# Svenska kraftnät – System challenges

Erik Wejander
Projects division

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- Svenska kraftnät
- The Swedish Power System
- System development plan 2018 – 2027
  - Challenges
  - What are we doing?

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# Svenska kraftnät
# Some facts

- Government Authority
- Swedish TSO,
- ~650 employees
- Turnover 2017: 900 mill Euro
- Investment 2017: 200 mill Euro

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# The Swedish National Grid

**Transmission lines**

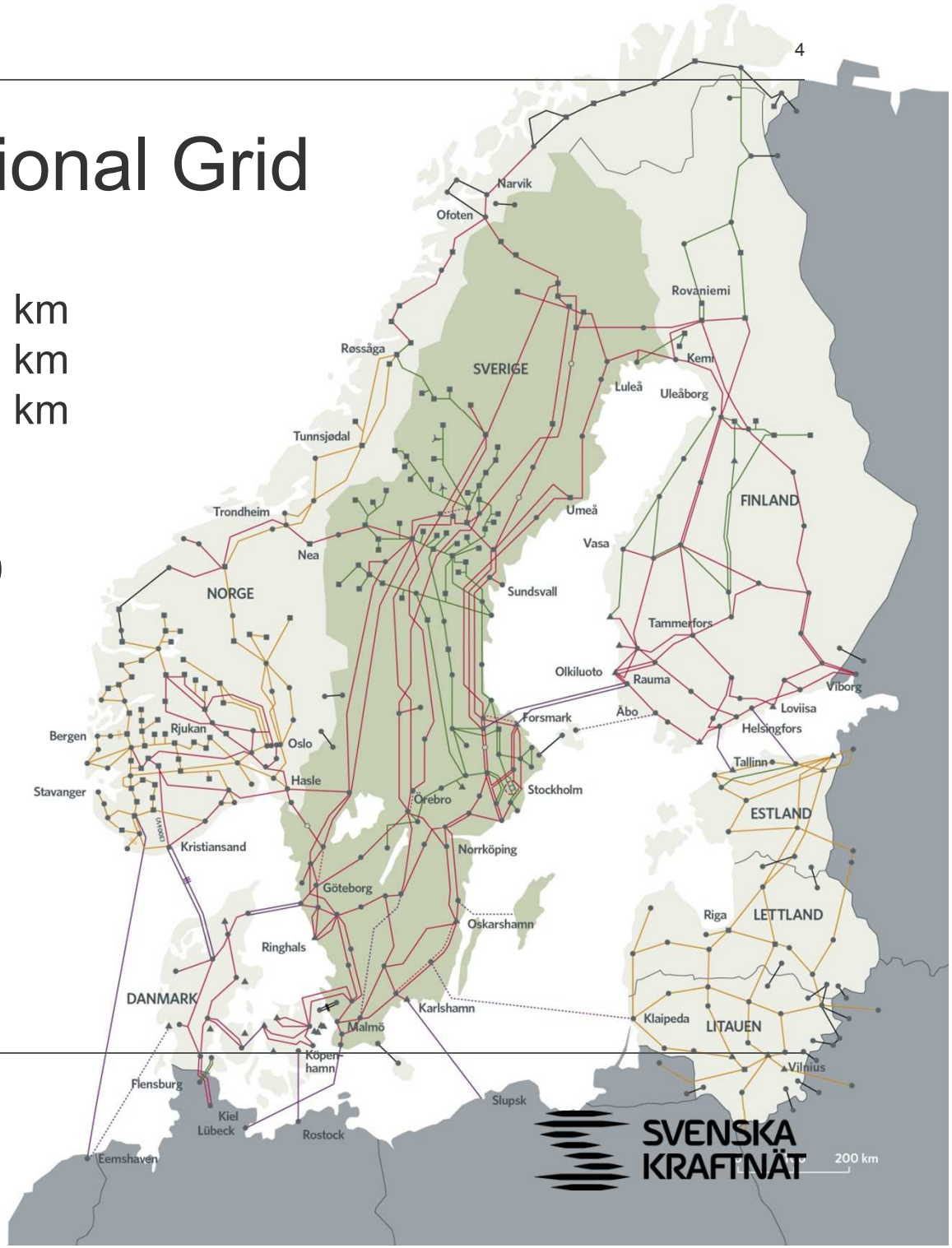
| | |
|---|---|
| Total length | 15 000 km |
| 400 kV | 10 800 km |
| 220 kV | 4 000 km |

