Challenges in the Swedish power system

Svenska kraftnät

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16 000+ km power lines

400kV and 220kV

200+

substations

135 TWh

electricity consumption 2023

16

international connections


More than doubled electricity consumption
2045
Climate-neutral Sweden*
*According to the parliamentary decision on long-term climate policy goals
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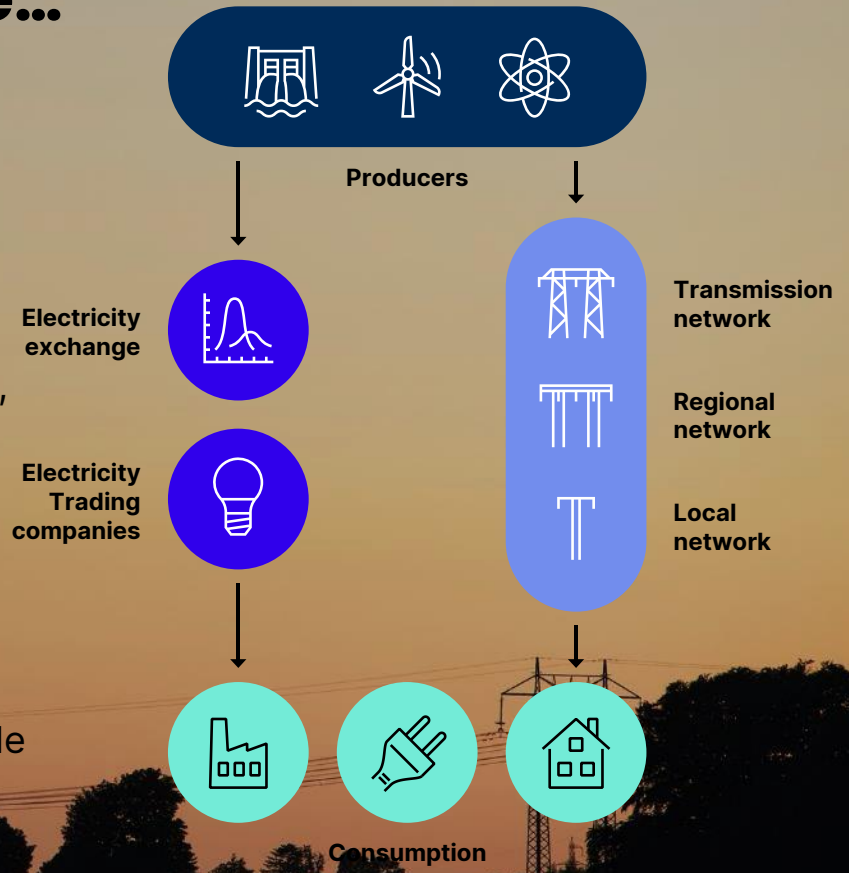
The entire system is changing with many new challenges to solve...

- **The electricity production mix is changing**
  New mix of power sources changes the system capabilities and characteristics.
- **The electricity grid is growing**
  Need for increased network capacity, new connections, changed flow patterns.
- **More advanced electricity trading is required**
  Evolving and expanding marketplaces. New roles.
- **The consumption is increasing**
  Increased demand of electricity, more active and flexible consumption.



National connection queue

Connection type	Power	
Production - Sun	3 855 MW	Growing, but from small numbers
Production - Landbased wind	8 010 MW	Levelling out with almost no new inquires
Production - Offshore wind	115 650 MW	Very high uncertainties in many areas
Production - Other	5 099 MW	Includes new nuclear
Energy storage	3 848 MW	Mostly batteries but also pumped storage
Consumption - Industry	23 950 MW	Still increasing fast
Consumption - Other	8 501 MW	Hydrogen production

