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Vysus Group

The future power system - Challenges with renewable energy

ESRA 2022

Significant footprint and legacy

80+ years

Heritage

650+

Employees worldwide

1930 — Lloyd's Register Energy

2005
- Capstone
- ODS

2008
- Human Engineering
- Celerity3
- ModuSpec

2010
- Scandpower

2012
- West Engineering

2013
- Senergy

2020 — Vysus Group

2021
- Promaps Technology

Content

- The characteristics of a power system
- The global power system is changing
  - Unregulated energy sources like solar and wind
  - Electrification of the society
  - The effect is now becoming clear
- What we need to do and what we can do
- Deterministic and probabilistic security constraint
- Probabilistic risk analysis - Use cases

Characteristics of power system

- Complex's system with a lot of components
- Need to be balance between production and load at all time
- Take a long time to develop a power system (long application- and installation time frames)
- The security criteria of power system is based on the **deterministic N-1** criteria to obtain a high security of power supply
- The N-1 criterion states that a system that is able to withstand at all times an unexpected failure or outage of a single system component, has an acceptable reliability level.

The global power system is changing

- Change in production – more solar and wind, less coal and nuclear
- Electrification of society – increase in load
- More weather – increase temperature – increase energy in atmosphere
- More interconnectors between countries/regions
- More depended on our neighboring power system than before
- More data available through digitalization
- More smart grid technology available
- Societies expectation of reliability of the power supply is increasing

The global power system is changing

- All of these changes create new possibilities but also new challenges
  - The changes in production and loads changes faster than the development of the physical power system
  - The new production is dependent on the weather
  - Spinning reserve in the power system will be important
  - This will challenge the power systems security of supply
  - More volatile energy prices and higher prices
    - Energy poverty
    - Will challenges the politics and the speed for reaching the clean energy goals

This challenge the Utilities main task

«To provide customers with a stable and secure energy supply

*(**security of supply**)*

combined with

a most efficient operation and development of the electricity grid in the company's licensing area »

And this will again affect the whole society!

What we need to do and what we can do

- Create predictability for all parties for the current and future state of the power system
  - Grid owners
  - Producers
  - Consumers
  - Politicians
  - Regulators

- Through more in depth analysis of power system in real time and updated prognoses analysis
  - Understand the inherit property of the power system for different time scale
  - Make the result available for all parties

- And based on this - plan for new security constraints in operation and development of the power system for increasing flexibility
  - Moving from deterministic to probabilistic security constraint

What is the difference between deterministic and probabilistic risk method

Deterministic and probabilistic in the nuclear industry

Probabilistic calculation – principle

Example: A Markov chain is a mathematical system that experiences transitions from one state to another according to certain probabilistic rules:

Think of a all the components in a power system like a Christmas three:

- with thousands of lights
- where each lightbulb has a probability for being in a lightning state (99,99 % of the time) or a fault state (for 0,01% of the time).

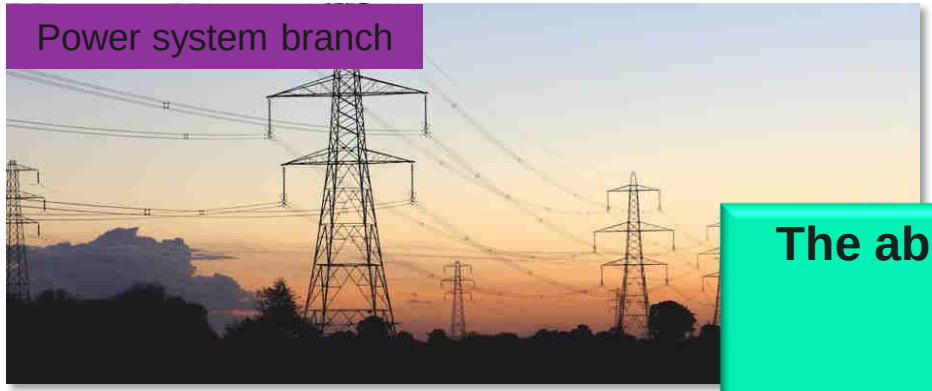
Fast-forward in time, the Christmas three will be blinking all over the three:

