Asset Management

Methods & Next Steps

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FINAL CONFERENCE
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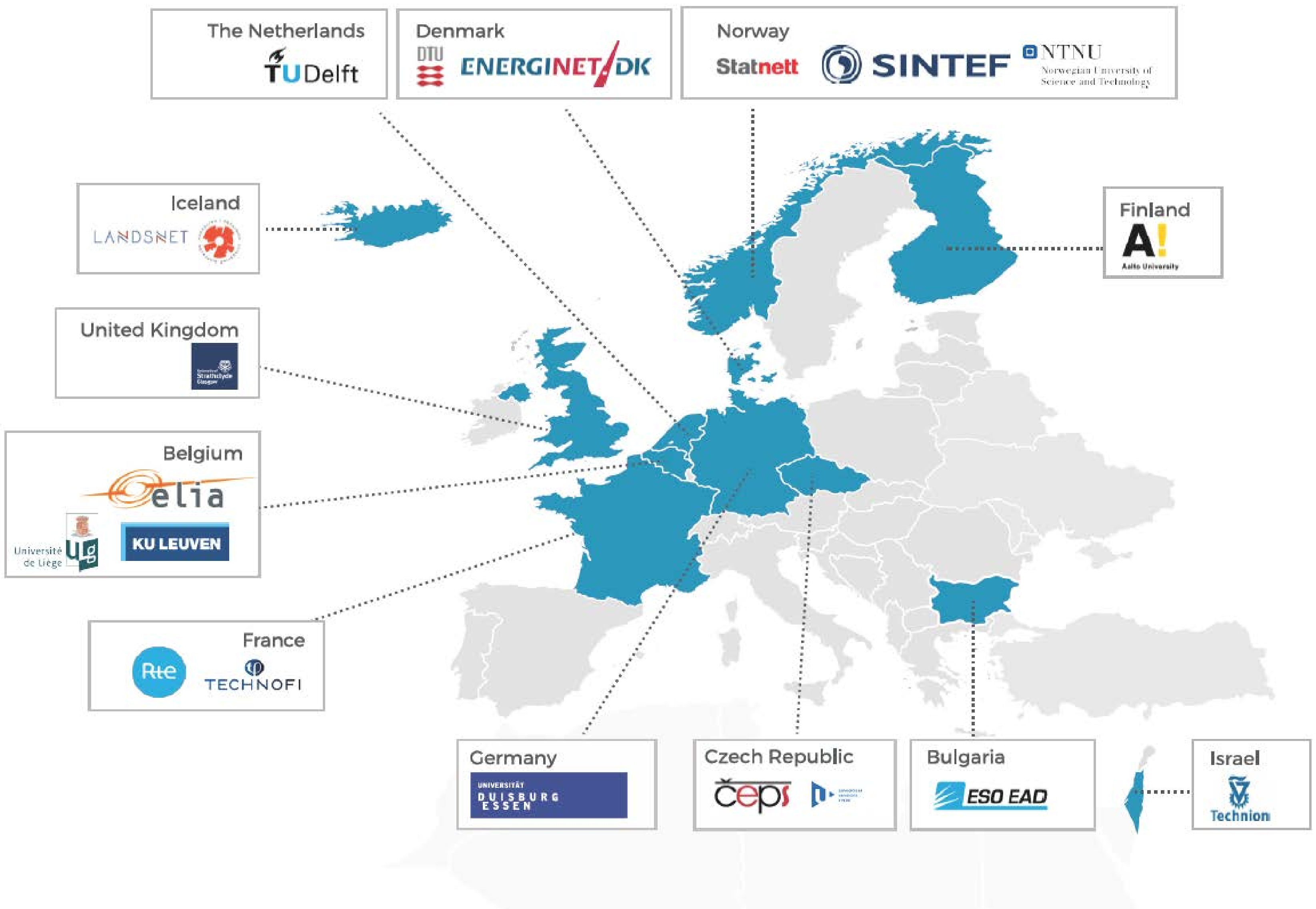
WP5 Contributors

Work Package on implementing GARPUR to Asset management



2 public deliverables
3 internal deliverables

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OUTLINE

Asset Management in GARPUR

What are we talking about?

Reliability assessment methodologies

Highlights on what happens behind the stage

Towards a probabilistic criterion

Asset Management in GARPUR

What are we talking about?

ASSET MANAGEMENT IN GARPUR

The reliability of the whole system depends on the reliability of the grid infrastructure

- N-1 rule ➡ no failure rates
- Assets well maintained ➡ fewer contingencies
- There is a balance to find between the money invested in asset management activities and the resulting reliability at the system level

A replacement wave is expected in the upcoming decades

- Several bottlenecks are looming ahead of us:
  budget, crew availability, manufacturing delays, outage management…
- The workload must be smoothed over time!

Outages due to asset management activities need to be wisely scheduled

- Renewable Energy Sources are already a game changer

Ambitions

GARPUR WP5 has been targeting:

- [Long-term] asset management policy assessment
- [Mid-term] outage scheduling assessment

Key features:

- Probabilistic assessment of the reliability and costs
- Lifecycle cost function: {Purchase+logistic} + {OPEX} + {interruption costs}
- The framework allows to monitor budget/workforce limitations
- Outputs for the global and local levels

