Some features of possible solutions of installing telecontrolled section switches and reclosers in the MV overhead network

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Evaluation of reliability of distribution systems

Tools applicable to reliability evaluation

- Aggregated indices based on average value
- Indices based on other characteristic values of the distribution
- **Expressing reliability in financial terms**
  - Function of damages
  - Valuation of energy not supplied
  - Costs of penalty payments

⟸ **Optimization tasks**

Customer's standards in Czech Republic

- **Duration of one interruption**
  - Limit 12 hours (MV)/ 18 hours (LV)
  - Penalization 10% from annual distribution payment (max. 370 € (MV)/185 € (LV)
- **Response to the fuse operation**
  - Limit 6 hours, penalization 37€
- **To keep the time of planned (noticed) interruption**
  - Penalization 10% from annual distribution payment (max. 370 € (MV)/185 € (LV)

Optimization of the telecontrol in MV systems

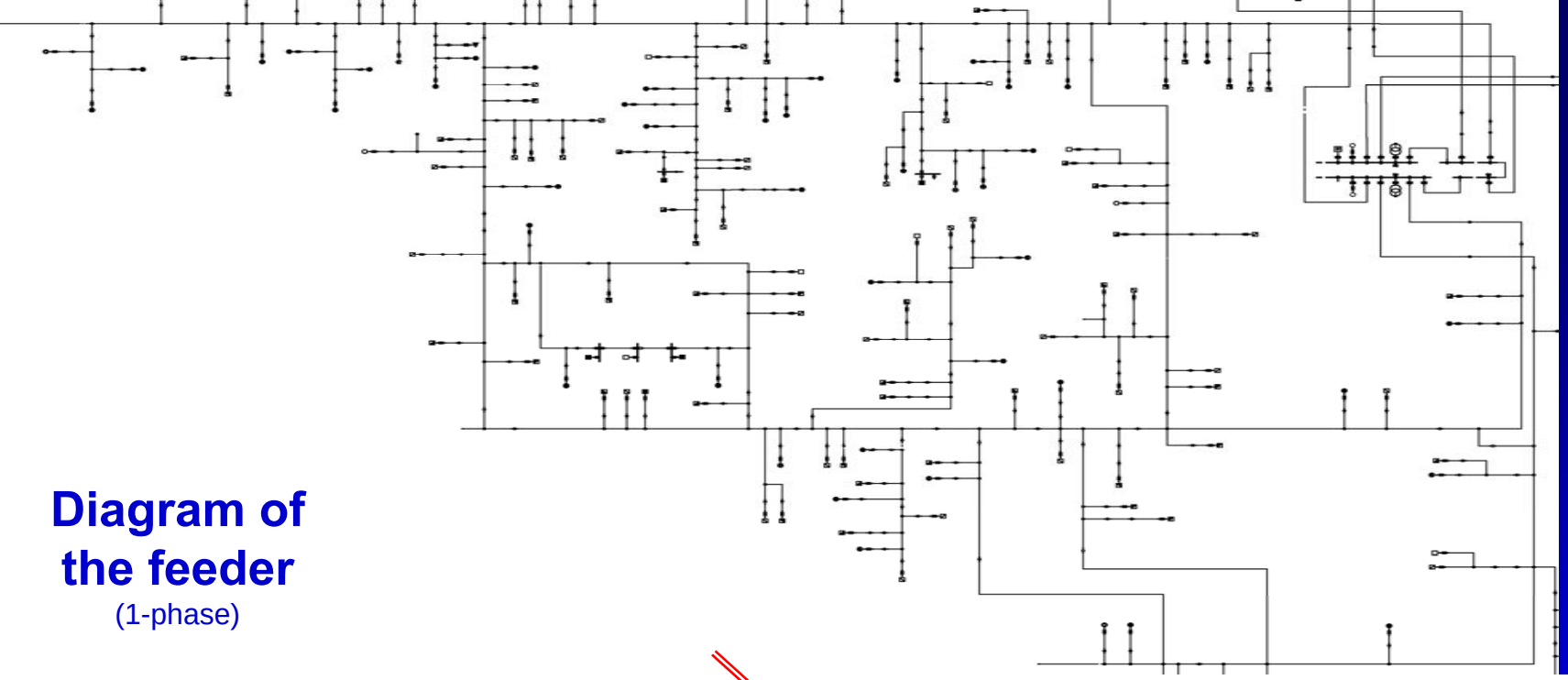
Most important factors influencing optimal number and placement of telecontrol switches on a feeder

- **Reliability of feeder**
  - Number of failures
  - Causes of failures
  - Durations of failures (successive restoration)
- **Feeder topology**
  - Number and lengths of laterals
  - Segmentation of feeder
  - Localization of connections to others feeders providing backup supply
- **Localization of customers**
  - Numbers of customers on individual feeder sections
  - Sorts of customers (small-, large-scale customers), their loads and sensitivity to interruption (chemical industry, banks, telecommunications, city centers)