Reducing its overall lightning capability

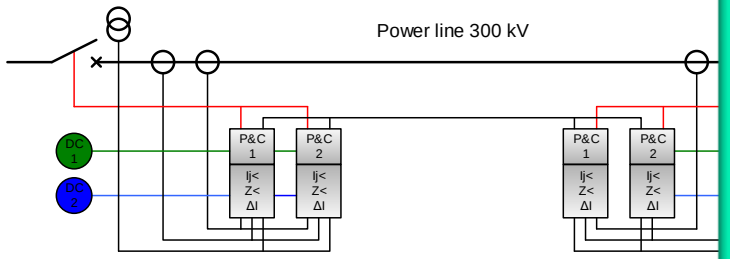
In a power system the same logic applies

Power system complexity

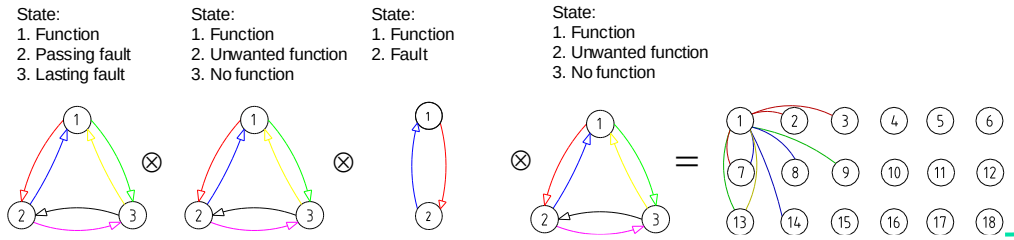
Power system branch



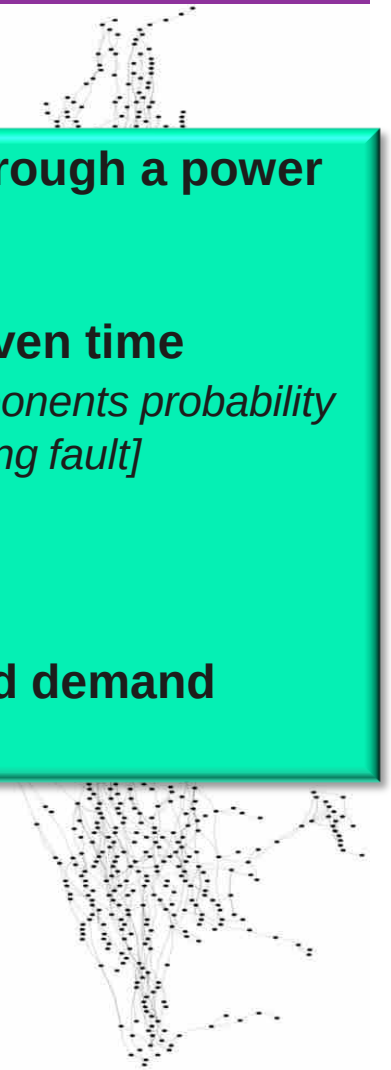
Consist of many component



With many potential many failure states



Power system consist of thousands of branches



The ability to deliver demanded power through a power system is given by:

1. **The probable capacity at any given time**
   given by the combination of all the components probability states [Function, temporary fault or lasting fault]