**Substations**

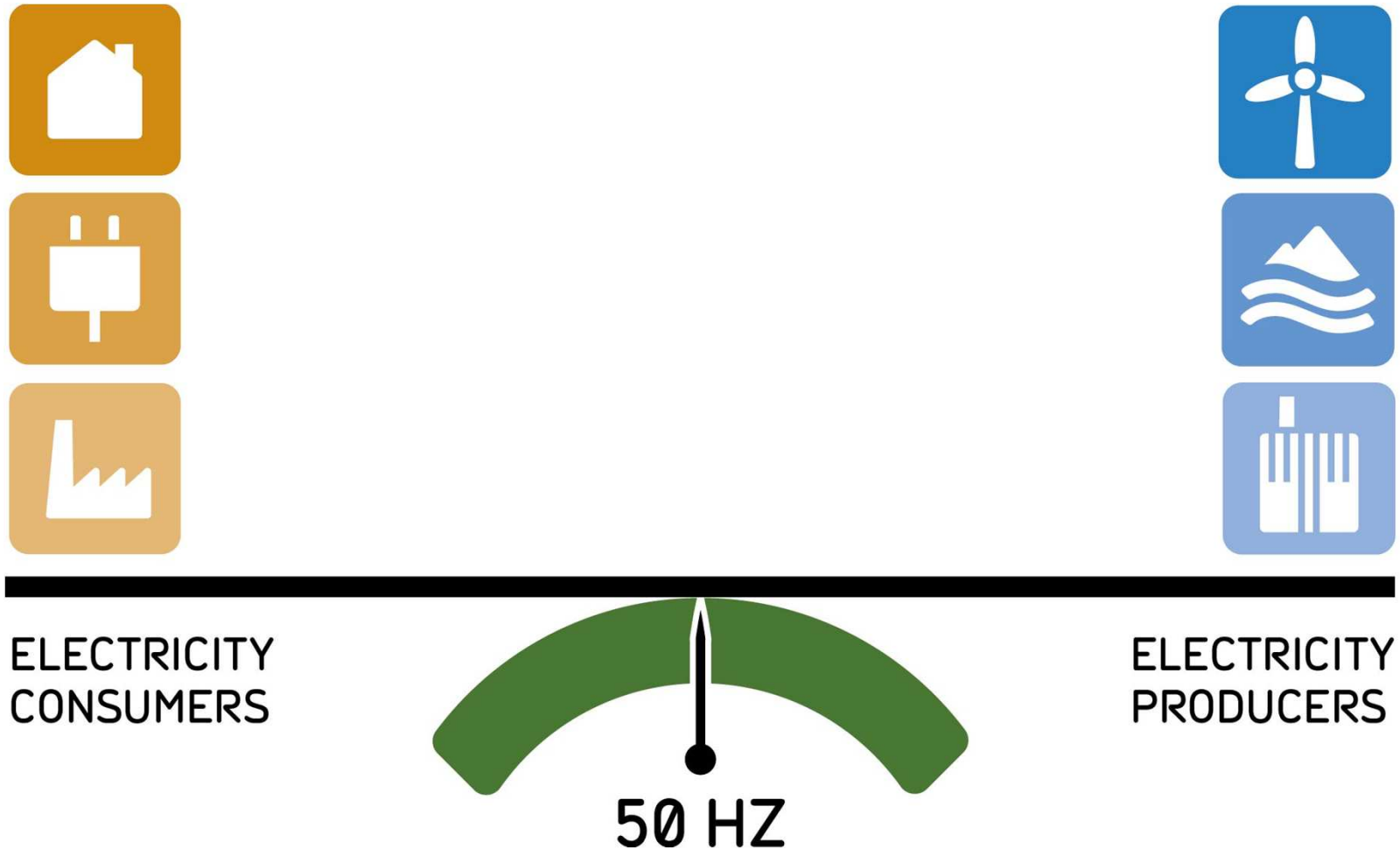
Total in the National Grid 180

**International connections**

16 (9 under sea cables)
Capacity 40 % of peak load