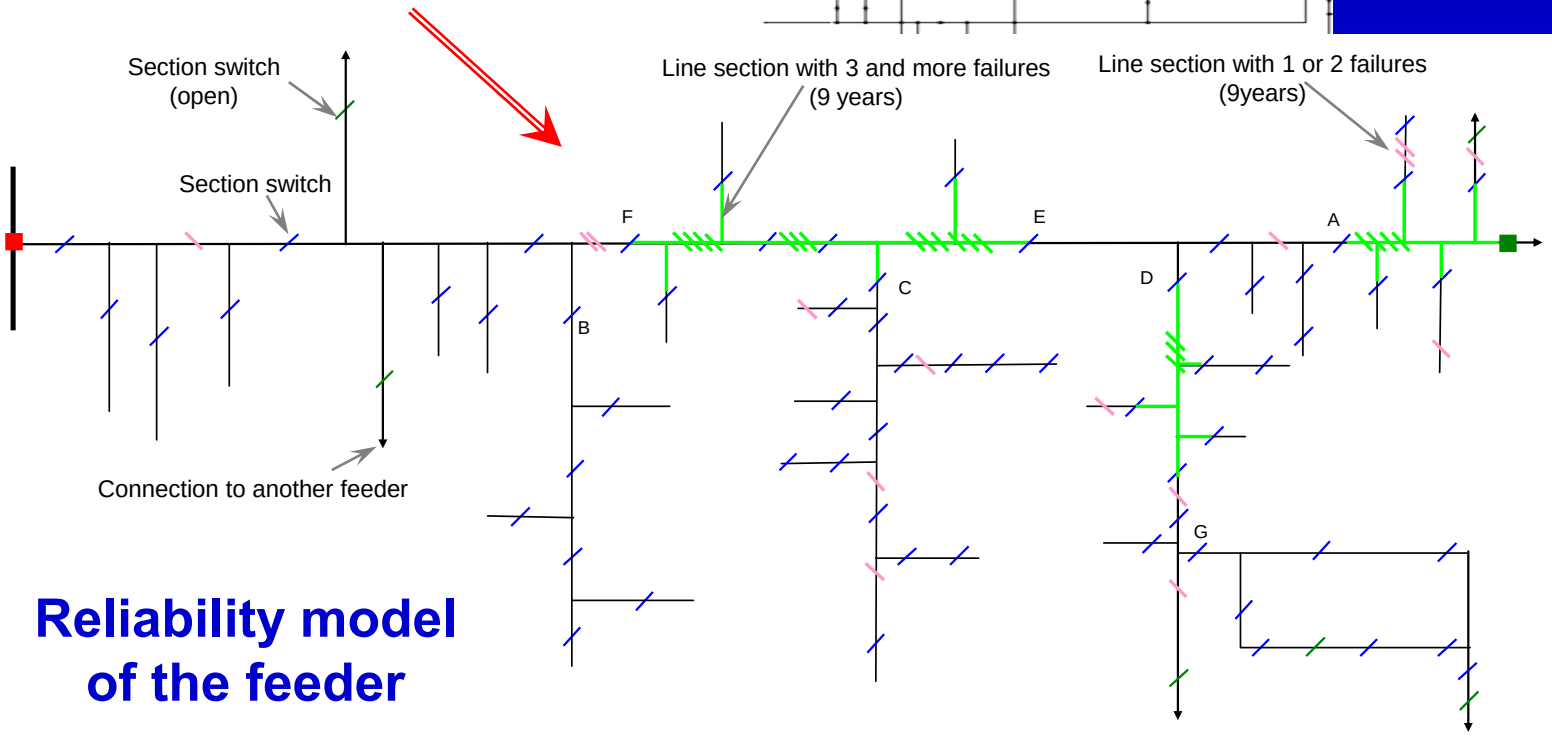
Transformation of electrical diagram to reliability model