& Combined with

2. Production, configuration and load demand

Production

Capacity

Load

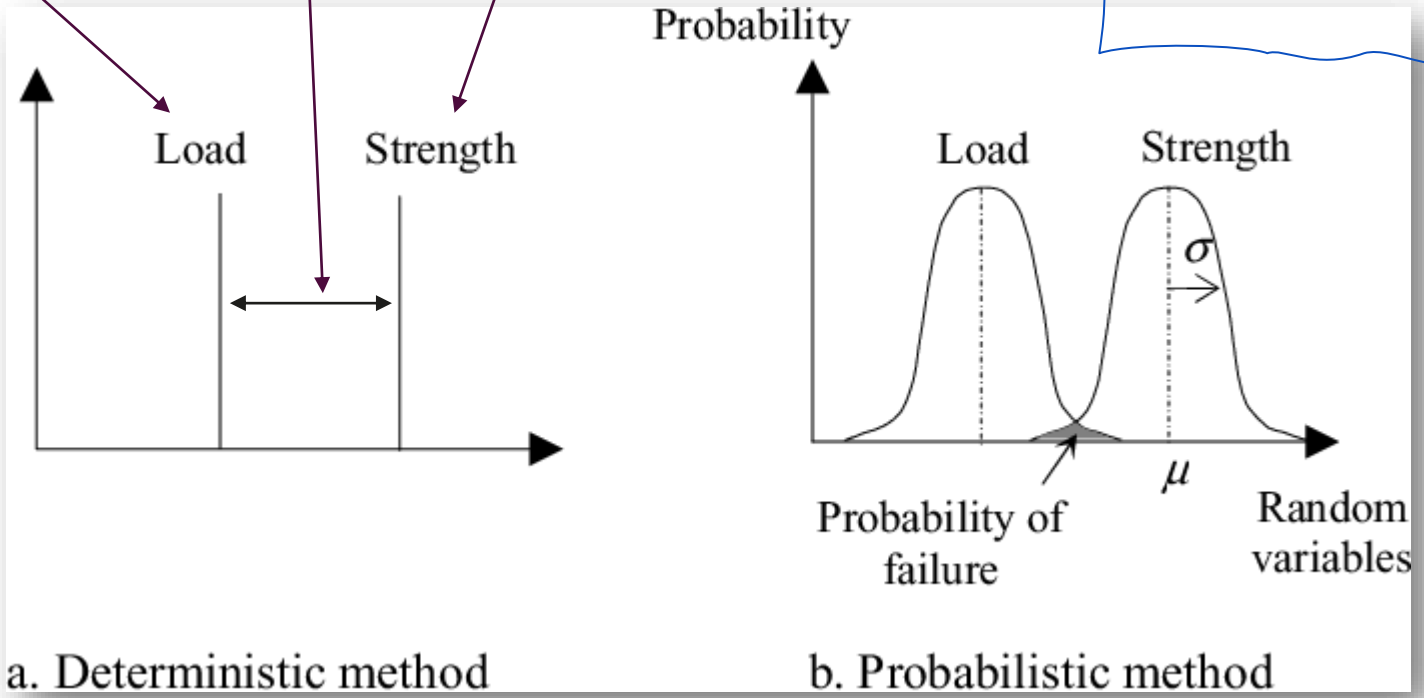
Deterministic vs. Probabilistic Safety Assessment

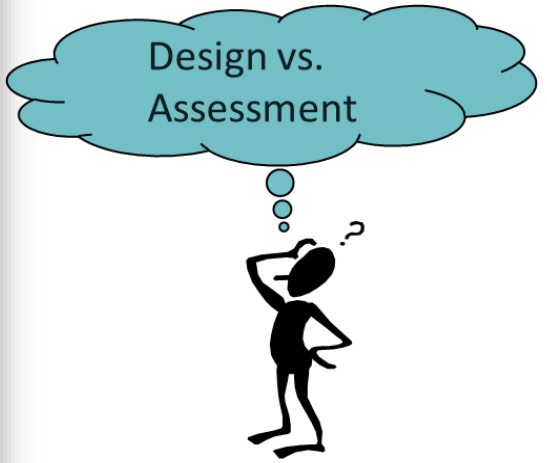
Design basis

- Margin
- Predefined bounding cases
- System design

Factors of uncertainty, e.g.:

- Scenarios not accounted for in design basis
- Variability in operation
- External factors (e.g. weather)
- Wear and tear (ageing)
- Human factor
- etc





Deterministic vs Probabilistic assessment – Nuclear industry

IAEA
International Atomic Energy Agency

"A safety analysis of the plant design shall be conducted in which methods of ***both deterministic and probabilistic analysis shall be applied***. On the basis of this analysis, the design basis for items important to safety shall be established and confirmed."

Deterministic N-1 principle

The N-1 criterion states that a system that is able to withstand at all times an unexpected failure or outage of a single system component, has an acceptable reliability level.

