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Network code on emergency and restoration – requirements and implementation in Finland

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NC ER implementation
24 h capability

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The automatic under frequency load shedding system

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Implementation of KoVa information exchange with Fingrid

General

Network Code on Electricity Emergency and Restoration (NC ER)

Defines common requirements and goals for managing the Emergency, Balckout and Restoration states of the electricity system:

- to prevent the escalation of an emergency situation and to prevent blackout and
- to enable efficient and fast restoration after a blackout.

Transparency
Impartiality
Efficiency

Co-ordinates and harmonizes operation of the electricity system in Emergency, Blackout and Restoration states inside the EU and with third countries.

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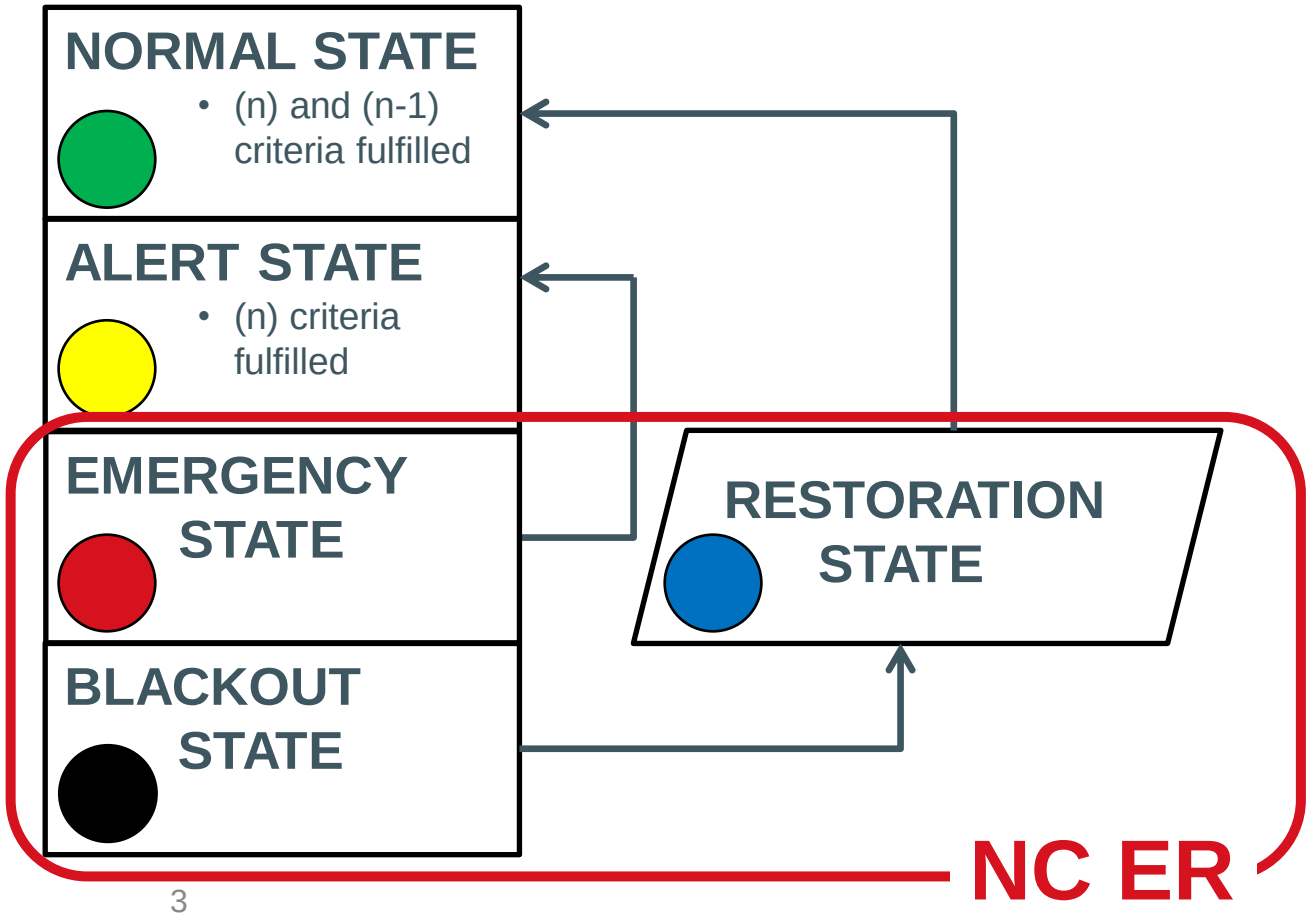
States of the electricity system