Diagram of the feeder

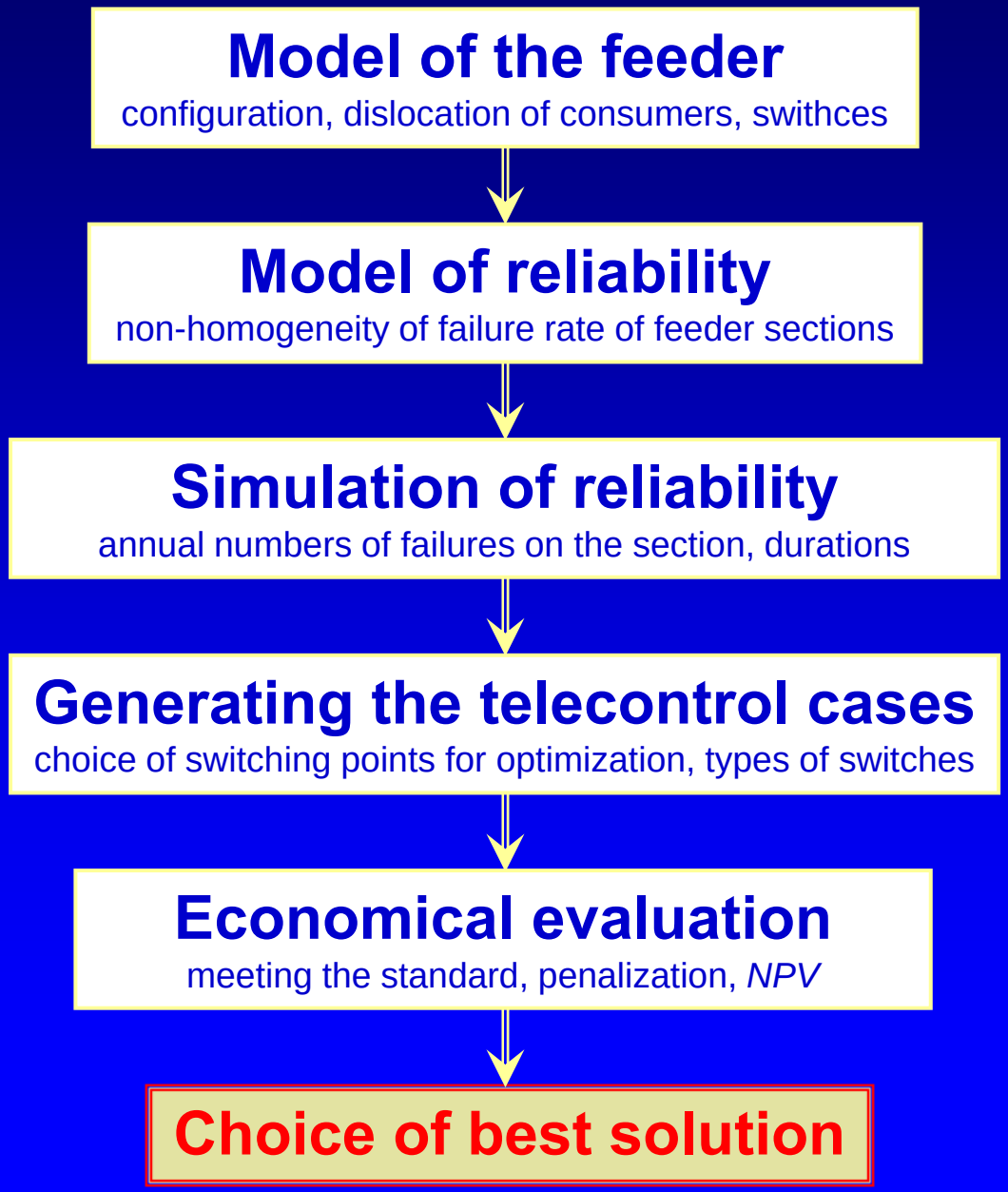
(1-phase)



Reliability model of the feeder



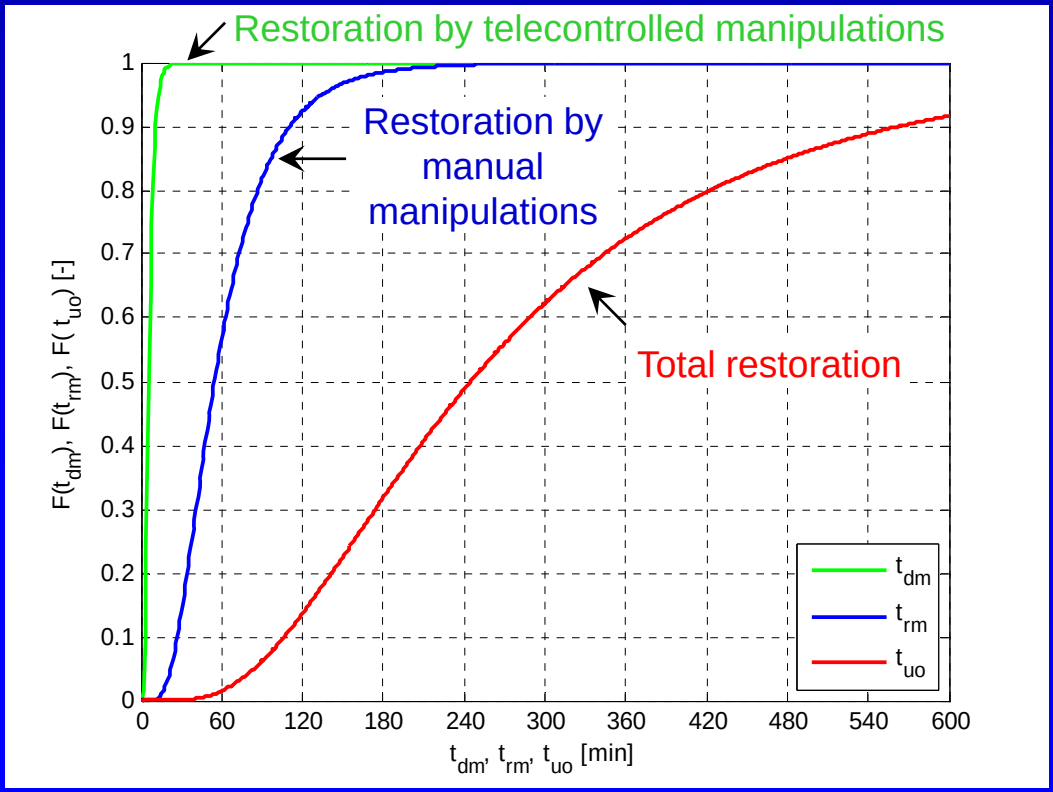
Optimization of the telecontrol in MV systems



Simulation of reliability

- Simulation of annual numbers of failures on sections (sections between switches)
  respecting the non-homogeneity of failure rate