- This implies that some simultaneous failures could lead to local or widespread electricity interruptions.
- **However, the N-1 criterion has achieved acceptable results over the past decades.**

IAEE Energy Forum - Electricity Transmission Reliability Management

Probabilistic principle

Calculate : **Expected Energy Not Served (EENS)**
- including all contingencies up to a certain cumulative probability of occurrence and connected cost for the power system

1. Failure probability for each component, each branch and the system a whole
   - Input data: failure rates, repair time and reconnection times
   - Failure rate can be based on component state (age, wear & tear and external factors: weather)
2. Combined with flow calculations including:
   - Production and Spinning reserve (type & location)
   - Configuration, Capacity restrictions, Load demand

Deterministic & Probabilistic Principle: Power System

New regulation ACER CSAM – Article 75

- **Source: ACER – Agency for the Cooperation of Energy Regulators (EU)**
  - *Document: Methodology for coordinating operational security analysis in accordance with Article 75 of Commission Regulation (EU) 2017/1485.*
  - ….. All TSOs shall publish, with the support of ENTSO-E, a report on the progress achieved in Europe on the **operational probabilistic coordinated security assessment and risk management.** The first report shall be published in 2021….
  - ….. development of the **methodology on common probabilistic risk assessment**……
  - ….. By 31 December 2027, all TSOs shall jointly develop the methodology on **common probabilistic risk assessment** taking full account of the requirements……

What is the value of use for Utilities, large consumer of power, regulators etc. Promaps Realtime

1. The software
2. Use cases 1 - 4

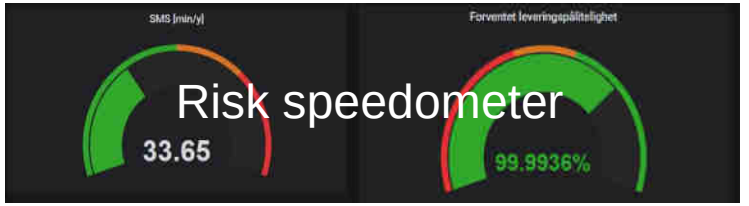
Promaps

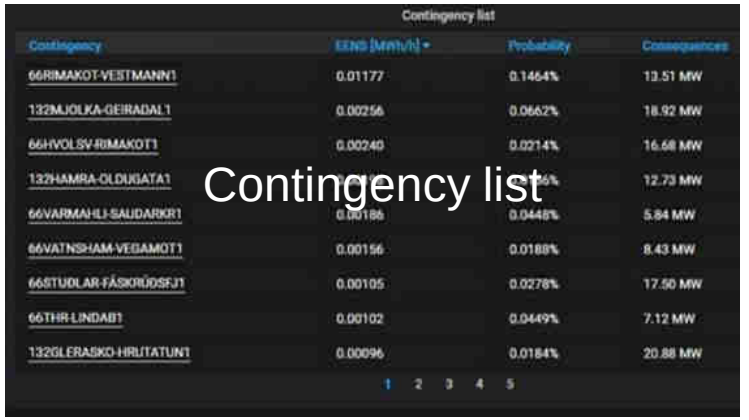
Probability Method Applied to Power System

Designed to give insight into complex power systems

Promaps Realtime

1. Reliability results
2. Power system risk





Power system risk is dynamic

(Security of supply the whole power system)