EMERGENCY STATE

At least one of the following is fulfilled:

- main grid power flows outside security limits even after remedial actions
- frequency outside 50 ± 0.5 Hz for more than 15 min
- frequency outside 50 ± 1.0
- complete loss of SCADA or another critical tool for more than 30 min (in essence, loss of Fingrid's control center functionalities)
- load shedding takes place
- electricity shortage in Finland

BLACKOUT STATE

At least one of the following is fulfilled:

- loss of more than 50 % of consumption in Finland
- total absence of voltage in the main grid for more than 3 min

RESTORATION STATE

- restoration process after blackout has been initiated **and**
- the TSO has started to activate measures to restore consumption and production.

Network code is the law!

- NC ER is applied to
  - transmission system owners (TSO),
  - distribution system owners (DSO),
  - grid users significant to the System Defence plan and the Restoration plan
  - defence service providers,
  - restoration service providers,
  - balance responsible parties,
  - balancing service providers,
  - nominated electricity market operators (NEMO).
- **Fingrid** is responsible for defining the practical measures required by NC ER monitoring their imlementation.
- **The Energy Authority** monitors the appropriate implementation of NC ER.
- **Each party** is responsible for implementing the required measures.

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What and where?

- NC ER can be found
  - in English on ENTSO-E's web site: https://www.entsoe.eu/network_codes/er/
  - in all EU languages on the European Union's web site:

    https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.312.01.0054.01.ENG

- Public material is available Fingrid's web site:

  https://www.fingrid.fi/en/electricity-market/market-integration/network-codes/operating-codes/
- More detailed material, incl. webinar presentations, will be delivered separately to those concerned.

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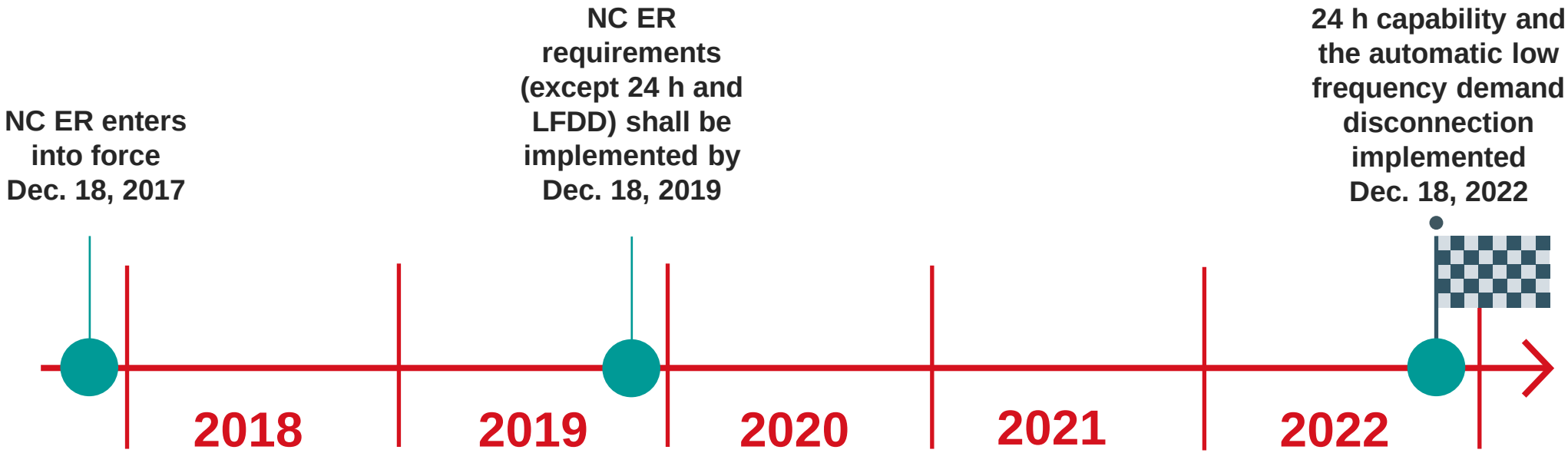
NC ER implementation time line