Reliability assessment methodologies

Highlights on what happens behind the stage

Asset management policies assessment problem

The AM policies encompass inspection, maintenance and replacement

- Several triggers : time-based, condition-based, corrective maintenance

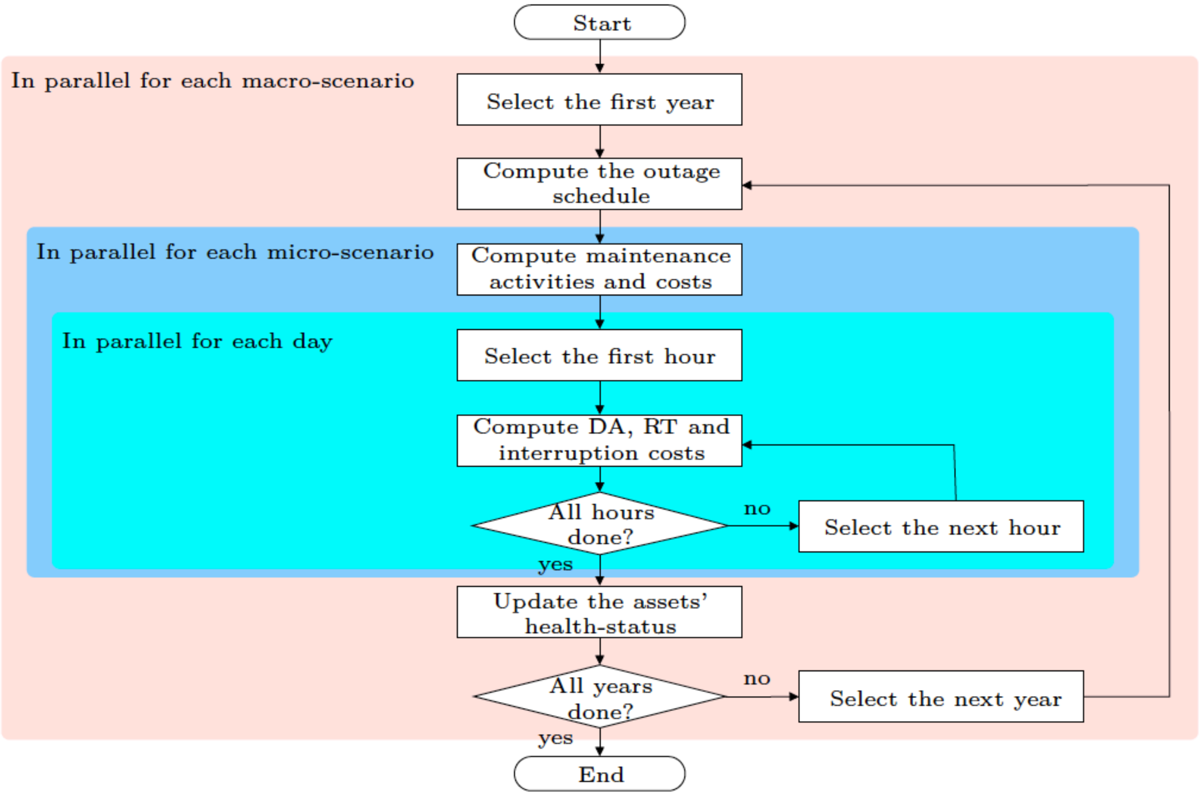
<u>Question:</u> How to define the asset management policies to ensure a safe operation in the future while being cost-efficient?

Preventive maintenance	Activity	Frequency (each X years)	Number of operators	External Cost	Duration	Outage needed
Regular Maintenance	Mounted inspection	6	4	-	1d /km	Yes
	Ground inspection	6	3	-	0,25d /km	No
	Helicopter inspection	3	2	1k€ /km	0,01d /km	No
	Repair	-	4	50k€ /km	1d /km	Yes
Painting	Painting	10	1	4k€ /km	1d /km	Yes
Trimming	Ground inspection	1	1	-	0,25d /km	No
	Trimming	-	1	3k€ /km	0,15d /km	No
	Main cycle	8-15	Depending on the amount of trees to be cut	3-5 k€ /km	Depending on the amount of trees to be cut	No

Holistic approach for AM policy probabilistic assessment

For a large range of credible scenarios

- Simulation over an horizon of ~20 years
- Monte-Carlo simulation
- Model the condition and ageing of components, update failure rates accordingly
- Model the different layers of decisions of the TSO (outage scheduling, generation redispatching, topology, (storage)…)
- Introduce contingencies, model the system response and compute the interruption costs



Hrm, what about tractability?

R&D topics of interest

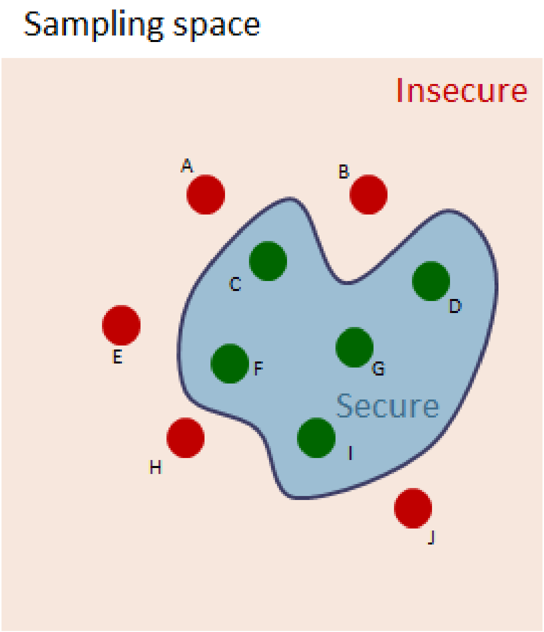
Definition of the exogenous scenarios

Models for the degradation process of the assets due to age and benefit brought by maintenance activities

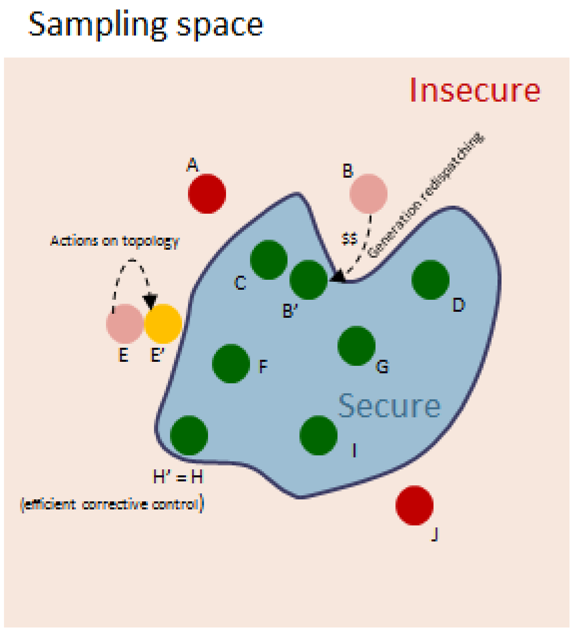
- Link this with the failure rate of the asset

Algorithms to (quickly) emulate the TSO behaviour and system response

- Large uncertainties ➡ large recourse to flexibilities
- Flexibilities need to be accounted for in the framework



Reliability assessment immediately following the sampling of exogenous scenarios



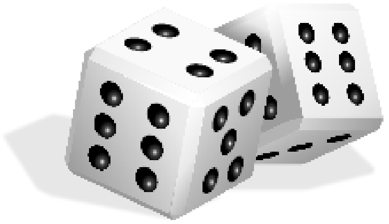
Reliability assessment considering future TSO actions

- Unacceptable sample (red)
- Acceptable sample (green)

Overcoming the computational burden for probabilistic assessment

Reminder: We want to model quite accurately the different layers of decision of the TSO, the contingencies, the system response, over 20 years, for many scenarios

- Tractability is at stake
- Need strong hardware & parallelization & proxies



What are the proxies?