Peak-hour demand in Sweden: 22GW-26GW

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Solutions

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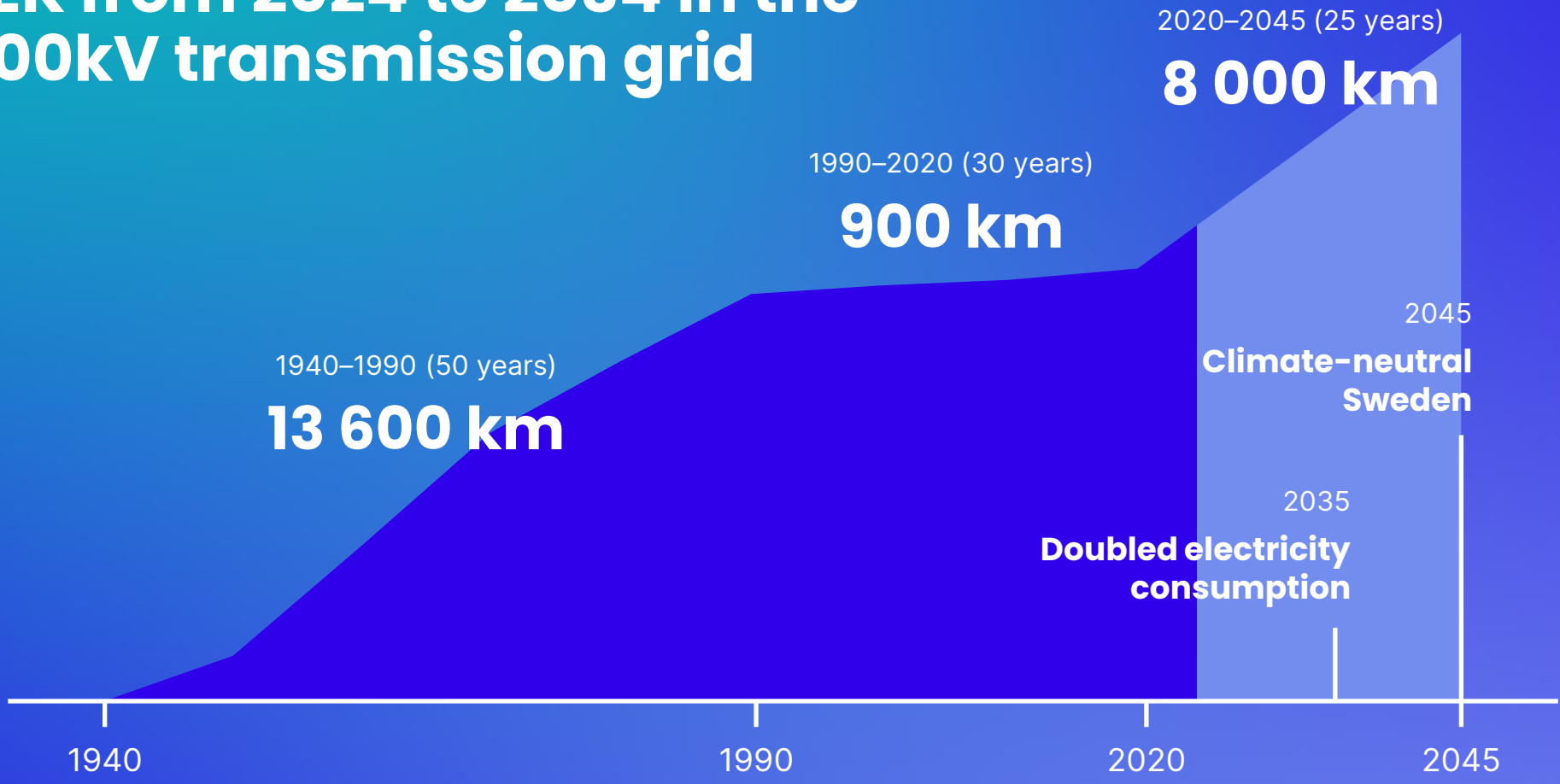
We plan to invest 204 billion SEK from 2024 to 2034 in the 400kV transmission grid