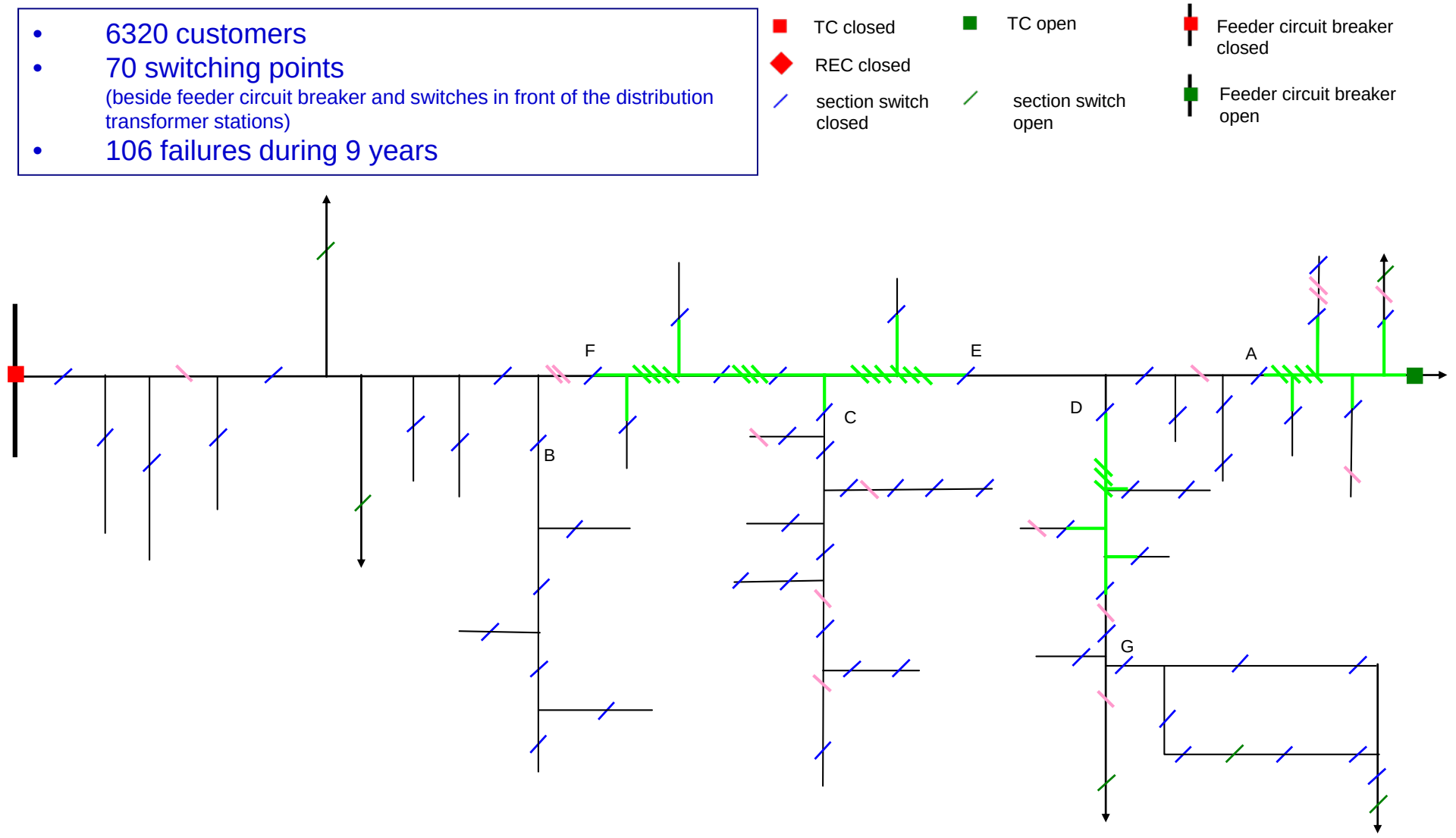
- Simulation of successive supply restoration
  - Time of supply restoration by telecontrolled manipulations
  - Time of supply restoration by manual manipulations
  - Time of total supply restoration in the damaged section



Optimization of the telecontrol on the feeder

Simplified connection diagram of the real overhead 22 kV feeder

- 6320 customers
- 70 switching points
  (beside feeder circuit breaker and switches in front of the distribution transformer stations)
- 106 failures during 9 years



Optimization of the telecontrol on the feeder

Switching elements being simulated

1. Manually controlled section switch
2. Remotely controlled section switch (TC)
   - Have remote control
   - Don’t have protection function
3. Recloser (REC)
   - Have remote control
   - Have protection function = customers connected between HV/MV station and REC being the nearest one to the failure record long interruption (>3 min)

Choice of switching elements for optimization

- Selected according to number of customers upstream and downstream the switching point and according to number of failures on line section
- All possible combinations evaluated

  7 switching points = 2187 possibilities
  8 switching points = 6561 possibilities

Economical evaluation

Evaluation of variants

Improvement of reliability in financial terms

- Reduction of the costs of penalty payments
  = penalties for base state – penalties for a given variant

$$\Delta C_p = C_{p,z} - C_{p,j}$$

- Composed customer's standard (with jump-like penalty)
  - Limit of the annual number of interruptions — L_n = 8 failures/year
  - Limit of the total annual duration of interruptions — L_t = 18 hours/year
  - Penalization per 1 consumer — c_p = 16,66 € (500 CZK)

Economical evaluation

Calculated economical indices

- **Net present value *NPV***
- Index of profitability *IP* (NPV/N_i)
- Internal rate of return *IRR*
- Payback period T_n