- Approximate methods to emulate the (future) TSO decisions or the system response, in order to assess the future OPEX and reliability
- Proxies need to be quick yet sufficiently realistic
- No need for very low level detail of what may happen in operation

Implementation of Proxies for RT/ST operation

TSO actions: generation redispatching, topology, PST,…

Method 1: human beings in parallel

- Most accurate method available, however…

Method 2: OPF-like algorithms

- Automatic, fairly accurate, but still very slow

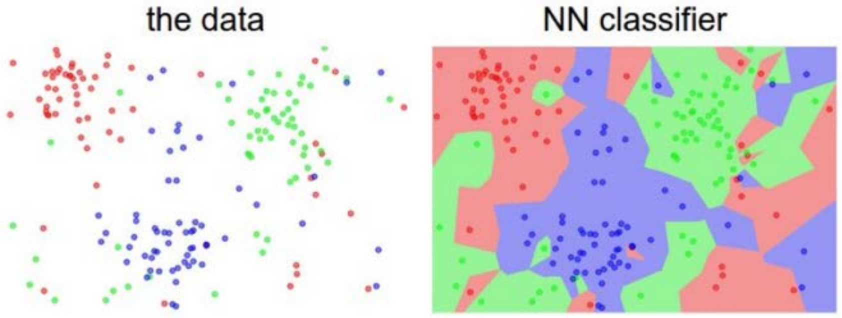
$$\min_{u} \sum_{i=1}^{N_G} C_i(P_i) \quad \text{s.t.}$$

$$P_k^G - P_k^L = \sum_{i=1}^{N} V_k V_i [G_{ki} \cos(\theta_k - \theta_i) + B_{ki} \sin(\theta_k - \theta_i)]$$

$$Q_k^G - Q_k^L = \sum_{i=1}^{N} V_k V_i [G_{ki} \sin(\theta_k - \theta_i) - B_{ki} \cos(\theta_k - \theta_i)] \qquad k = 1, \dots N$$

Method 3: machine-learning

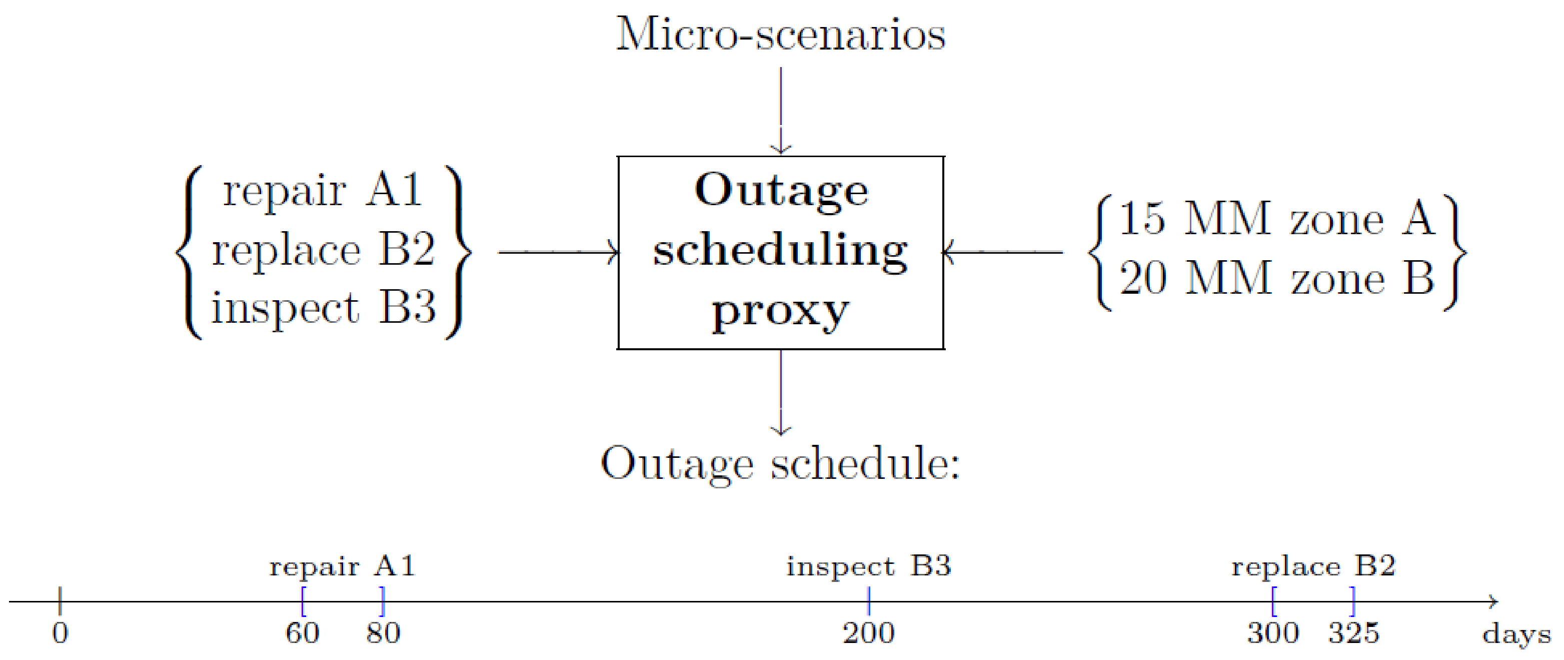
- Build a very large training set through OPF methods
- Use machine-learning techniques to exploit this knowledge
- Slight loss of accuracy but tremendous gain in speed



Proxy for outage scheduling in long-term studies

Issue: a too large amount of simultaneous outage requests can be unmanageable in operation. Long-term reliability management analyses have to model these outages as realistically as possible (not every outage in August…)

- Some (electrically close) outages cannot be undertaken at the same time
- Crew availability needs to be taken into account



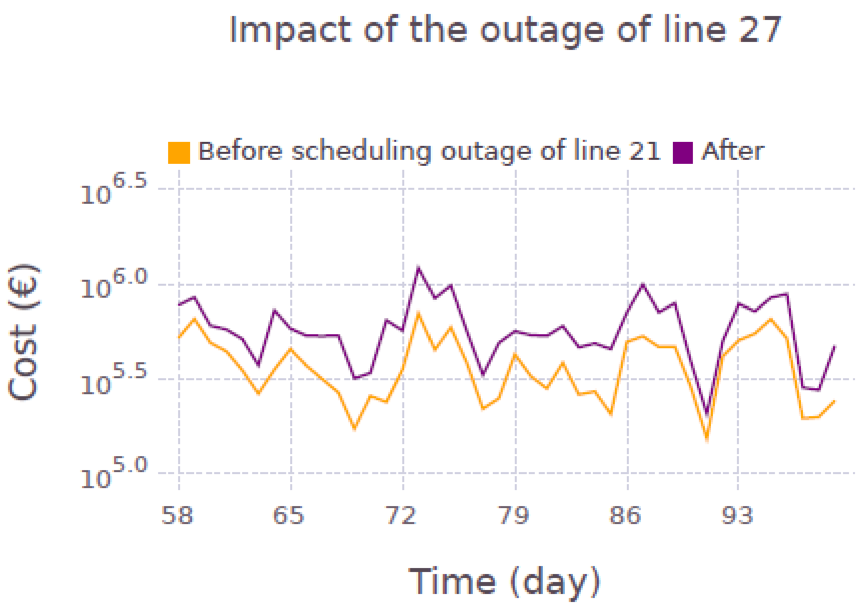
Proxy for outage scheduling: greedy approach

