

Consideration of the overarching issue in the Power Grids

Everything done in a grid company in all divisions, including new investments, reinvestments, maintenance, emergency planning, operational planning, and operational management, aims to ensure that customers receive the service they pay for, namely electricity. This delivery must have as high uptime as possible for: 1. delivering what the customer pays for (of course) 2. and avoiding the grid company's reduced revenue cap. This is why everyone has their function in a grid company.

To ensure that all the above activities are done correctly and as cost-effectively as possible, one must assess the probability that the grid company is able to deliver electricity at all times and what cost this entails now and expected in the future.

To ensure that this principle has been fulfilled, the N-1 criterion has been a guiding philosophy from new investment to operational management in the past. This philosophy is expensive and inflexible in relation to a rapidly changing power system. Furthermore, few or no grid companies have been able to comply with this principle historically, and there has been no ambition to do so across the entire power system (as this equation does not add up).

Therefore, there is a need for another principle: probabilistic risk assessment throughout the value chain. This risk assessment must originate from operational management, it must be quantitative (i.e., probabilistic), and it must be assessed equally by all. In this way, the current risk level and the risk level for the next 12 hours can also serve as a starting point for all other planned activities, including maintenance, emergency preparedness, reinvestment, and new investment. It all boils down to the impact intended activities have on the company's ability to deliver electricity to the customer at the lowest possible cost. That is to say, what does it cost? What do we get in return for it?

This argument applies to both short and long time horizons. However, to achieve the ambition, the risk assessments must be consistent (the impacts of all actions must be able to be demonstrated in terms of the ability to deliver electricity now and in the future with associated costs) throughout the value chain for this specific purpose (delivering electricity now, with the highest possible uptime at lowest possible cost)

1. What is risk in the power system?

Risk is a product of probability and consequence. We have good statistics on the probability of failure for each component type at each voltage level over many years. Power system components will fail in all power systems over time, depending on load level, age, maintenance, manufacturer, etc. However, the consequence of failure on power system

components is what matters for the grid company's main objective. That is, to what extent will component failures lead to our inability to deliver electricity, and for how long? This depends on the operating situation, including load situation, switching configuration, level of immediate redundancy, switching possibilities, production access, production reserve, and how well operational management is prepared to handle the situation now and in the coming hours. Therefore, it is crucial that the probability of failure of power system components combined with the current operating situation be quantitatively risk-assessed, and that this information is included as decision support for the grid company.

The value from Promaps Realtime

Promaps Realtime is a tool for condition monitoring of the power system using probabilistic risk monitoring in real-time. The figure below shows how Promaps Technology envisions real-time risk monitoring as an integrated part of operations and how results from Promaps Realtime can be used as input in the grid owner's value chain.