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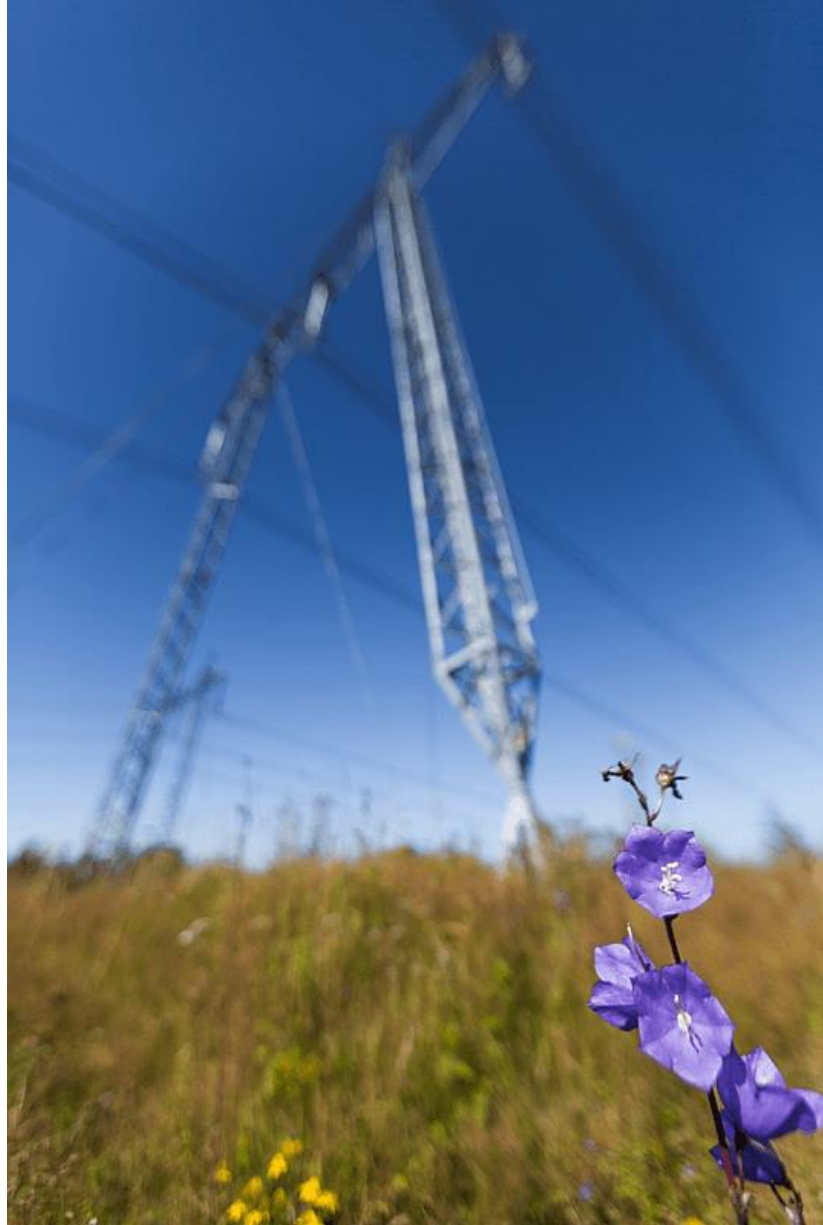
Grid codes requirements is one of the most powerful tools for keeping the system stable

- **More requirements to come, RFG 2.0, national regulations etc. D**evelopment of the requirements related to power converters. Requirements on voltage regulation, fault-ride-through etc. Requirements on battery storage.
- **Keep informed and understand the grid codes requirements!**