- Monte-Carlo approach: use the proxies for system operation to build an “outage impact” matrix on many micro-scenarios
- Identify the most difficult/costly outage for operation. Schedule this one first. Remove it from the list of outages to be scheduled
- Assuming this outage is committed, update the costs for the remaining outages and iterate

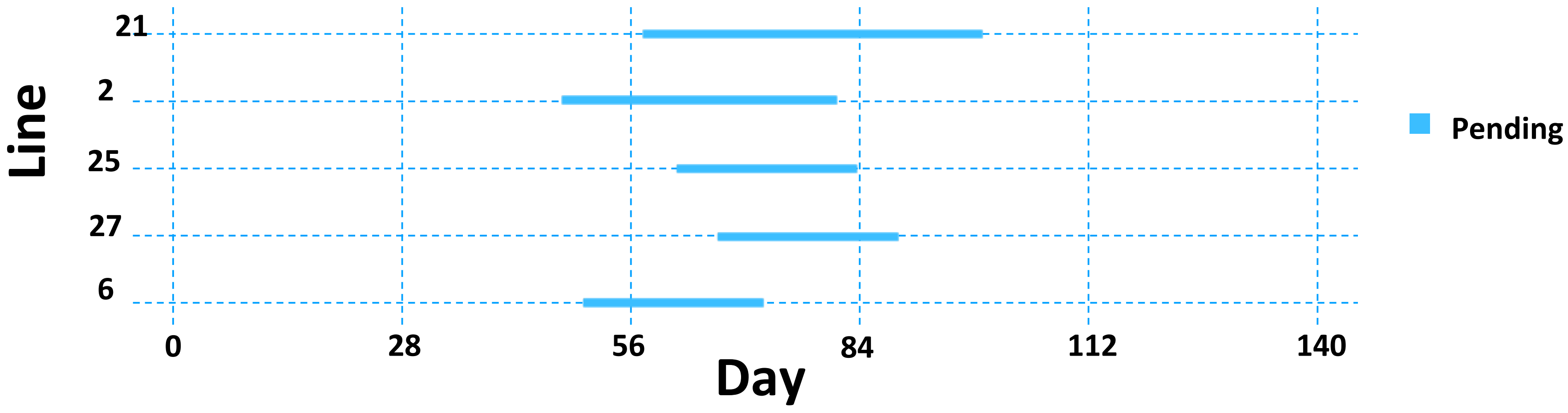
Act./day	1	2	...	d	...	D	o.d.
1	$\overline{c}_{1,1}$	$\overline{c}_{1,2}$	...	$\overline{c}_{1,d}$	...	$\overline{c}_{1,D}$	od_1
2	$\overline{c}_{2,1}$	$\overline{c}_{2,2}$	...	$\overline{c}_{2,d}$	...	$\overline{c}_{2,D}$	od_2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
i	$\overline{c}_{i,1}$	$\overline{c}_{i,2}$	...	$\overline{c}_{i,d}$	...	$\overline{c}_{i,D}$	od_i
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
A	$\overline{c}_{A,1}$	$\overline{c}_{A,2}$	...	$\overline{c}_{A,d}$	...	$\overline{c}_{A,D}$	od_A