⟸ **Optimization criterion**

Optimal equipping of the feeder

Optimal solution

L_n = 8 failures/year, L_t = 18 hours/year, c_p = 16,66 €

ΔC_p = 46 thous.€/year

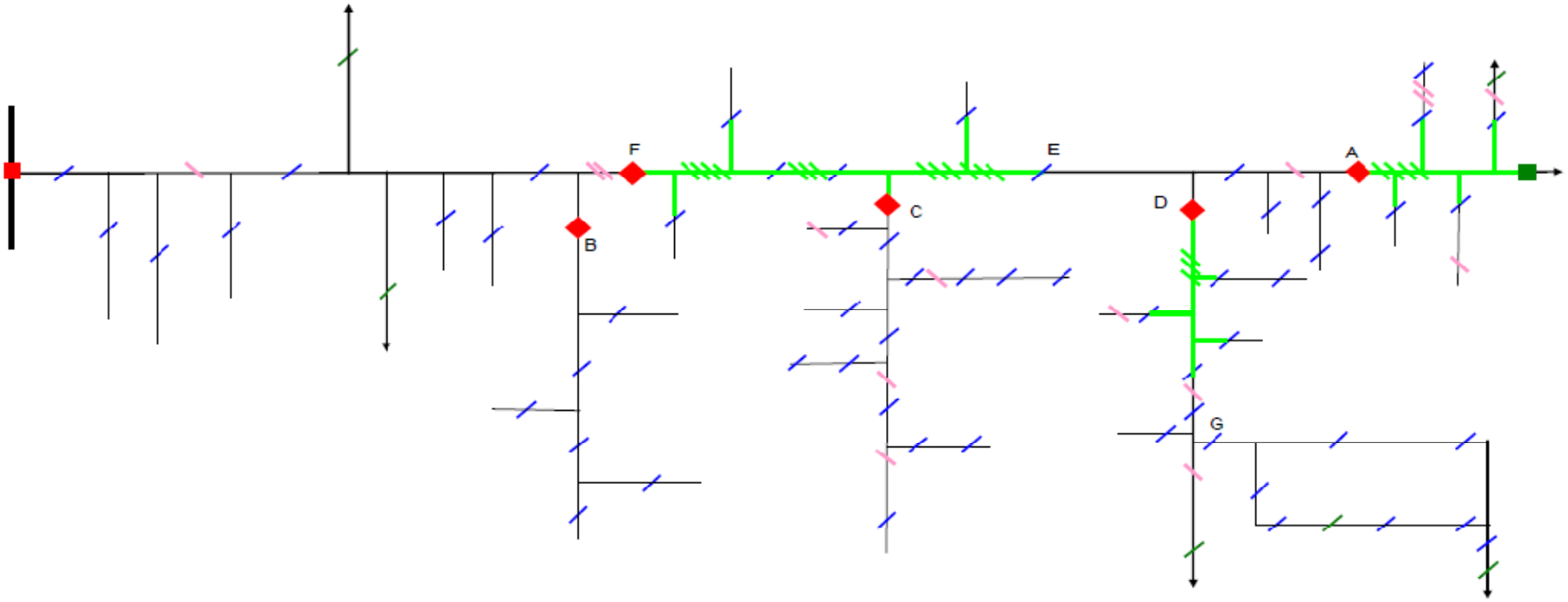
***NPV* = 210,2 thous.€**

***IRR* = 35,4 %**

T_n = 3,6 year

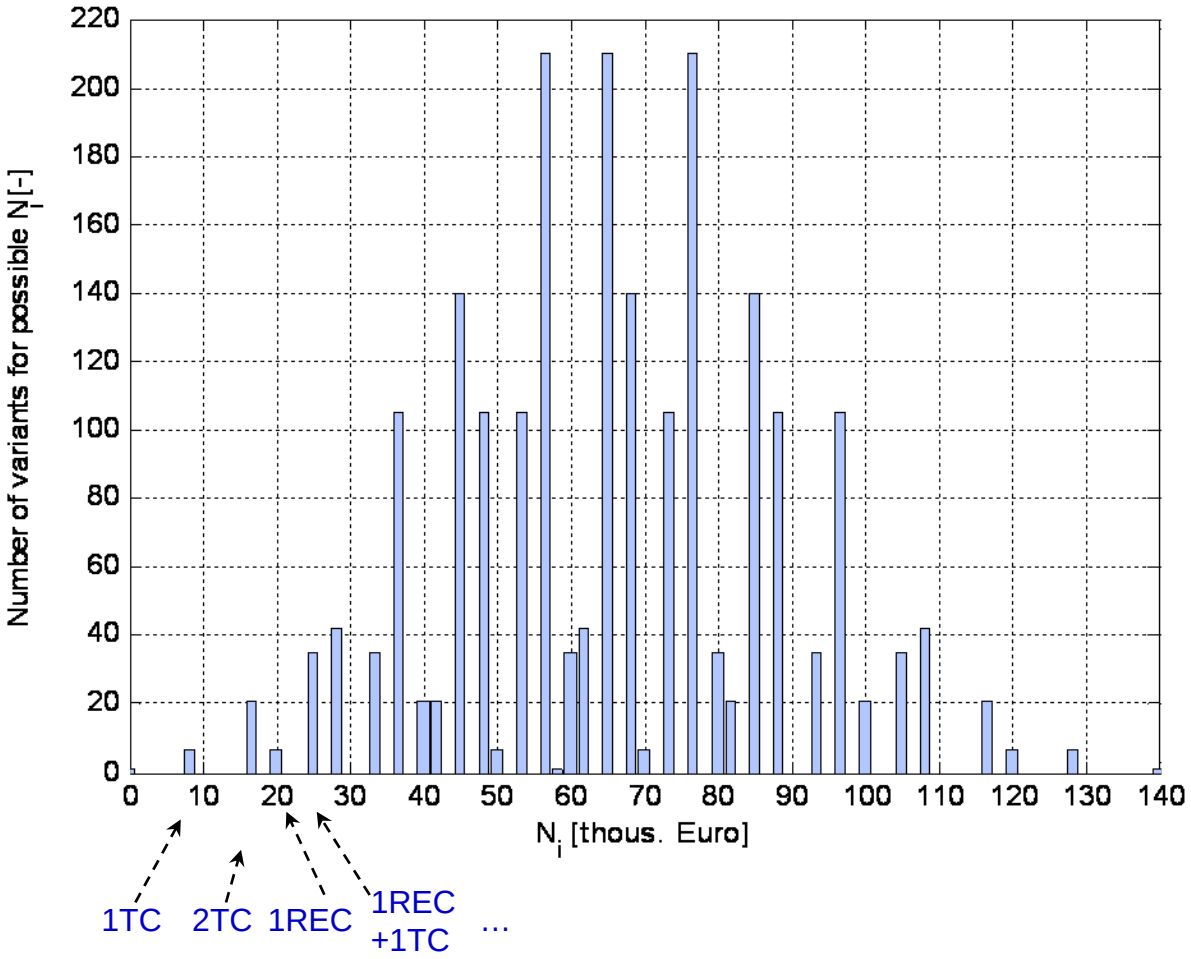
$\Delta SAIDI$ = - 66 min/year

Optimal solution = to add 5 reclosers