EXAMPLE

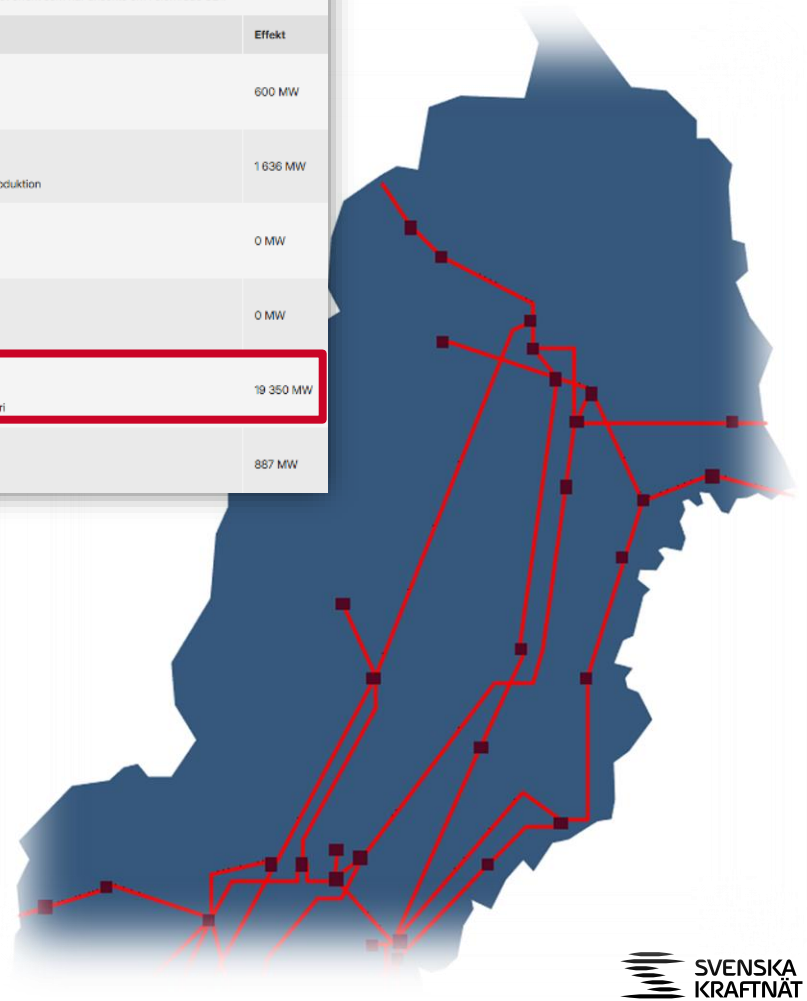
Electrification in northern Sweden

- Northern Sweden is becoming highly complex due to the planned installation of several gigawatt-scale power-to-X facilities together with rapid expansion of wind power. Moreover, the electrical area interfaces with series-compensated lines extending into Finland and southern Sweden.

Elområde 1 - SE1

Statistik över hur mycket effekt som har ansökts om i elområde SE1.

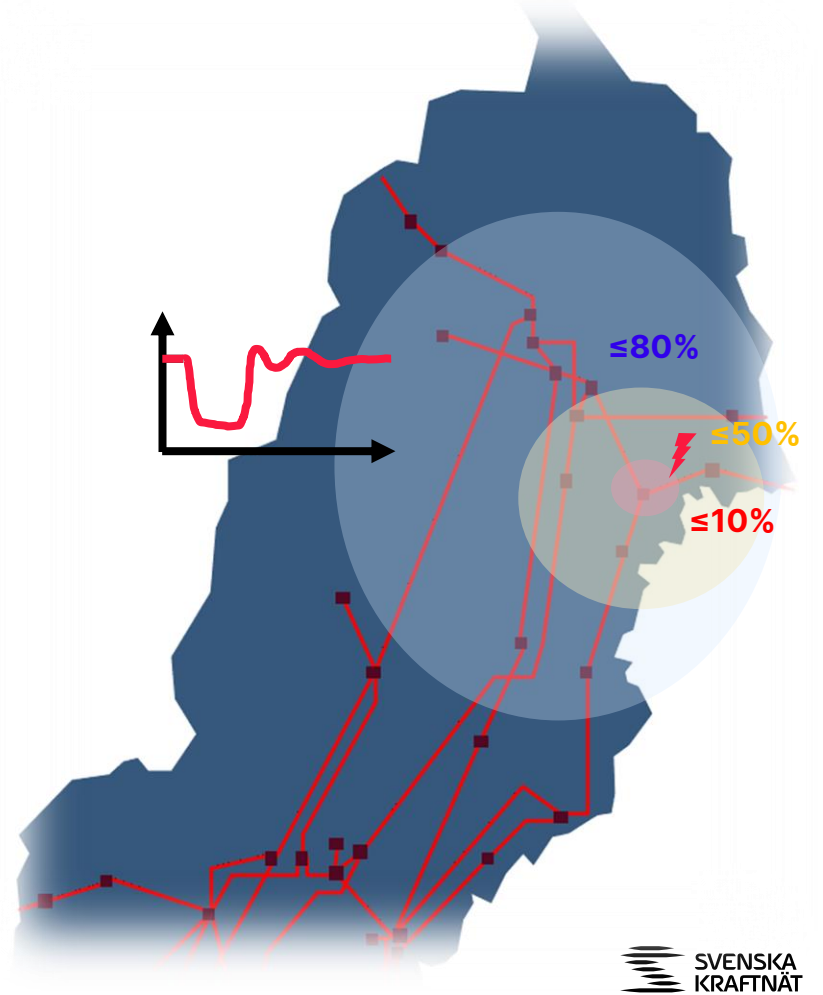
Anslutningtyp	Effekt
Solproduktion	600 MW
Landbaserad vindproduktion	1 636 MW
Övrig inmatning	0 MW
Energilagring	0 MW
Förbrukning - industri	19 350 MW
Övrig förbrukning	887 MW