# Balance between generation and demand

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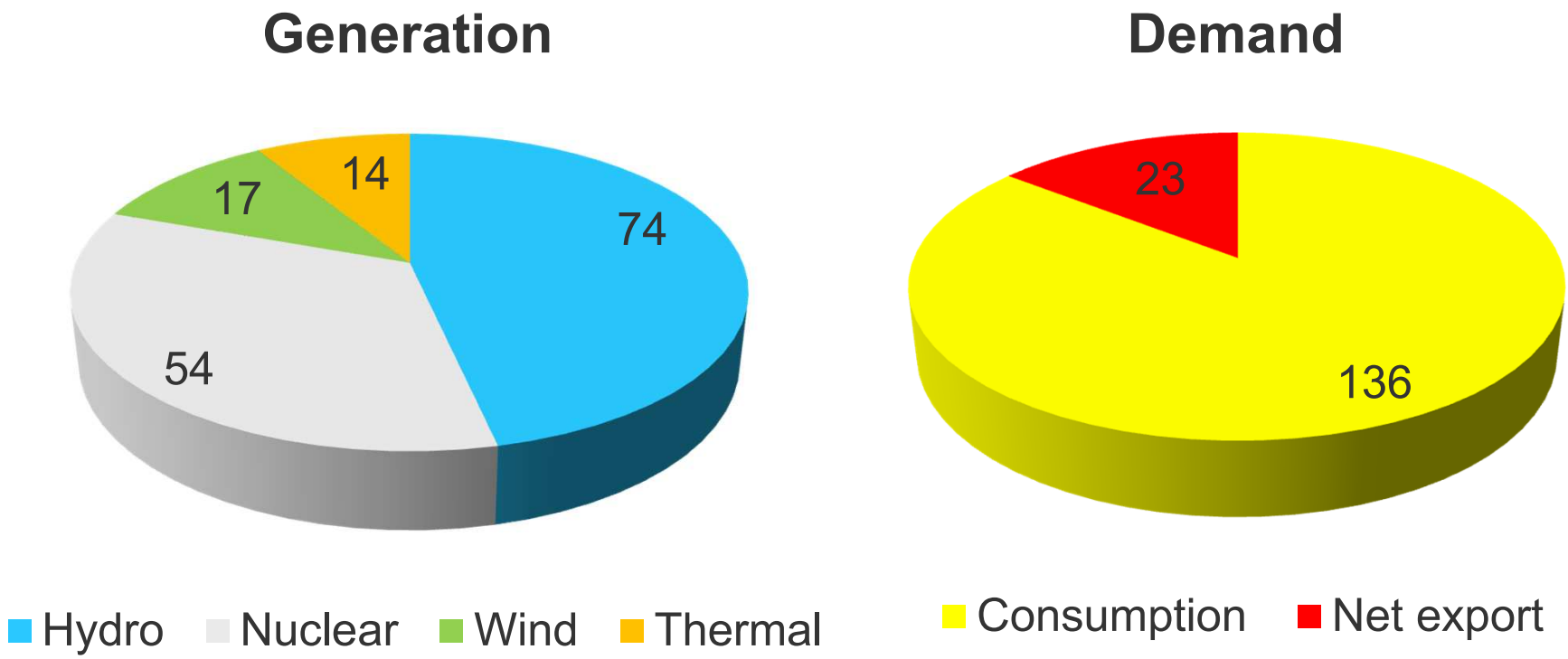
# National Electricity Balance 2015 (TWh)