Features of variants of equipping the feeder

Number of cases of applying telecontrolled switches for 7 chosen optimized switching points



2187 variants in total

Possibilities for a given switching point:

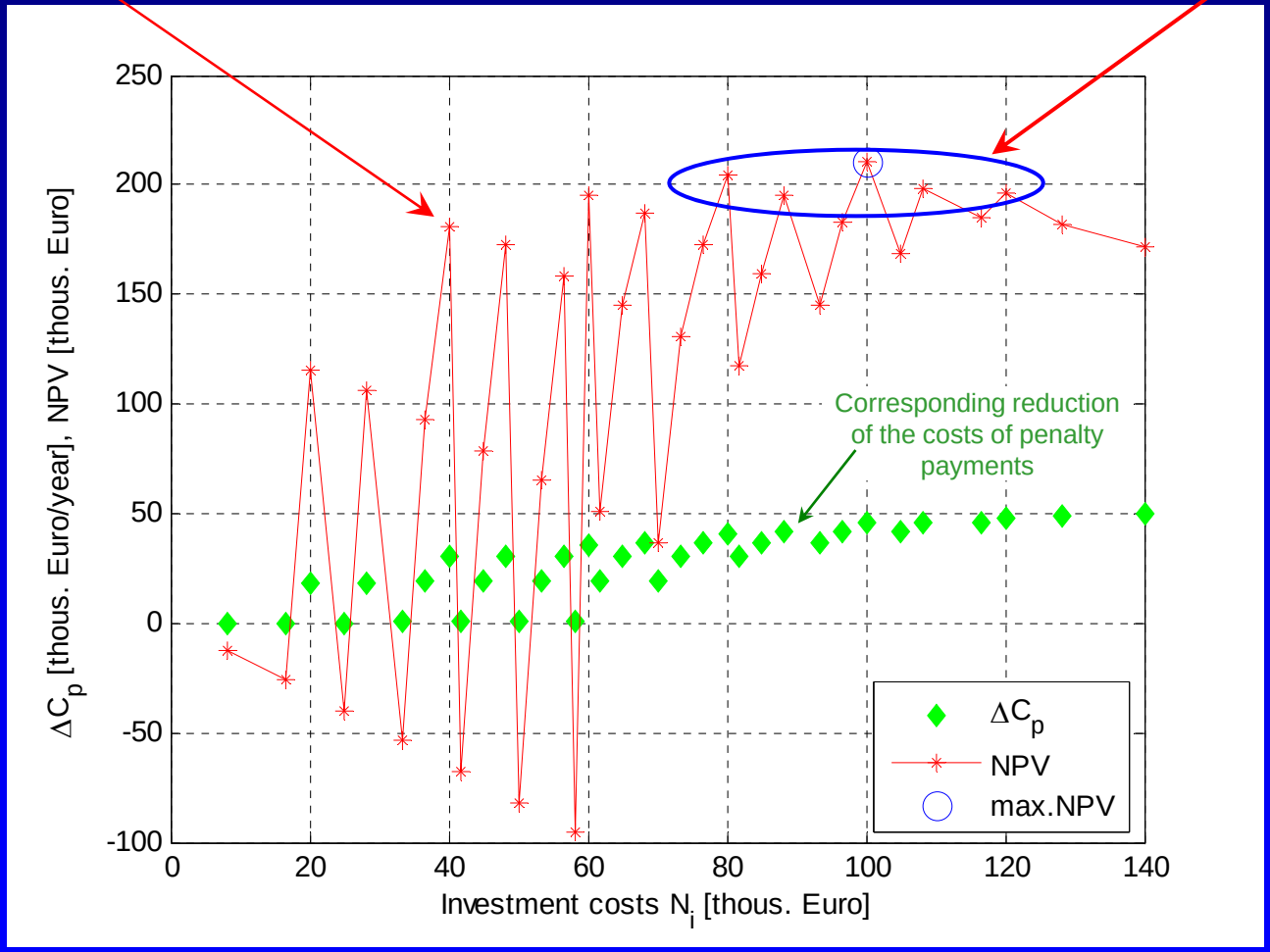
- Existing sec. switch = 0 €
- Telecontr. sec. switch = 8,3 thous. €
- Recloser = 20 thous. €