EXAMPLE

Electrification in northern Sweden

- Due to the meshed nature of the grid, voltage dips can propagate over large areas, affecting a large number of facilities.
- In converter-interfaced demand facilities, post-fault active power recovery is governed by the converter and the underlying process (e.g., hydrogen production), which may lead to delayed or insufficient recovery.
- This can have significant impact on frequency stability.



Electrification in northern Sweden

- Historically, there have been no/limited requirements for demand facilities to ride through faults.
- However, considering the number and scale of such installations expected in the coming years, requirements pertaining to fault-ride-through and post-fault active power recovery will be critical.

Develop a grid map

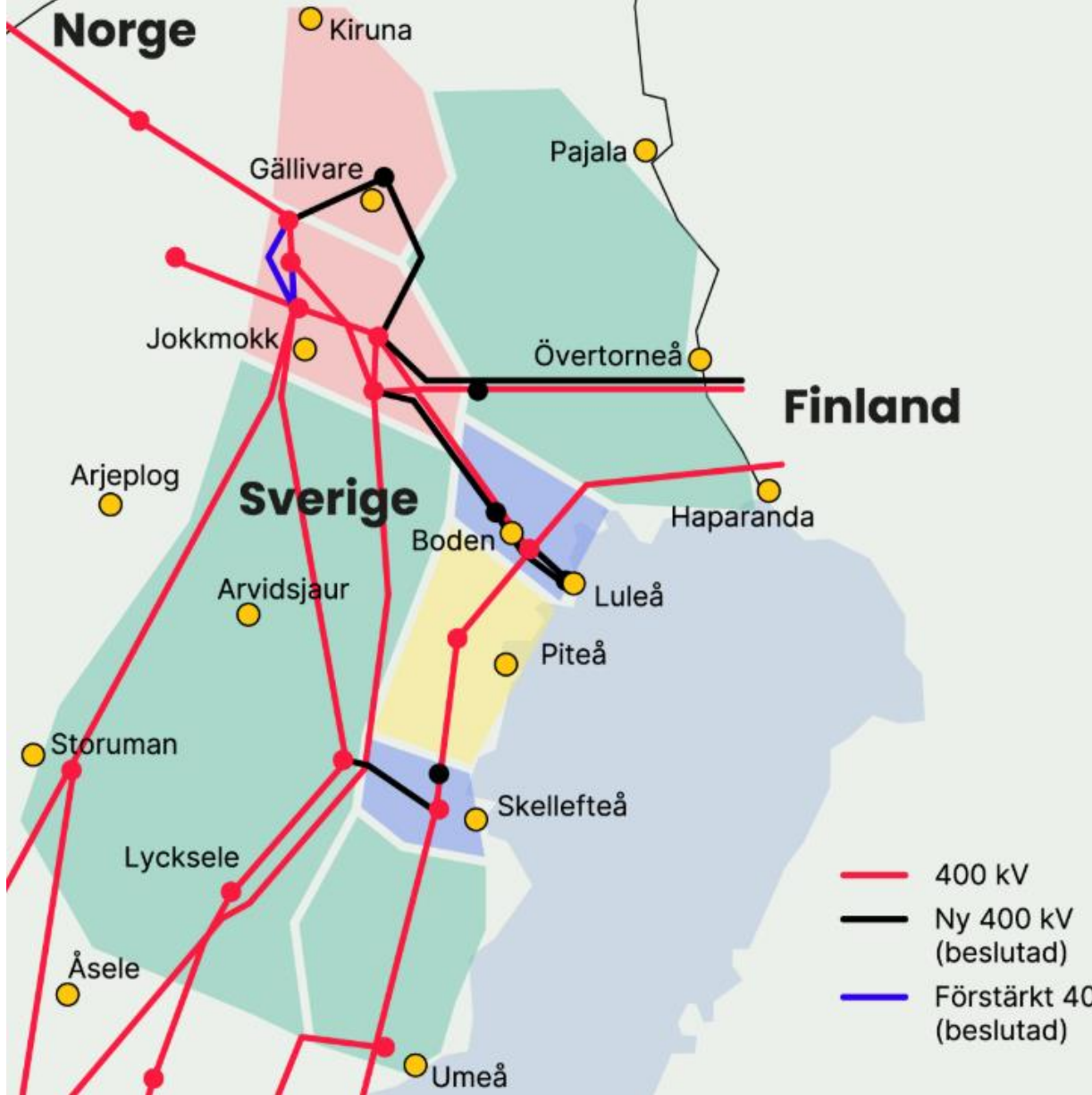
- Grid map to guide production, demand and flexible resources
  - Start with northern and southern part of Sweden
  - Cover the total Sweden end of 2026
  - Published externally on the web
    Så planerar vi elnätet för framtiden | Svenska kraftnät