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The System defence plan, the Restoration plan and the siginificant grid users

NC ER obliged the TSOs to create two plans:

System defence plan

- The scenario:
  - the situation is severe, but the lights are still on in the nation
  - the "normal" actions have been taken (the automatic and manual reserves have been activated, Fingrid's reserve power plants are running etc.)
  - ...and this might not be enough.

➢ What further actions need to be taken and which tools are needed in order to avoid blackout? And with whom shall these actions be taken?

Restoration plan

- The System Defence plan was not sufficient or fast enough to prevent blackout.

➢ What actions and tools are needed to do the restoration? And who else do we need?

...and to nominate the grid users which are significant for the implementation of these plans.

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Grid users significant for the System defence plan

- **All** distribution system owners and owners of high voltage distribution systems (DSOs): approx. 90 DSOs.
- Electricity consumers directly connected to the main grid: approx. 20 consumers.
- Existing and new power plants of type C and D (> 10 MW or connection point in the main grid): more than 200 power plants.

Responsibilities for the grid users significant for the System defence plan

- Obligation to participate in the implementation of the automatic under frequency load shedding system
- Obligation to participate in the implementation of an automatic under frequency production disconnection system (in case such a system will be implemented in the Nordic synchronous area and in Finland)
- Obligation to obey the TSO's instructions regarding active and reactive power, voltage control and demand and production disconnection
- Obligation to relay the TSO's requirements to the nominated significant grid which are connected to its grid
- Obligation to follow the test requirements regarding the automatic systems

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Grid users significant for the Restoration plan

- Distribution system owners and owners of high voltage distribution systems (DSOs) connected directly to the main grid and with an average consumption of more than 30 MW: approx. 70 DSOs.
- Existing and new power plants of type D (> 30 MW or connection point in the main grid): approx. 150 power plants.

Responsibilities for the grid users siginificant for the Restoration plan

In addition to the requirements related to the System defence plan:

- Requirement 24 h capability regarding critical tools and facilities, including
  - control center,
  - substations significant to the Restoration plan,
  - SCADA and the systems necessary for its operation, incl. telecommunications to the significant substations and power plants and
  - voice communication towards Fingrid.
- Implementation of the voice communication in such a way that the calls coming from the TSO can be prioritized
- Testing and monitoring requirements regarding the 24 h capability, automatic systems and voice communication

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Reasoning:

System defence plan siginificant grid users:

- a longer list: the parties that
  - are needed in the implementation of the automatic under frequency load shedding
  - are able to provide assistance in the emergency state to avoid blackout
- compatibility with the power plant classification in NC RfG (Network code on requirements for grid connection of generators) and VJV (Fingrid's requirements for generators)

Restoration plan significant grid users:

- a shorter list:
  - the bigger parties together with whom the restoration process after blackout is in practice carried out
- compatibility with Fingrid's existing procedures for managing serious disturbances
  - regarding both the DSOs and power plants
- regarding power plants, compatibility also with the power plant classification in NC RfG (Network code on requirements for grid connection of generators) and VJV (Fingrid's requirements for generators)

Naming of significant grid users is based in the Energy Authority's information

- Sähköverkkotoiminnan tekniset tunnusluvut 2010 (Electricity grid operation technical data)
  - "Verkkopalveluasiakkaille siirretty sähköenergia ja tästä laskettu vuosikeskiteho" (Energy transmitted to grid service customers and yearly avg. power calculated from this)
- Voimalaitosrekisteri 27.8.2021 (Power plant registry)
  - the column "Maksimi yhteensä MW" (Max total MW)

Substations significant for the Restoration plan

- All substations in the main grid which are classified as transformer stations or switching stations and which contain remote controlled switching equipment: approx. 120 substations.
- Those substations owned by DSOs or other significant grid users
  - which are on the path from a distribution grid connected significant power plant to the main grid or
  - through which a main grid power line passes and
  - and which contain remote controlled switching equipment.
  - In total, approx. 120 substations.