Certain investment costs = more solutions

Features of variants of equipping the feeder

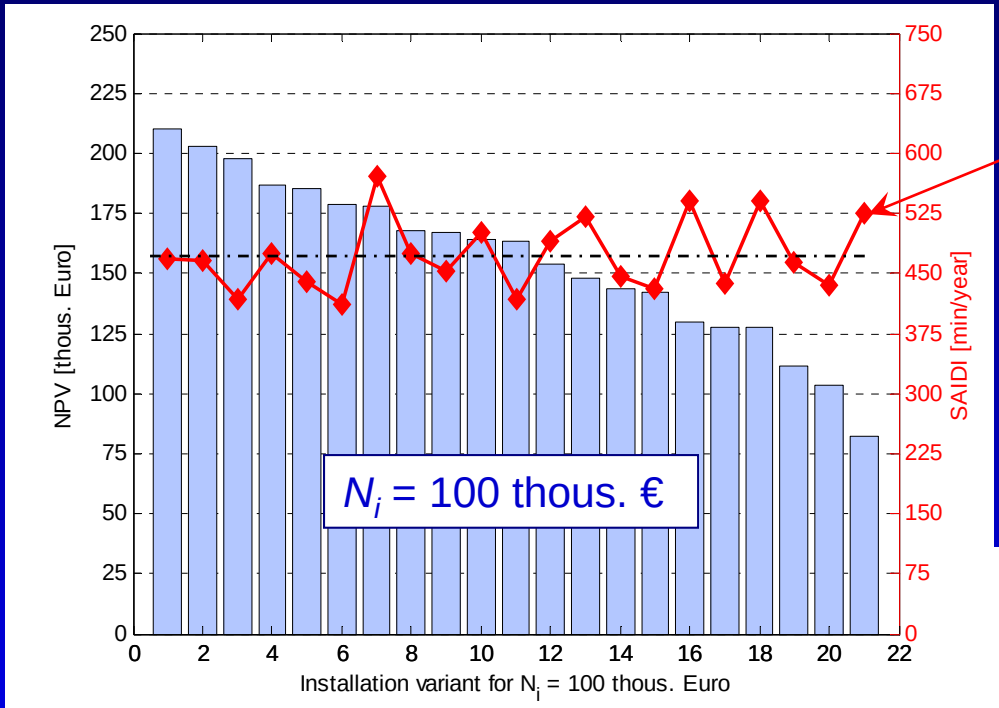
Envelope curve of *NPV*
= solution with the highest *NPV*
for the given magnitude of investment

Area of the flat optimum
= space for considering other operational influences and needs