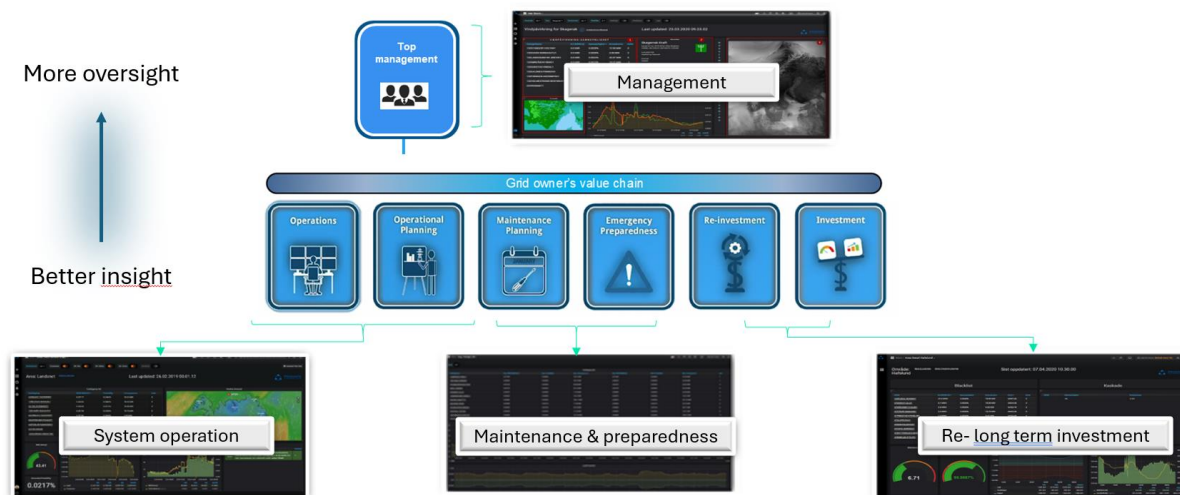


FIGURE 1: PROBABILISTIC REAL-TIME RISK MONITORING OF OPERATIONAL MANAGEMENT AND PLANNING OF OPERATIONS - A STARTING POINT FOR CONSISTENT RISK MANAGEMENT OF THE ENTIRE VALUE CHAIN

Today, operational risk is subjectively assessed by each operator. This means that the level of risk is assessed differently from person to person based on experience. (Testing the hypothesis: What is the delivery reliability right now? That is, what is the probability that we can deliver the requested power now?)

Promaps Realtime quantitatively calculates this level so that operational management and operational planning can assess this level uniformly. In this way, the impact of measures can be assessed in real-time and for planning the next shift, including assessing the impact of: maintenance, switching plans, purchase of special regulation, or other measures), and cost-benefit can be evaluated and quantified. Furthermore, a conscious approach to risk and a uniform assessment of this level will reduce expected interruptions that "cut" the load (the same number of faults will occur in operations, but something can be done about the consequences of the fault).



"A little risk is fun, but too much risk is neither fun nor cost-effective."

Furthermore, a quantitative ongoing risk assessment will contribute to operational management and operational planning being able to both argue for and document needs and action patterns much better than before. If outsiders like Statnett, or within the company, are undertaking or planning activities that have a direct impact on operational management, the consequences can be documented. Consequences can be documented in terms of the probability of our ability to deliver electricity in the relevant period and the expected cost we are exposed to. This will be valuable insight that can form the basis for a comprehensive cost-benefit assessment throughout the company.

Are there alternatives to Promaps Realtime?

No. Promaps Realtime is the first commercial software that calculates risk (probability times consequence) for power systems in near real-time.

Some existing EMS/SCADA systems and DMS conduct outage analyses. These analyses indicate which single faults or combinations of faults lead to "power clipping" and rank them in a list from largest to smallest, that is, a direct consequence. Direct consequence is not risk. Risk is defined as the probability of something happening multiplied by its consequence. The probability of this happening is currently subjectively assessed from person to person, along with the expected duration to clear the fault and consequently the consequence.

An "outage list" that is adjusted for the probability of the outcome occurring and the expected duration of the impact on the load (i.e., how long there is reduced or no power delivery to the affected load(s)). This outage list should not be confused with outage analyses performed by other systems.

To illustrate this difference: In the example below, from Promaps Realtime, risk (probability times consequence) of outages is ranked from high to low for the top 10 network segments in this network area with the highest risk shown. The example shows that at position number 1, there is a potential outcome with high probability and significant consequence. At position number 2, there is a potential outcome with the highest probability of occurring, but with moderate consequence. Looking at position number 10 at the bottom, there is the outcome with the greatest consequence, but with low probability of occurring. In comparison, a traditional outage analysis (conducted by some systems today) for this case would rank outcome number 10 at position number 1!

Contingency list				
Contingency	EENS [MWh/h]	Probability	Consequences	Delta
[Redacted]	0.01162	0.1446%	19.51 MW	0
[Redacted]	0.00988	0.1535%	6.44 MW	1
[Redacted]	0.00982	0.1382%	9.59 MW	-1
[Redacted]	0.00642	0.1056%	7.48 MW	0
[Redacted]	0.00537	0.0484%	22.57 MW	0
[Redacted]	0.00461	0.0687%	23.01 MW	0
[Redacted]	0.00380	0.0154%	26.67 MW	0
[Redacted]	0.00363	0.0846%	5.78 MW	0
[Redacted]	0.00334	0.0959%	6.18 MW	0
[Redacted]	0.00316	0.0408%	26.30 MW	0



That means that faults or combinations of faults ranked as the worst in a traditional outage analysis could have a completely different severity assessment in our risk analysis. Promaps Realtime includes the probability of the outcome occurring and the expected duration of the fault for the affected load point, allowing risk to be assessed and quantified uniformly by all, expressed with expected not delivered energy and cost of not delivered energy that the company is exposed to at any given time. Furthermore, various planned measures can be tested to see their impact on the risk level.