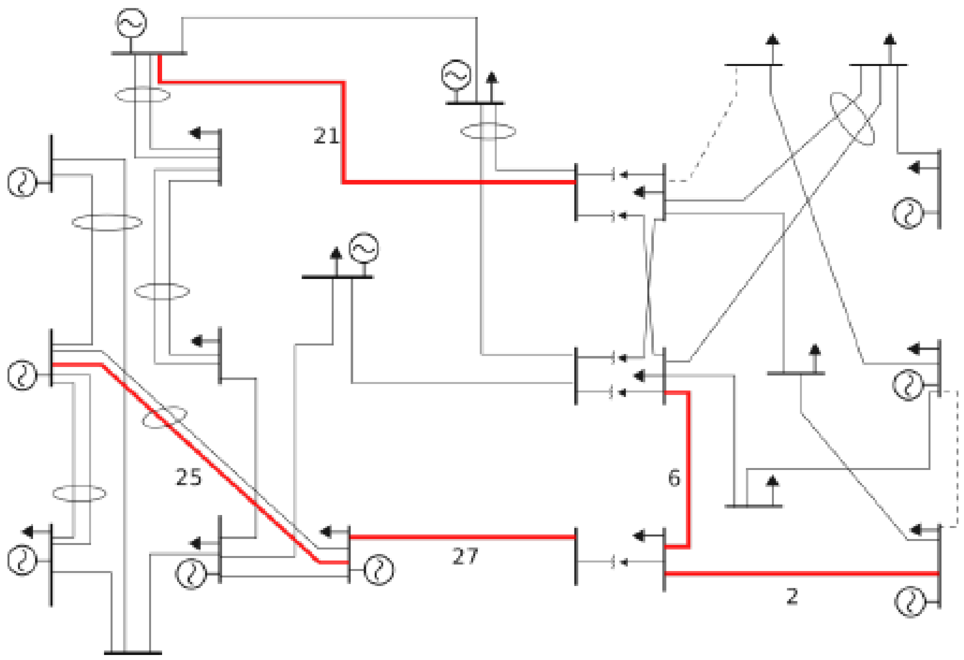
$\longrightarrow$

C_1
C_2
⋮
C_i
⋮
C_A

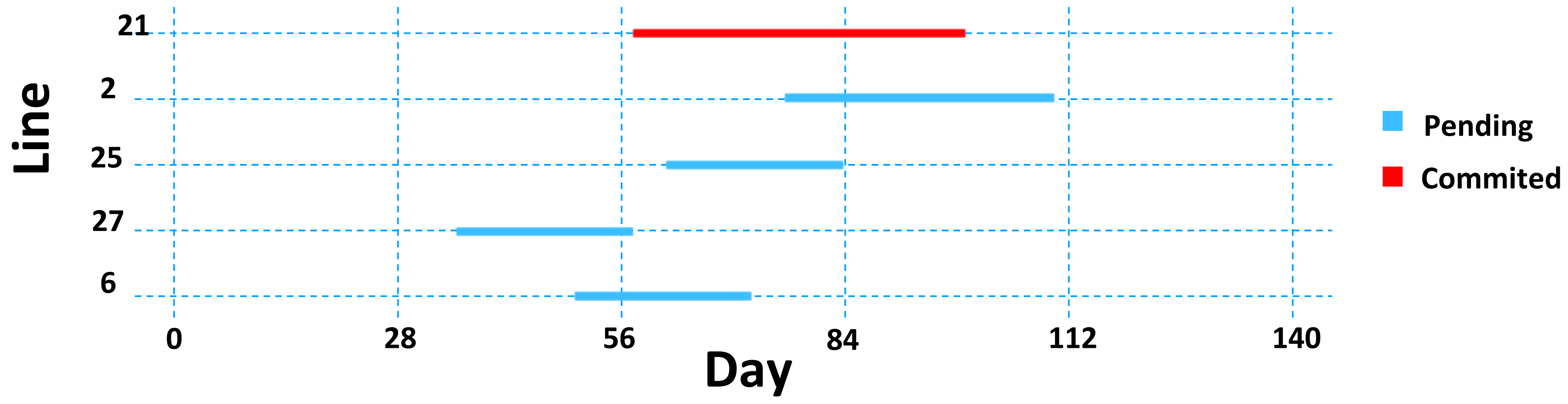


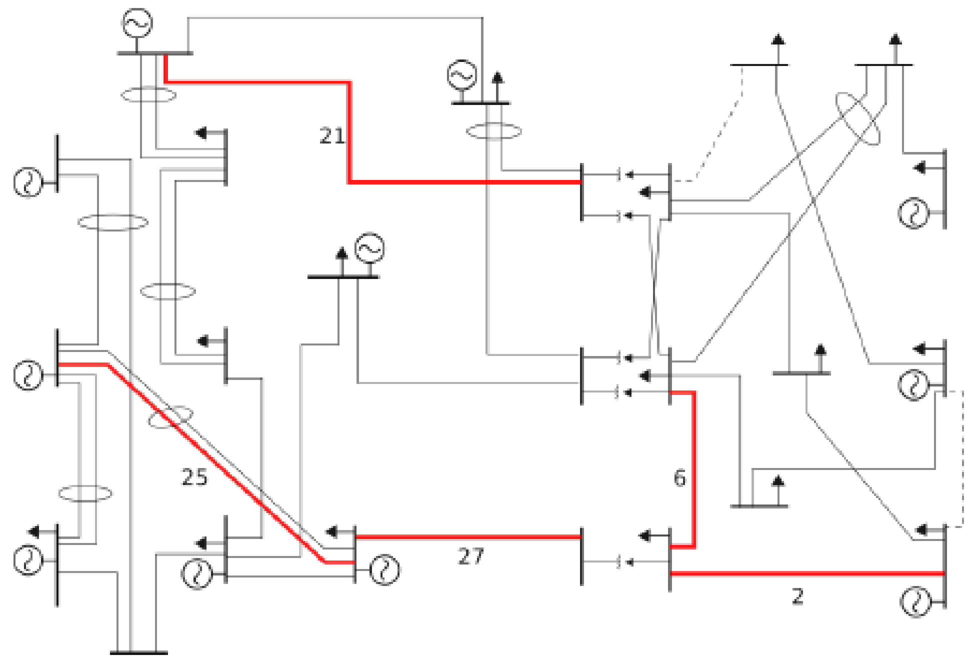
Proxy for outage scheduling





Proxy for outage scheduling





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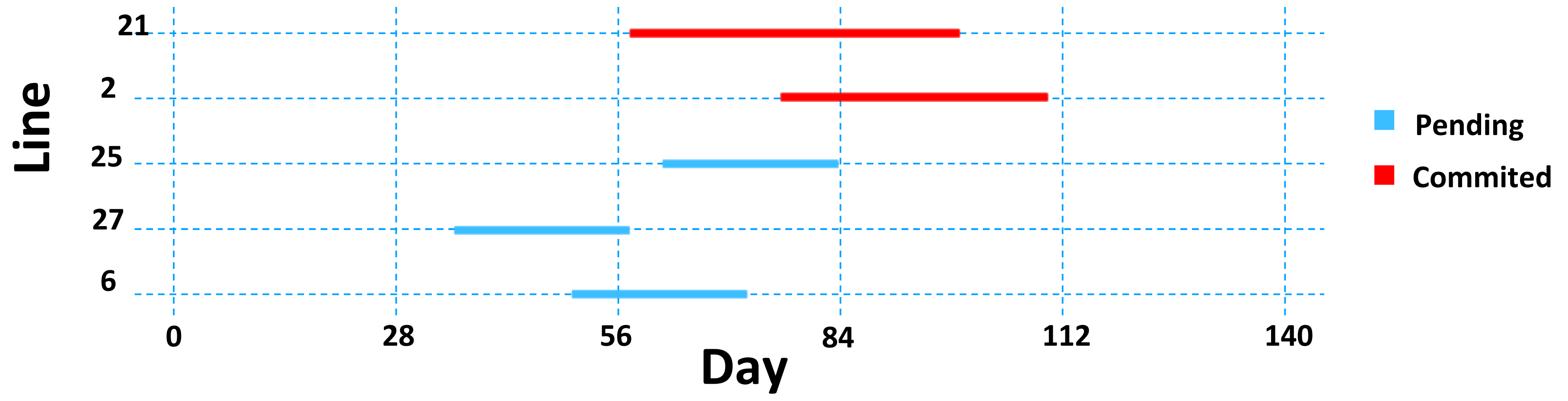