24 h capability requirements for the substations significant for the restoration plan

In case of loss of external power supply:

- the significant grid users own voice communication shall remain operational for at least 24 hours,
- the measurement and status data from the substation remain available in the SCADA system of the party responsible for the operation of the substation, for at least 24 hours,
- it shall be possible to remotely switch the equipment necessary for restoration after blackout, for at least 24 hours and
- the standby power supply shall be capable of covering the substation's house load for at least 24 hours, taking into account that
  - it shall be possible to open and close each of the above specified equipment at least 6 times.

The 24 h capability of the grid users significant for the Restoration plan:

Implementation

24 h capability in general

Grid users significant to the Restoration plan shall, by December 18, 2022, for the critical tools and facilities listed below, have a 24 h capability in case of loss of external power supply:

- control room (in case control room services are outsourced, this applies also to the service provider's control room),
- control and monitoring functions of the SCADA system regarding the substations and power plants which are significant for the Restoration plan,
- 24 h capability of its substations and power plants which are siginificant to the Restoration plan and control of the equipment which are significant for the Restoration plan,
- LFC controller and telecommunications for the major parties,
- real time data exchange with Fingrid and
- voice communication between its control center and Fingrid's main grid control center and voice communication to its substations and power plants which are significant for the Restoration plan.

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But why...?

- The last blackout in the Finnish main grid was in the seventies
- ...but elsewhere in the world, there are recent examples indicting that anything is possible.
- Inspite of all preparing and training, it is impossible to say how long it would take to restore the electricity system after a blackout.
- In any case, we need to prepare ourselves for the possibility that it will take more than a few ours
- ...and make sure we have the necessary means to co-operate the different parties.
- Operating capability of the current tools during a blackout:
  - mobile phones: << 24 h
  - Virve: << 24 h
  - satellite phones will in principle work for as longs there is power in the battery, but for example the number of simultaneous calls seems to be limited
  - service providers' tele communication networks: ??
- NC ER's minimum requirement 24 h is a significant improvement!
- ...although it does require a lot of work.