Products from Infinigrid that gives value for Utilities/Prosumers of Power

PROMAPS Product Modules	
Component Name	Component Description
Promaps Realtime	<p>Promaps Realtime is a simulation tool for probabilistic risk assessment of large power system in near real time. The tool gives decision support for system operation and planning of operation. Data input is based on a full-model export from a SCADA system every five minutes. Information covers statistical component failure rates and repair and reconnection times, as well as dynamic, weather-dependent failure rates for power lines. Our simulation tool combines a flow model of your power system with reliability models of each system component. The software calculates the risk level continuously while highlighting any dangerous situations the operators must be aware of. Promaps Realtime can also test the influence any actions may have on the system before they are implemented, by using the Study Mode.</p> <p>Features: • Uncovering the risk situations in the grid as soon as they occur. • Identify the best action • Forecasted risk warnings for the next hours • Look at the consequences of planned actions • Reduces cognitive stress for operations personal • Become the base case for all risk evaluation in the Grid owners value chain.</p> <p>Methodology: Based on new developed mathematics. Part of methodology included in international textbook in system reliability. Solves the dimension problem connected to Markov models using Kronecker product. Permits the use of unit models.</p>
Component Name	Component Description
Promaps Maintenance	<p>Based on the same calculation engine as from Promaps Realtime. Promaps Maintenance Dashboard give vital information for prioritization of which component to perform maintenance on based on the influence the components have had on the overall security of supply over time. This enables the Grid owner to prioritize the components that will influence the security of supply the most, from most to least. In this way if there is a back log of maintenance and there is only budget for maintain some components, the most important component will be listed in a "Super list".</p> <p>When maintenance work packages are set out in the work schedule the security of supply for the period of maintenance is calculated</p>

	<p>and updated in a set interval. If one of the schedule maintenance work pages is delayed, then its possible to evaluate to stop, or move planned maintenance is the calculated security of supply is above acceptable.</p> <p>Features: • Constantly evaluation of: What is the impact on the security of supply by the set maintenance schedule: - Now,- Prognosis next 10 days. •If power system risk is increasing due to unplanned outage, disturbances or changing weather prognosis: - Delay, re-arrange or cancel planned maintenance work task- Instantly see impact of the above action on system risk in dashboard- Coordinate with system operation if difficult situation is arising- Test if there is reconnection possibilities for alterative flow to reduce risk- or if acquiring of extra spinning reserve is necessary</p>
Component Name	Component Description
Promaps Reinvestment	<p>Based on the same calculation engine as from Promaps Realtime. Promaps Reinvestment Dashboard give vital information for prioritization of which component to reinvest on based on the influence the components have had on the overall security of supply over time. This enables the Grid owner to prioritize the components that will influence the security of supply the most, from most to least when evaluation of reinvestment strategy and budget. The Promaps Reinvestment security of supply analysis will be combined with the grid owners traditional power system analyses for the calculation of the net present value that underpins the investment decision.</p> <p>Feature • Prioritize of re-investments plans; where, when and what • Calculated improvement in risk level and connected reduced cost based on new components impact on the total system • Include risk cost in evaluation of re-investments analysis.</p>
Component Name	Component Description
Promaps Management Dashboard	<p>Promaps Management Dashboard summarize calculations form Promaps Realtime, Promaps Maintenance and Promaps Reinvestment to give top management full overview of the impact on the current and future security of supply for all planned action at the Utilities. Top management can monitor in near real time and by constantly updated prognose if action is needed to be taken to adjust the course as a function of changing risk and the connected cost</p> <p>Feature • Summary of historical, current and predicted future risk and connected cost the Utility is exposed for • Top management</p>



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risk monitor for all action being done in the company that affects the company's goal • Set CPI risk parameters for the organization.