Various magnitude of investment

Features of variants of equipping the feeder

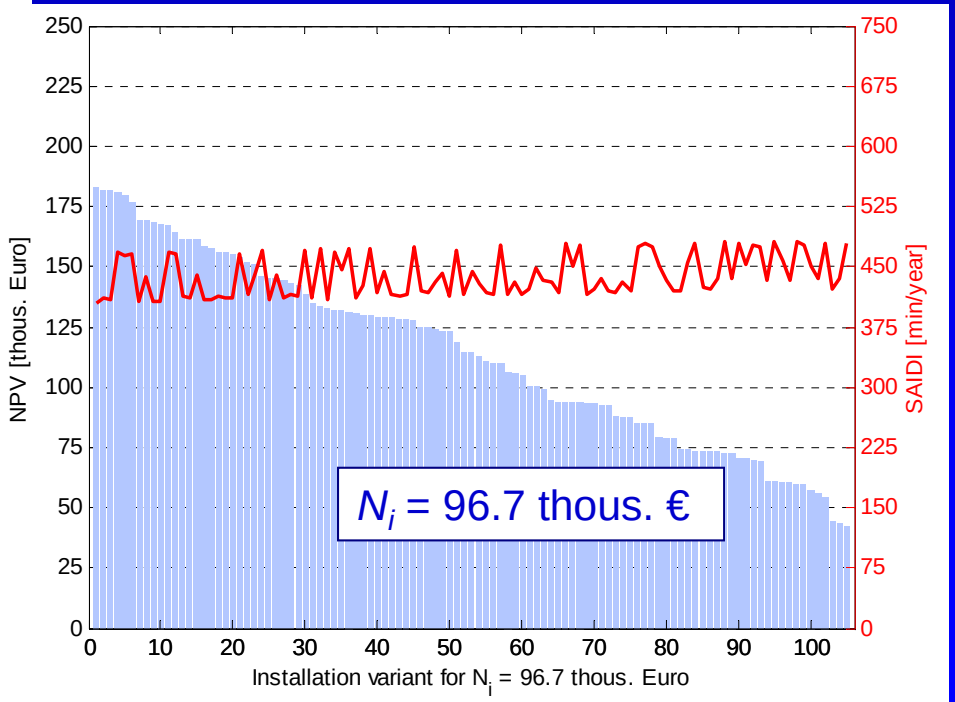


At the same investment:
same *SAIDI* but very different econom. effect

SAIDI is not a good measure for the appropriateness of the variant

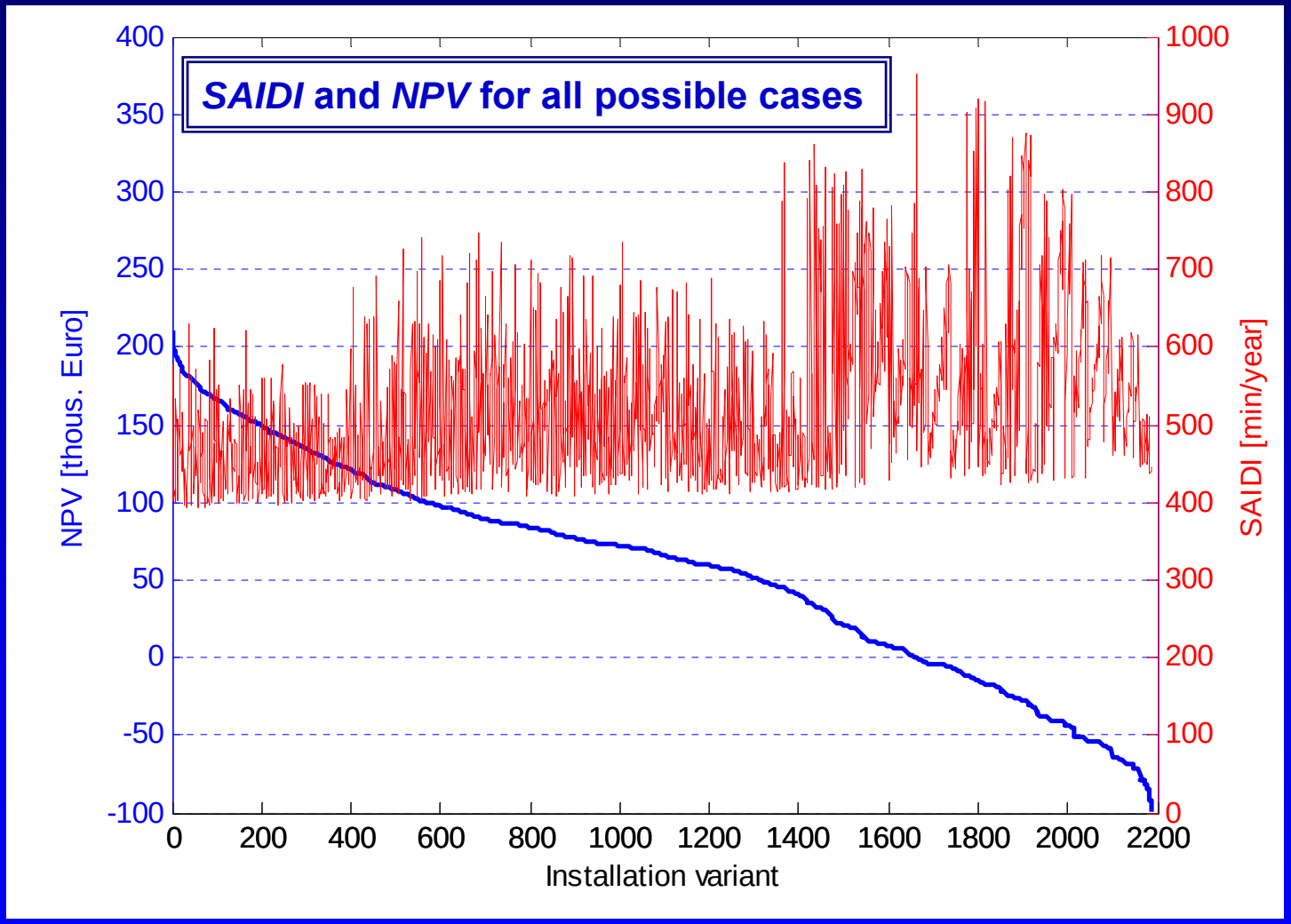
The same investment costs
=
various economical effect
small change of *SAIDI*

Solution for the same investment costs
N_i



L_n = 8 failures/year
L_t = 12 hours/year
c_p = 16.66 €

Features of variants of equipping the feeder



L_n = 8 failures/year
L_t = 12 hours/year
c_p = 16.66 €

A lower limit exists under which *SAIDI* cannot be reduced by using the measure of the given type

Conclusion

- **Optimal allocation of telecontrolled elements depends on**
  - Topology of the feeder
  - Reliability of the feeder
    - It is necessary to take into account observed data for a long period of time
  - Distribution of customers along feeder

- **With regard to ongoing regulation of supply continuity we consider appropriate to express the supply continuity in financial terms by using the customer's standards**
  - ⇒ when the regulator manifests the tendency to establish a customer's standard with a limit of annual number of supply interruptions and a limit of total annual durations

- **The using of customer's standards may lead to different optimal solutions when compared with the costs of ENS**

- **Research of influences of regulation on optimal solutions in area of distribution system can bring useful results for**
  - **distributors** when looking for robust optimization techniques and decision-making procedures
  - **regulators** bringing them to understand how their regulation could work in real systems