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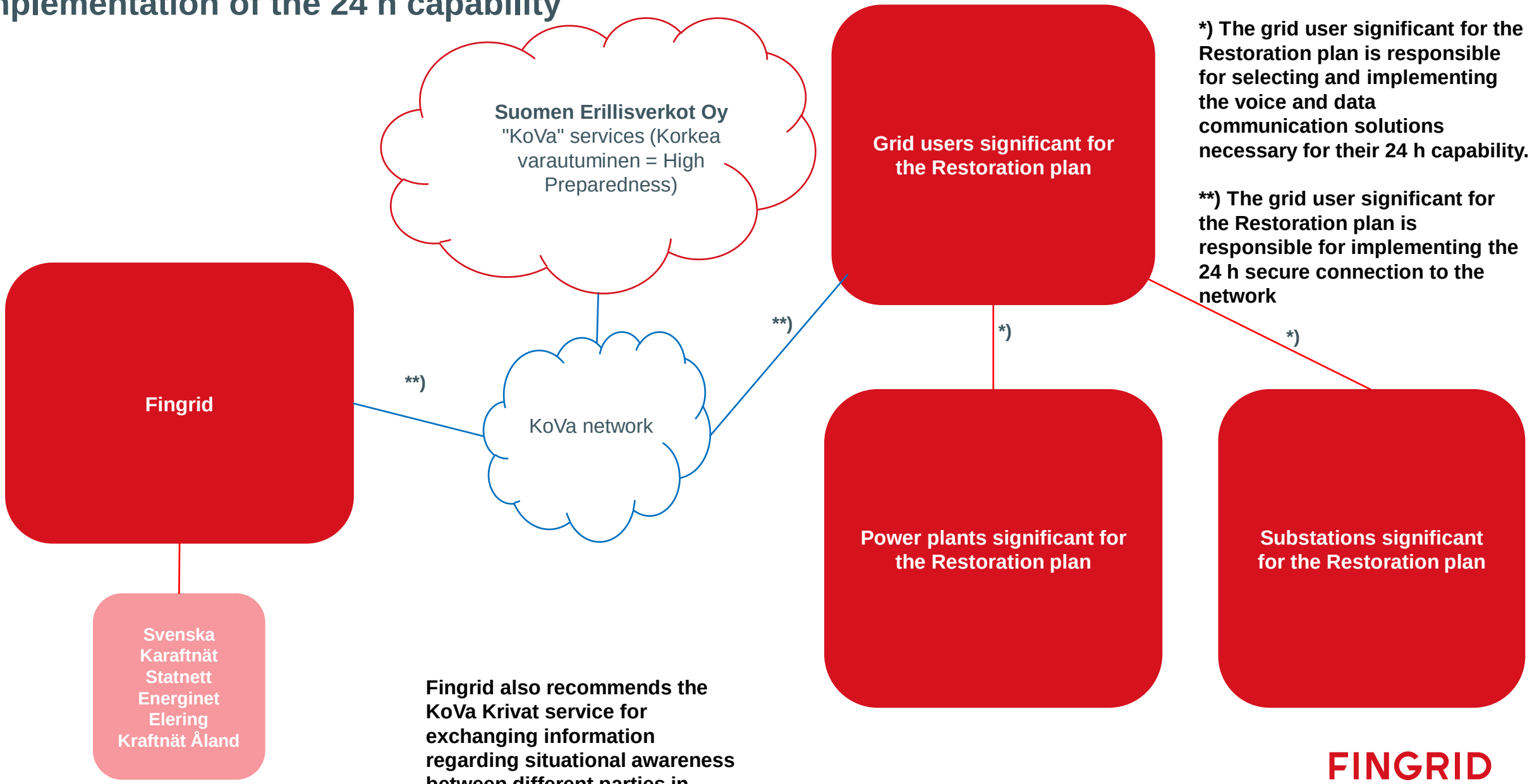
Reuirements for the grid users significant to the Restoration plan regarding the implementation of the 24 h capability



***) The grid user significant for the Restoration plan is responsible for selecting and implementing the voice and data communication solutions necessary for their 24 h capability.**

****) The grid user significant for the Restoration plan is responsible for implementing the 24 h secure connection to the network**

Fingrid also recommends the KoVa Krivat service for exchanging information regarding situational awareness between different parties in emergency situations.

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The automatic under frequency load shedding system (UFLS):

Implementation

What is the new UFLS and why do we need it?

- The UFLS automatically sheds a part ióf the electricity consumption when the frequency is eeceptionally low (48.8 Hz or lower). The purpose is to save the majority of the electricity system and prevent a blackout.
- In an event like this, the UFLS is the last straw. By shedding load we try to stop the decrease of the frequency and prevent a blackout.
- The current implementation of the UFLS, which in Finland is implemented using main grid 110 kV breakers, is not capable of taking into account the loads which are critical for society or the distributed electricity production.
- By taking the UFLS from the main grid to the distribution grids and to the main grid consumption sites
  - the critical loads can be secured and
  - the amount of production which is disconnected when the UFLS is activated, can be minimized.
- The current implementation of the UFLS cover approx. 10 % of Finland's electricity consumption, whereas the requirement in NC ER is 30 %. Increasing the amount of consumption by this much using the main grid breakers is impossible without endangering operational security..