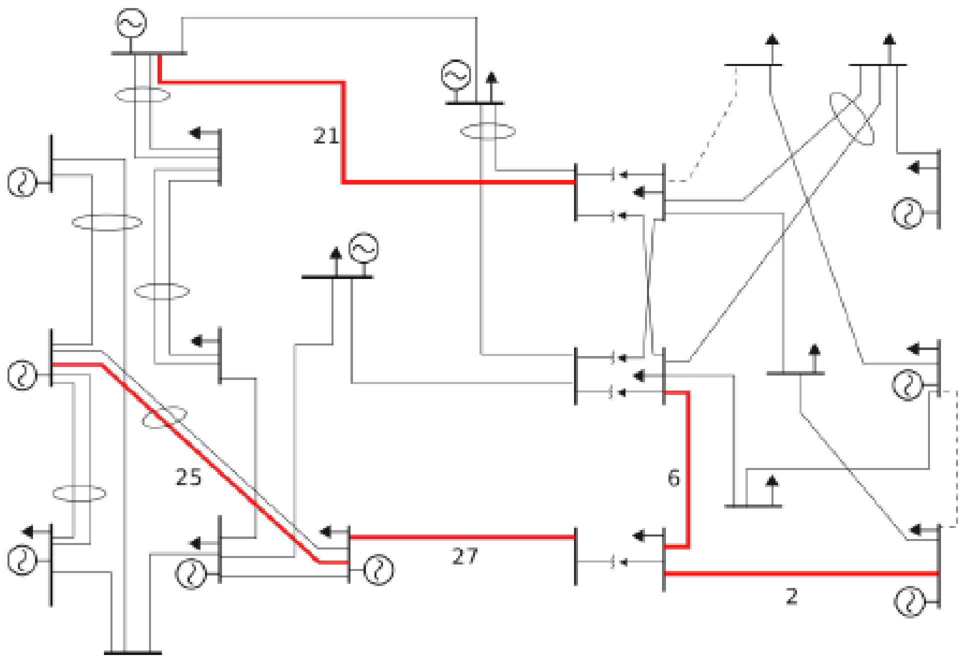

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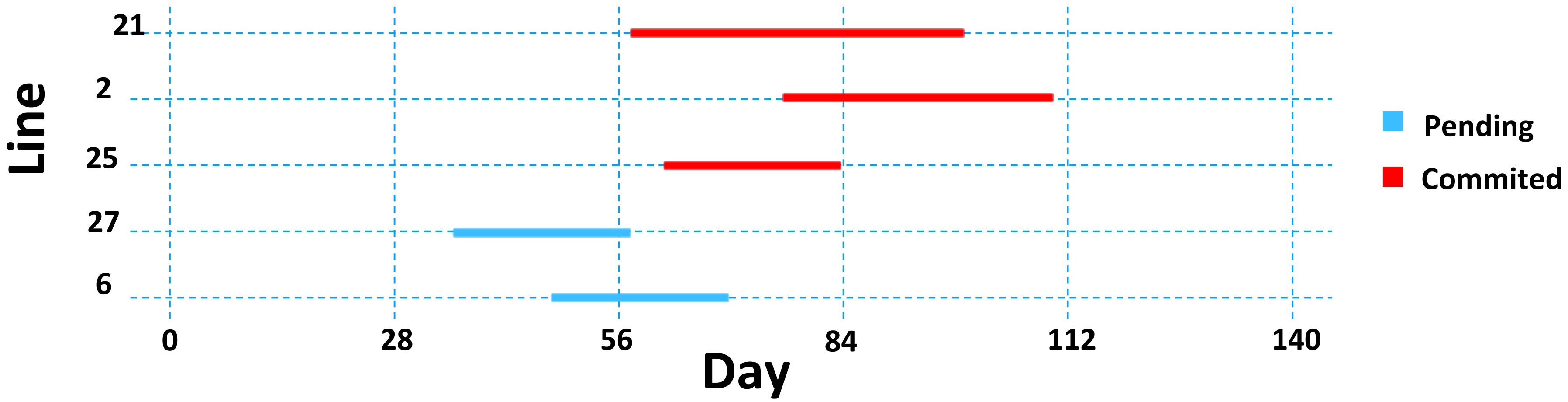