High consumtpion; Need for more flexible resources

High consumtion, Need for non volitile production

Need for more non volitile production

Need for more production



Modified connection principles for connecting to the Swedish transmission grid

To ensure efficient grid utilization and cost effective grid expansion, as well as a robust and reliable power system

- Connect at the **optimal voltage level**
  - Connections should always be made at the lowest appropriate voltage level.
- Enforced **mature connection** inquires
  - Connections should always be based on a real as well as clearly and thoroughly described need with detailed energy analysis and followed-up milestones for permitting and construction.
- Connect at the **best localization** related to system needs
  - Connections will be matched against the grid map and connections that fulfil the identified need will be investigated first (first in line)
- **Easy to understand** and shallow connection cost allocation principle
  - Costs related to the meshed transmission grid is covered by Svenska Kraftnät, even if the driver for the cost is the connecting party

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Conditional connection agreements

- Conditional connection agreements are a way to enable (faster) connection of consumption and production before grid reinforcement is in place
  - Means that all or part of the allocated electricity grid capacity cannot be guaranteed during all hours of the year until the necessary grid reinforcements are implemented to provide prime capacity.
  - Conditional connection agreements are by definition temporary according to current regulations and are converted into (prime) connection agreements when network reinforcements are implemented
- Pilot projects ongoing

What are conditional access agreements?

- A set of agreed conditions for connecting capacity to the electricity grid
- Includes conditions to limit and control input to and withdrawal from the grid during normal operation
- A category under the umbrella of “flexible contracts”

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Capacity Measure

Procurement process started

New concept is tested: Svenska kraftnät, together with Vattenfall Eldistribution, has developed a new concept called the “capacity measure” to enable earlier grid connections.

Pilot region selected: Resources shall be located within the red marked area in the Figure.

Temporary solution until reinforcements: The capacity measure involves making greater use of existing grid capacity by procuring flexible resources until permanent reinforcements are completed.

Stakeholder engagement: A supplier dialogue was held in spring 2025, resulting in valuable input that helped shape the concept. Svenska kraftnät extends its thanks to all contributors.

Summary

- The electrification is here to stay!
- The challenges are global with limited capacities in the existing grids and a more complex energy system
- Everyone need to contribute, as well as grid owners, consumers, producers, permitting authorities, regulation etc.
- Nordic collaboration is a catalyst for evolving into a new power system

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Thanks

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