Energy surplus 10-20 TWh export last five years

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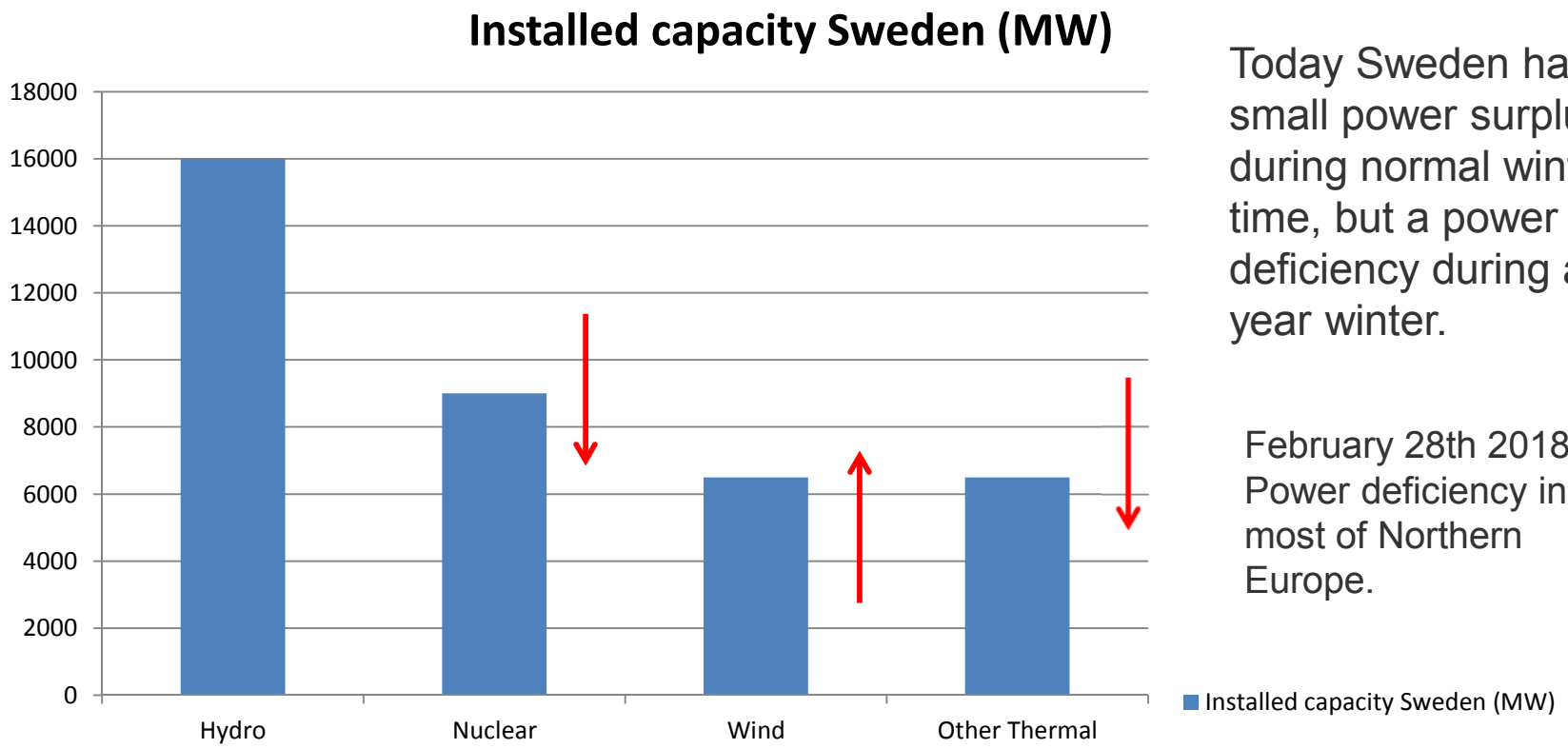
# Installed Capacity

## Approx 39 GW - Peak demand 27 GW




Today Sweden has a small power surplus during normal winter time, but a power deficiency during a 10-year winter.

February 28th 2018: Power deficiency in most of Northern Europe.