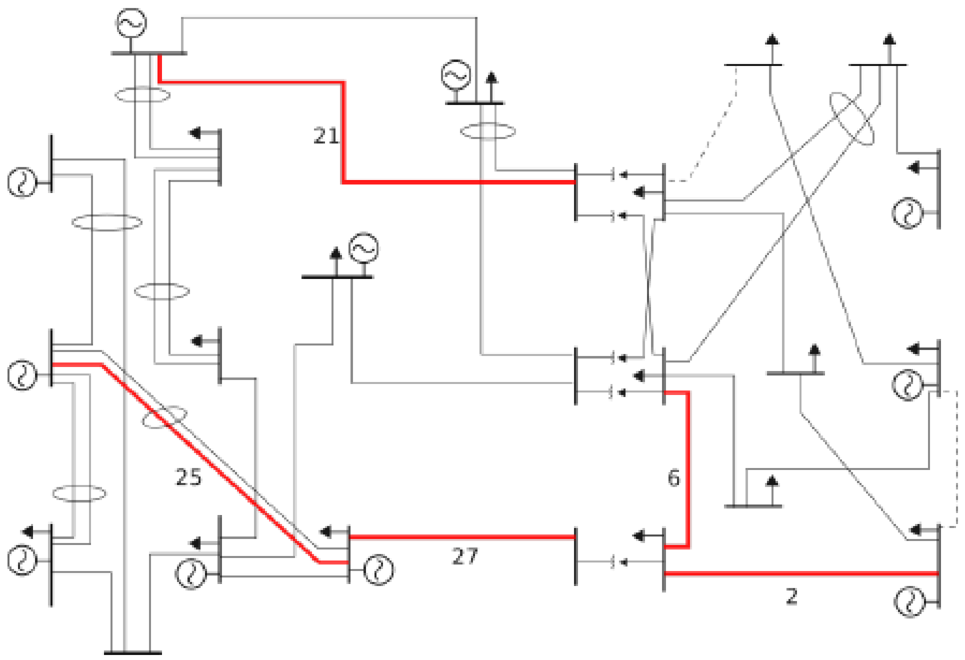

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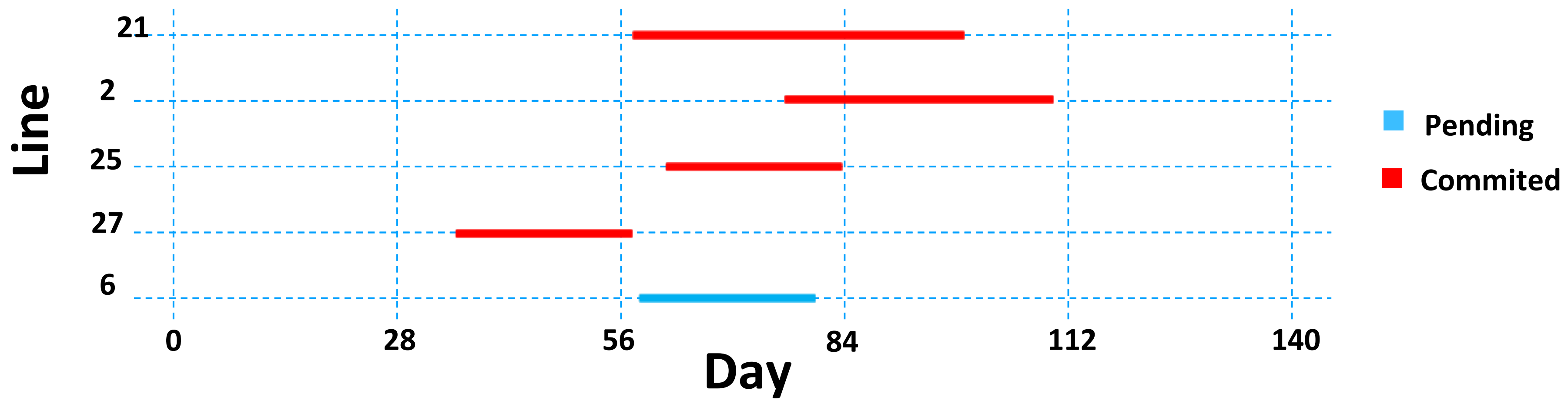

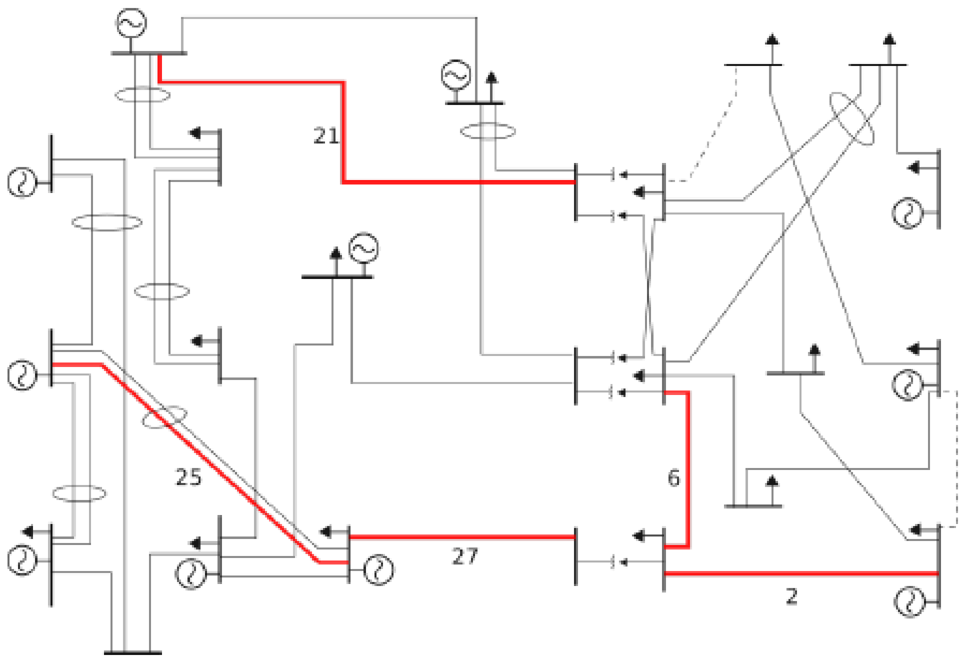

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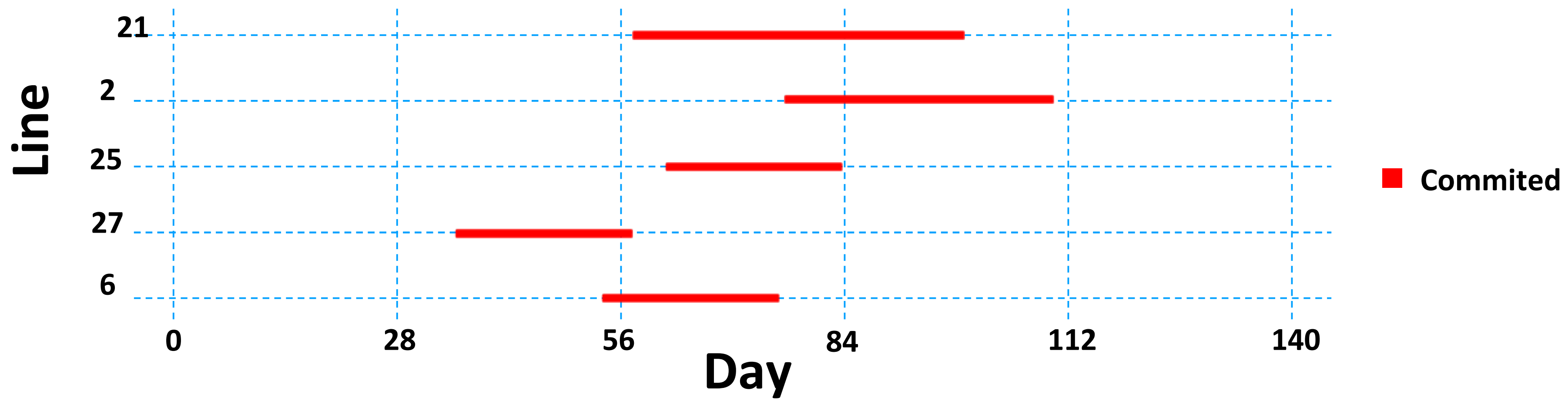
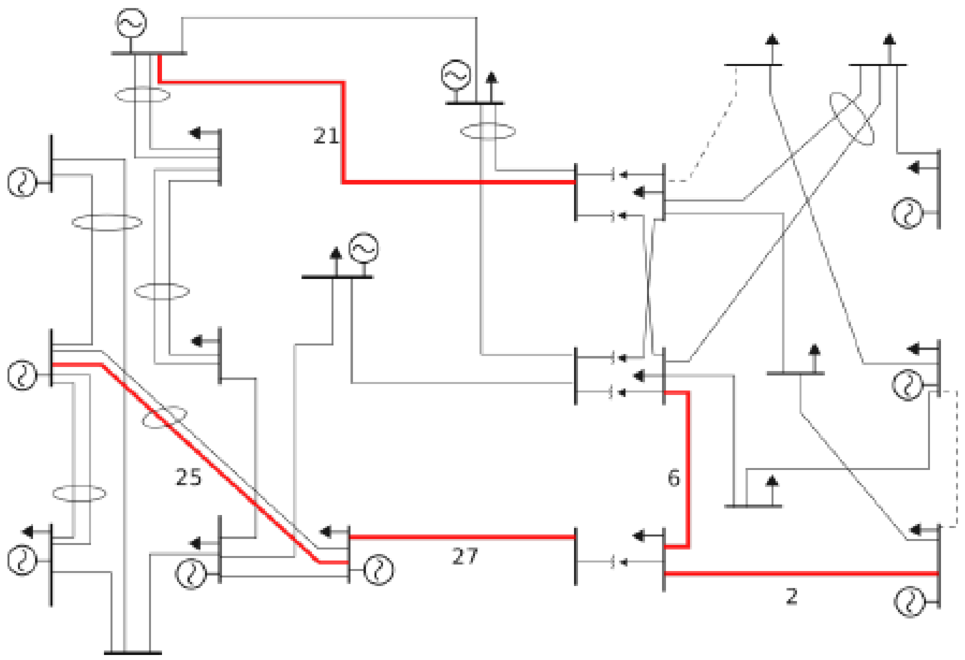