The higher the graph the higher the risk for outage

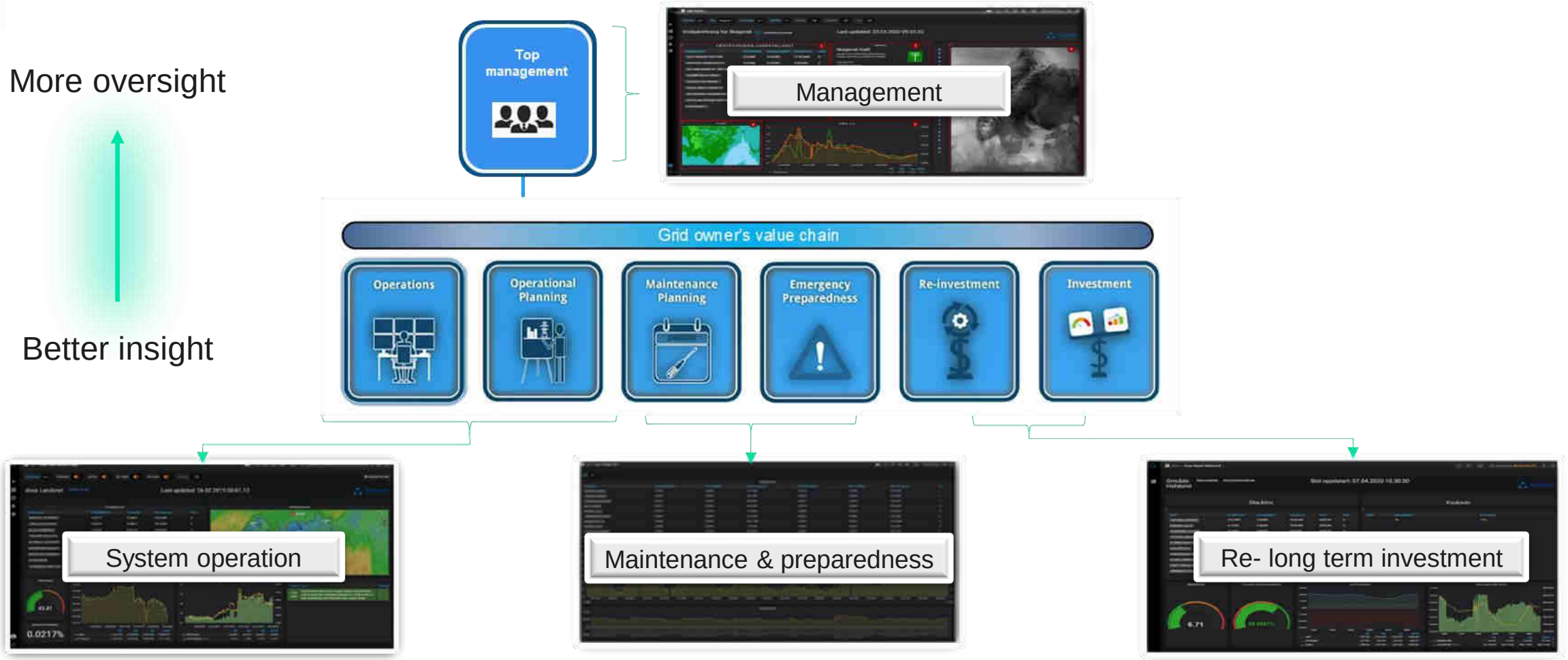
What will the future risk level be?

What is the correct risk level?

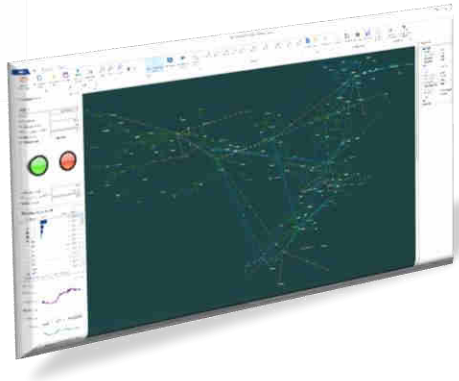
Use cases: probabilistic analysis in the value chain

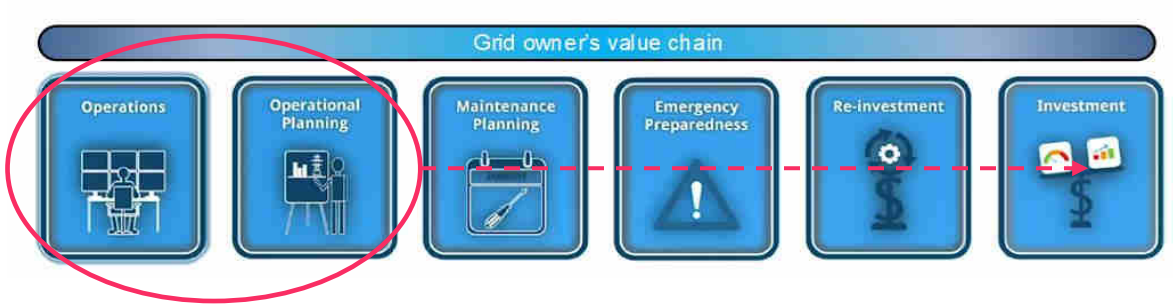
More oversight

Better insight



Use cases 1: System operation and planning of operation





In operation:

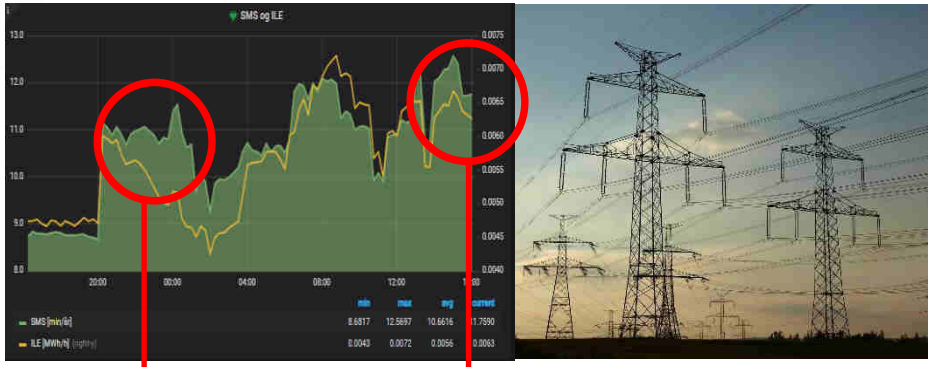
- Monitor system risk in real time: one look at the screen for assessing if the risk is okay or not
- If high risk state occurs - go in to Promaps “study mode” and test which action can be done to reduce high risk before it is set in operation

In planning of operation:

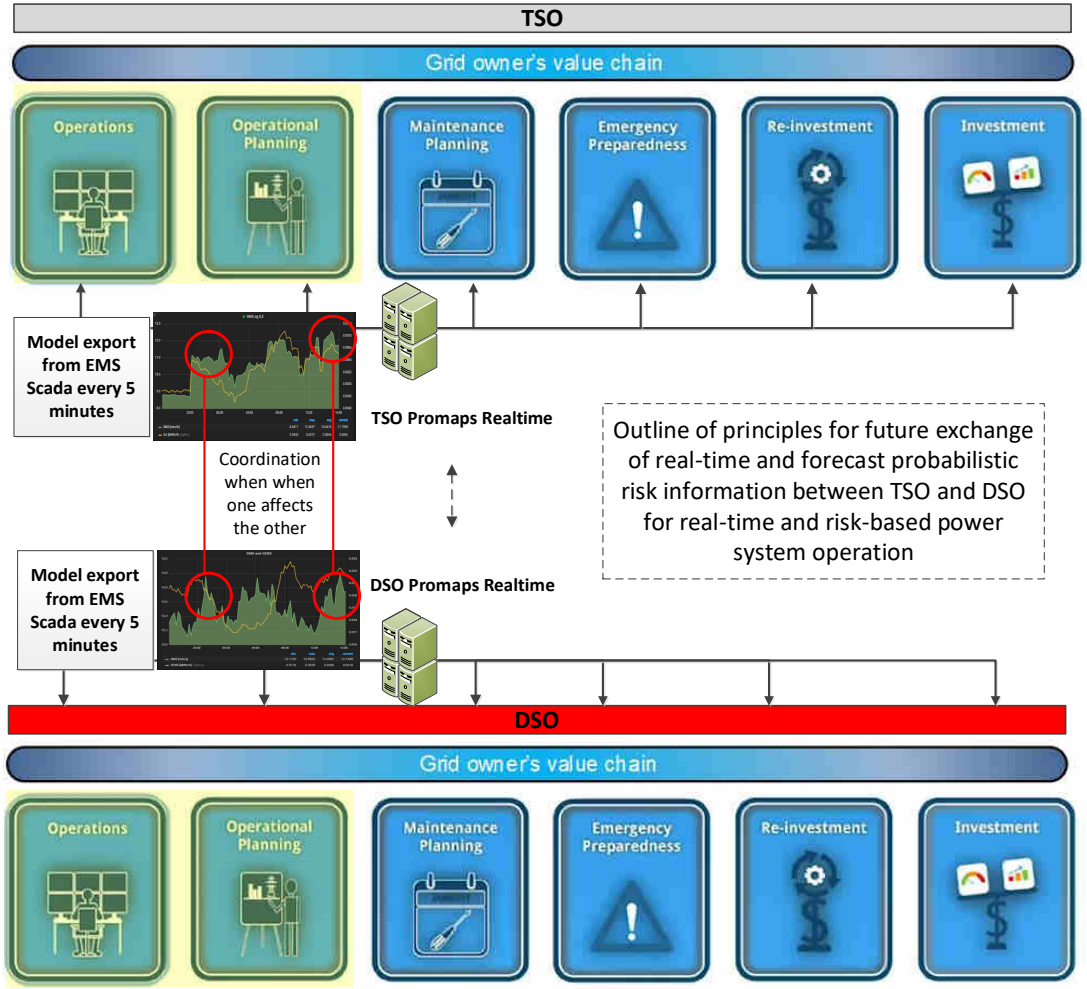
- Risk forecast next 45min - 48 hours
  - Taking into account planned outages, maintenance schedules, weather forecast, configuration and load etc.
  - Reserve planning: spinning reserve, countertrade, grid temporary limits and other operational calculation and evaluation