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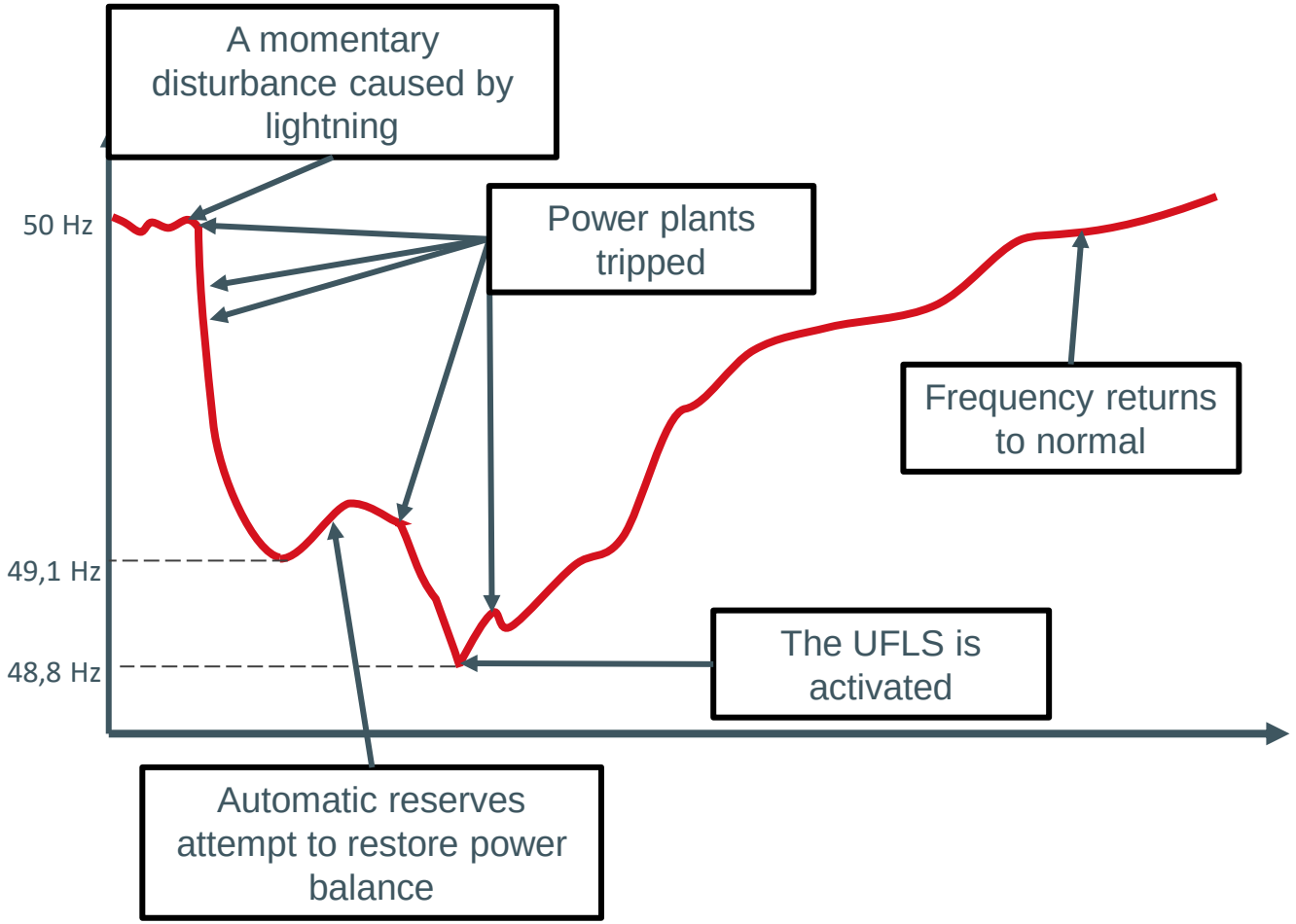
The UFLS is needed extermely seldom

- ...but when it is, the need is critical.
- In Finland, the UFLS has never been activated.
- But there is a recent example from Great Britain: a serious disturbance on August 9, 2019



- 1.1 million people lost electricity for 15-50 min.
- The UFLS prevented a nation wide blackout: 5 % of consumption was disconnected but 95 % remained.
- The UFLS was crudely implemented in the main grid substations, so some critical load was also disconnected.