Proxy for outage scheduling

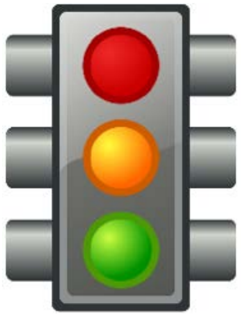
This method enables to propose a tentative outage schedule

- Which is reasonable w.r.t. the expected operational conditions and remedial actions available to the TSO
- Which avoids simultaneous outages that could lead to a large degradation of the system performance
- Which accounts for workforce constraints
- Highly parallelizable

Enables to assess whether outage management may become a bottleneck

If yes, consider hiring crew / investing in livework technologies / anticipating parts of the work

Probabilistic RMAC for AM policy assessment



Two possible perspectives

- Budget given: achieve best reliability
- Reliability target given: minimize the costs

Step 1: solving resources bottlenecks

- Yearly budgets OK?
- Workforce OK despite corrective/condition-based maintenance requests?
- Health statuses manageable in the long-run?

Step 2: ensuring safe operation in the future

- Reliability OK at the global and local levels for a **sufficiently large proportion of scenarios**?

Step 3: comparison of different strategies, optimization of the costs

Towards a probabilistic criterion

Data and models challenges

Same needs as for the other time-frames

- Failure rates, EENS, VoLL, RES (and load/conventional generation) modelling, corrective control and its probability of failure, clustering/filtering of scenarios…
- While considering spatio-temporal correlations

Degradation process of the assets and corresponding failure rates

- Asset management rather works at the subcomponent level while we need failure rates for the whole assembly (e.g. whole line)
- Some theoretical models exist – the difficulty is to tune them, especially the impact of maintenance operation on the health states
- Prior models combined with TSO expertise can provide a reasonable start
- Accelerated ageing tests could also help
- In operation, the failure rates should depend on the weather AND the actual condition of the assets

Algorithmic challenges

Proxies

- Need accurate and fast implementation working on large systems
- Start with slow but accurate proxies, then experiment faster methods and check the output remains sufficiently accurate

Algorithms for (probabilistic) reliability control

- Can be validated once we trust the algorithms for probabilistic reliability assessment
- TSOs are not that much interested in the mathematical optimum. Instead, having a set of a few satisfactory alternatives would be desirable

TSO Side

Need new software for such goal

- Costs in software development, validation, training
- Open question: GUI to take decisions based on probabilistic output

Asset managers need to be trained

- Good understanding of the probabilistic data, system operation and its approximated modelling, economic background,…

Validation: pilot testing the methods on the real system

- Start with the outage scheduling method to close the feedback loop quickly and validate the data and proxies for short-term operation
- Continuous improvement of the data and models

Conclusion

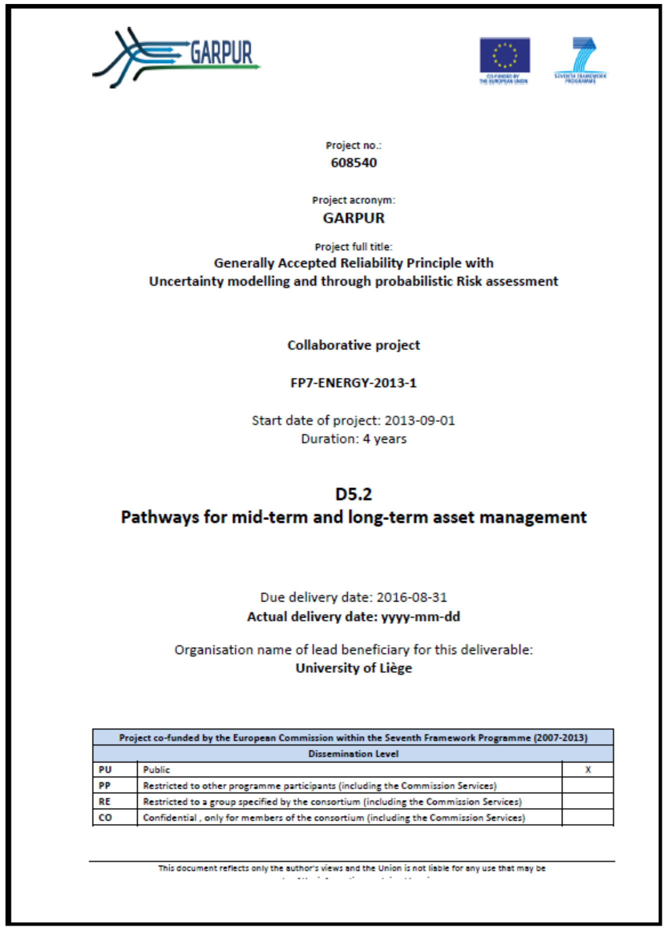
CONCLUSION

We propose methods for a probabilistic assessment of

- Given asset management policies
- Given outage schedules

Main public deliverable of WP5 online

- Available at http://www.garpur-project.eu/deliverables
- Addresses two publics: TSO engineers (main body) and research-oriented people (appendices)


GARPUR

Project no.:
608540

Project acronym:
GARPUR

Project full title:
Generally Accepted Reliability Principle with
Uncertainty modelling and through probabilistic Risk assessment

Collaborative project

FP7-ENERGY-2013-1

Start date of project: 2013-09-01
Duration: 4 years

D5.2
Pathways for mid-term and long-term asset management

Due delivery date: 2016-08-31
Actual delivery date: yyyy-mm-dd

Organisation name of lead beneficiary for this deliverable:
University of Liège

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential , only for members of the consortium (including the Commission Services)	

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Looking into the future

- Growing interest for asset management
- Exploitation/Asset Management/Grid Development should not work in silo
- Being an asset manager will require many skills and knowledge!

THANK YOU FOR YOUR ATTENTION!