Provides base case analysis to the rest of the value chain

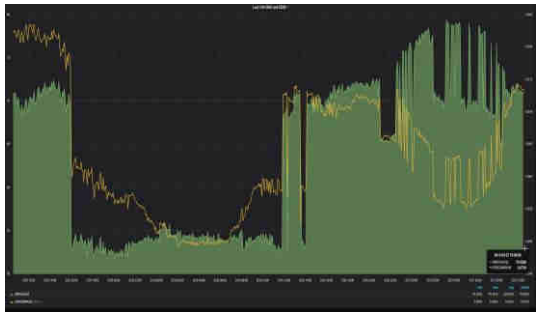
Use case 2: TSO-DSO coordinated operation



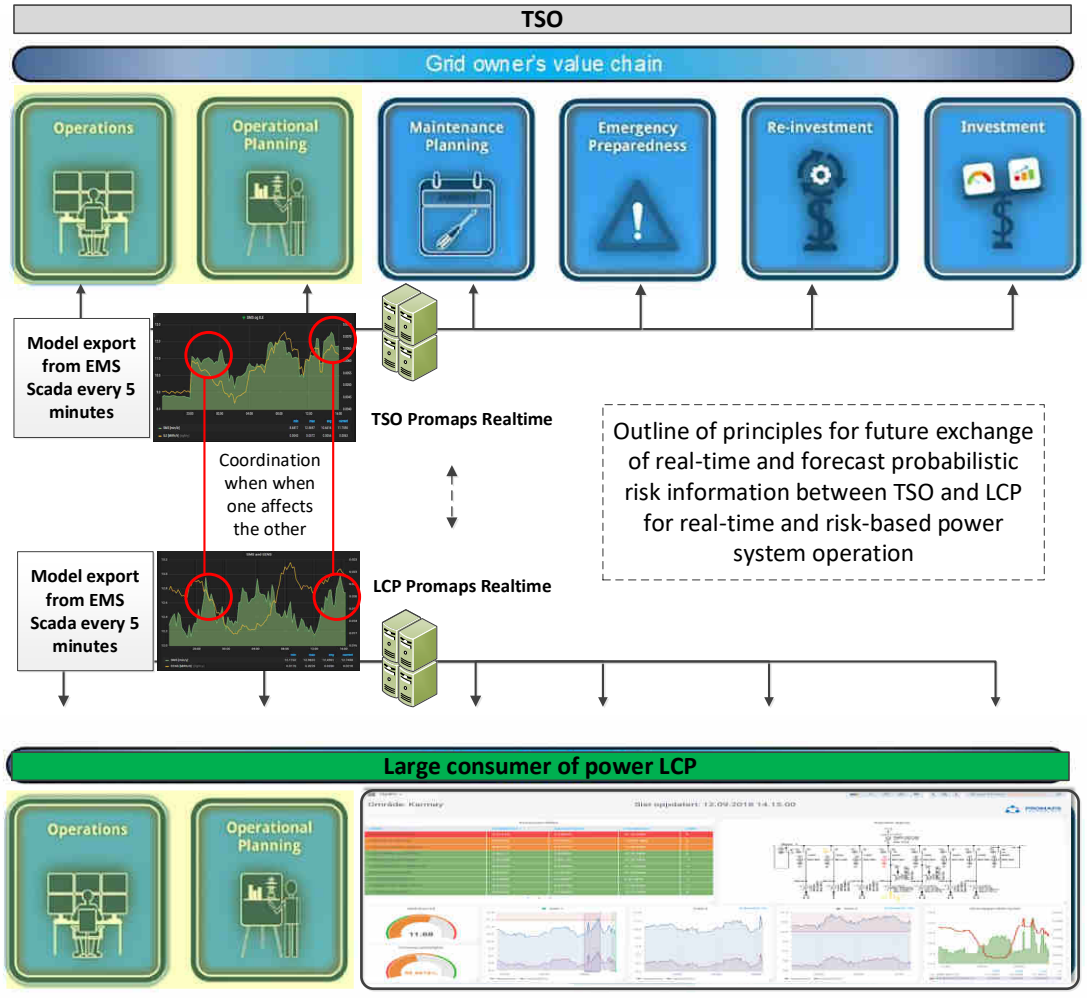
High risk for black outs, need for coordinated actions