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Background

- NC ER obliges the TSOs to implement an automatic under frequency load shedding system.
- The UFLS is a part of Fingrid's System defence plan, which was delivered to the Energy Authority in December 2018.
- 30 % of the consumption in Finland in real time shall be included in the system (approx. 3000 MW on average). The current implementation includes less than 10 % (< 1000 MW) => the system must be changed and extended.
- The frequency is the same in the entire synchronous area => Nordic TSOs will implement the system according to common principles.

Current implementation

	f (Hz)		Delay (s)		%
Step	Fast	Slow	Fast	Slow	of load
1	48.5	48.7	0.15	20	5
2	48.3	48.5	0.15	20	5

New implementation

	f (Hz)	Delay (s)	%
Step		Fast	of load
1	48.8	0.15	5
2	48.6	0.15	5
3	48.4	0.15	5
4	48.2	0.15	5
5	48	0.15	10

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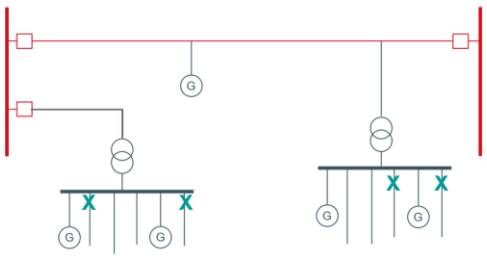
Implementation of the UFLS

- The new UFLS shall be implemented by December 18, 2022.
- The system shall include
  - 30 % of the distribution grid load (on average approx. 2000 MW)
  - 30 % of main grid connected industrial load (on average approx. 1000 MW)
- Each DSO shall implement the UFLS in their grid using the most suitable method
- Fingrid agrees with each industrial customer how the UFLS shall be implemented in their systems

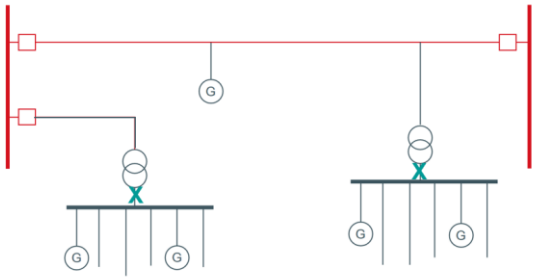
Implementation guide

- A working group consisting of the Finnish Industry, DSOs and, Fingrid) has created an implementation guide (in Finnish): https://www.fingrid.fi/globalassets/dokumentit/fi/yhtio/tki-toiminta/raportit/frequency-based-emergency-disconnection-policy-review-for-the-nordic-region-v1.0.pdf
- **The DSOs and the main grid connected consumers shall select the implementation the implementation method best suited for their needs.**
- **Alternatives:**

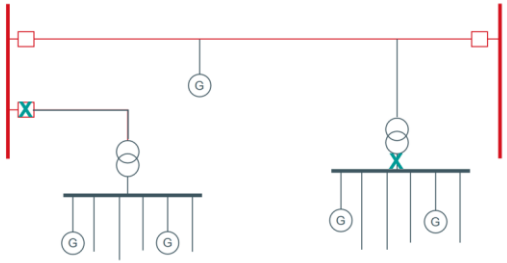
Alternative 1 RECOMMENDED
- ULFS implemented at the medium voltage level (or lower)



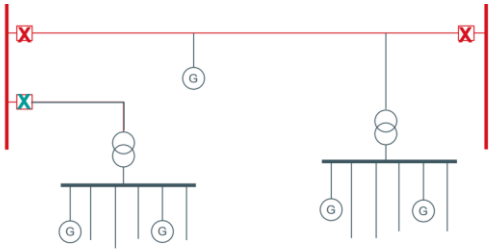
Alternative 2 ACCEPTABLE
- ULFS implemented in whole or in part in the distribution grid at the substation level



Alternative 3 ACCEPTABLE
- ULFS implemented in whole or in part in the main grid radial lines



Alternative 4 NOT ACCEPTABLE
- ULFS implemented on the main trunk lines



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