electricity trade → increased flows over the lines
- Need to invest in new network reinforcements
- Several methods focus on social welfare
- How to invest taking also into account the power system security?

# Security-Constrained Optimal Power Flow

- Novel “hybrid” formulation → full AC-OPF with linear sensitivities for security constraints
- Minimize Total Generation Cost
- Constraints for FACTS devices
- N-1 security criterion:

$$|S_{ij}(\theta, V) + LODF_{ij,mn} \cdot S_{mn}(\theta, V)| \leq F_{ij}$$

Line outage

$$|S_{ij}(\theta, V) + GGDF_{ij}^k \cdot P_k| \leq F_{ij}$$

Generation Outage

# Framework

- Minimize “Cost of Security”
  - N-0 secure: Standard OPF (no security constraints)
  - N-1 secure: Security Constrained OPF
  - Compare the solutions of the SC-OPF and the standard OPF → “Cost of Security”
- Minimize Total Generation Costs
- Examine different levels of system loading (vary the loads)
- Examine individual line loadings

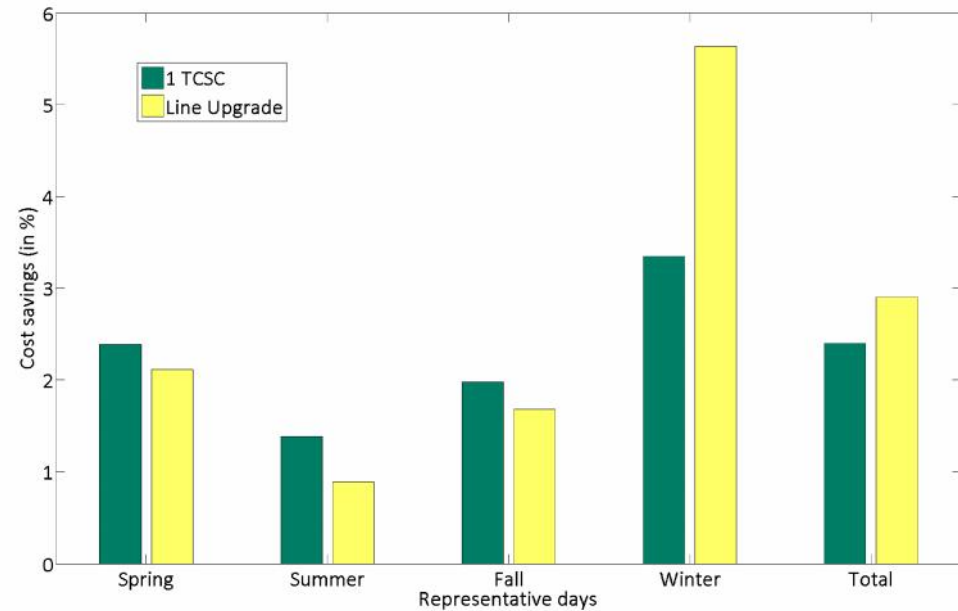
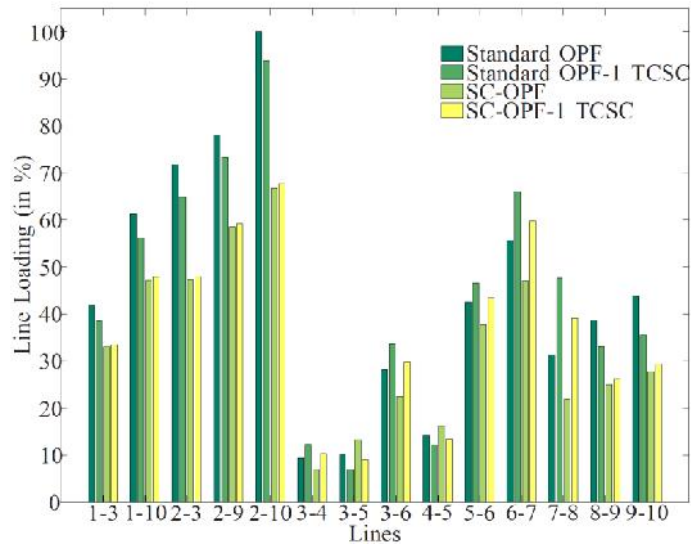
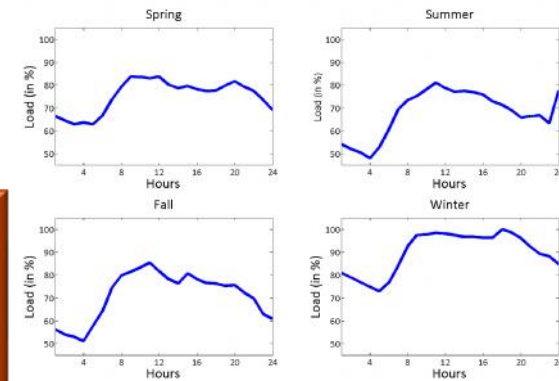
# Cost of Security

$$CoS = [SC-OPF] - [AC-OPF]$$

## Cost of Security

<b>Base Case</b>	29'923 Eur/h
<b>1 TCSC</b>	21'690 Eur/h
<b>Reduction</b>	<b>27.5%</b>

## FACTS vs. Line Upgrade



# Conclusions

- With FACTS:
  - system is N-1 secure
  - dispatch similar to N-0 } FACTS eliminate the “cost of security”
- TCSC better at lower loading conditions
- Line Upgrade better for peak load
- Optimal placement
  - Line upgrade on the congested line
  - FACTS placement depends on network topology

# Thank you!

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