Use case 3: TSO - Large consumer of power (LCP)



Norsk Hydro consumptions: 12% of Norway's total consumption



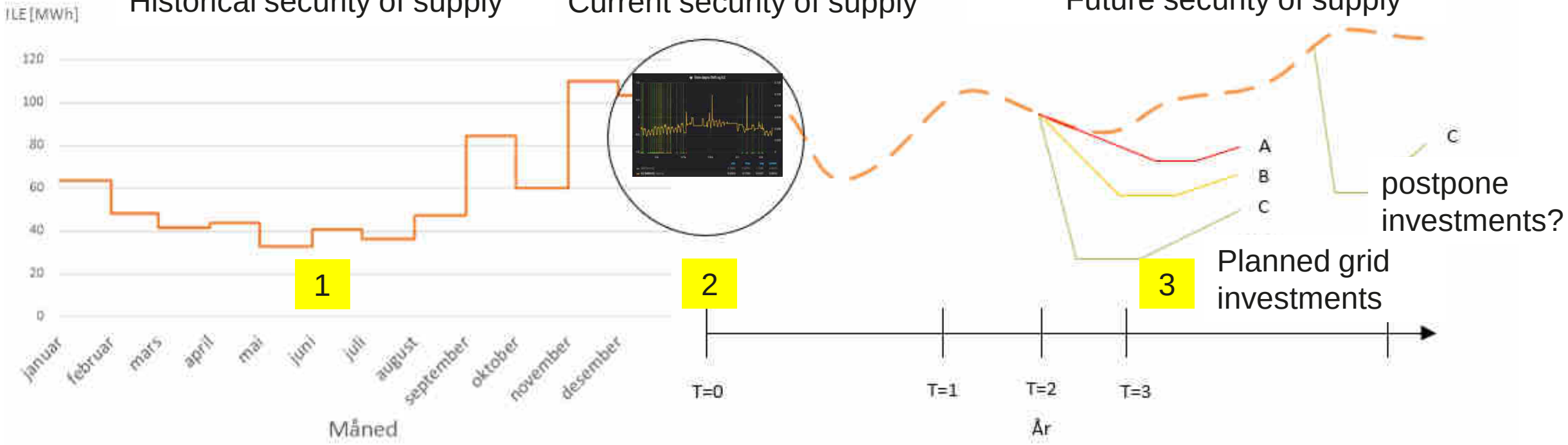
Use case 4: Investment analysis

Click here for more

Historical security of supply

Current security of supply

Future security of supply



Conclusions

- Power system is rapidly changing with more renewable production and increase load demad
- The security of power supply will be challenged
- There is no quick fix for solving this
- A part of the solution: Need to understand the inherit property of the power system in real time:
  - The impact of the changes that are coming
  - Introduce new technology and production based on this insight
- Probabilistic real time risk assessment will give vital insight for achieve this

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