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# Challenges

> Investment Portfolio

> A Changing Power System

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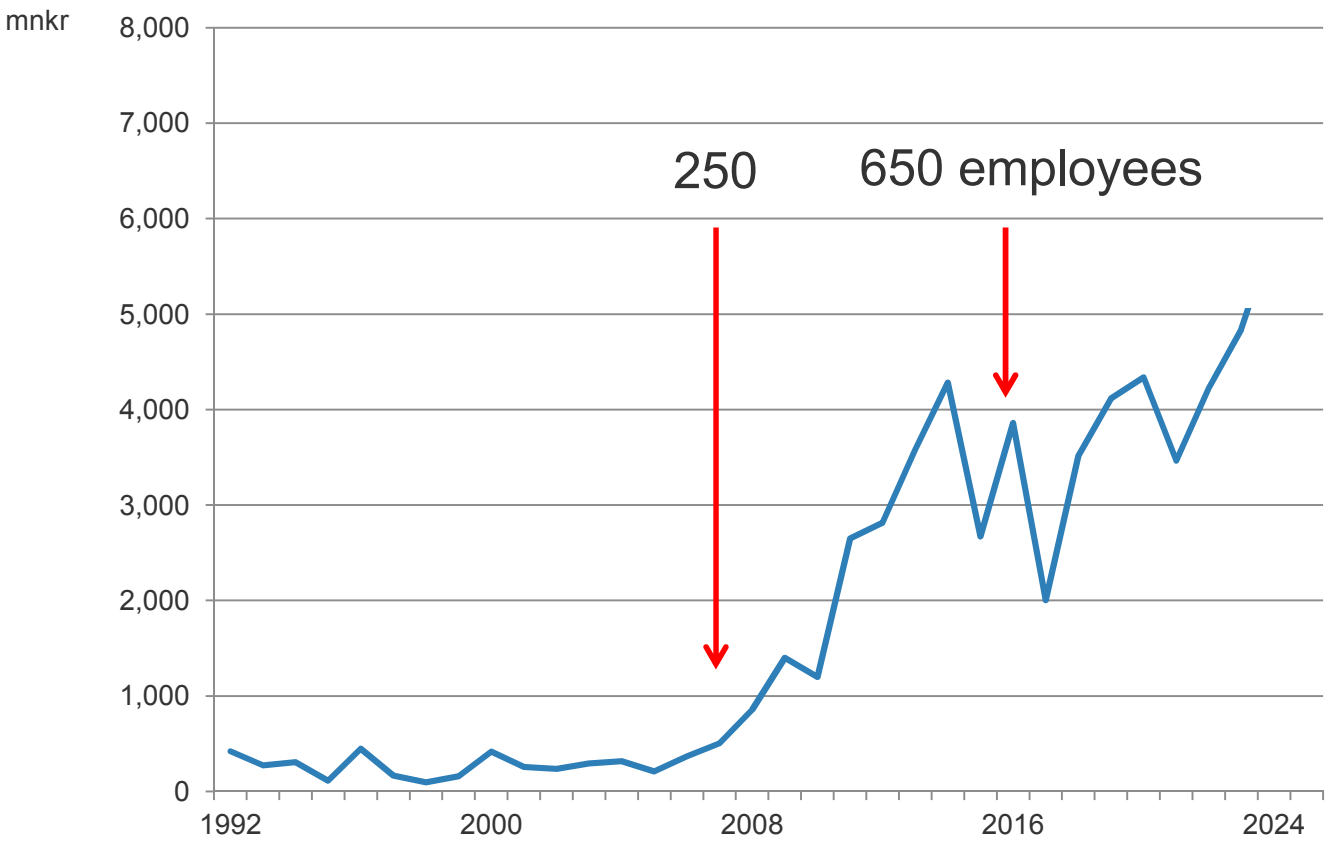
# Investments 1992-2025 (MSEK)

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# Main drivers for investments

- Connection of new generation
- Market integration
- Reinvestments of old assets
- Connection of ”new” large loads

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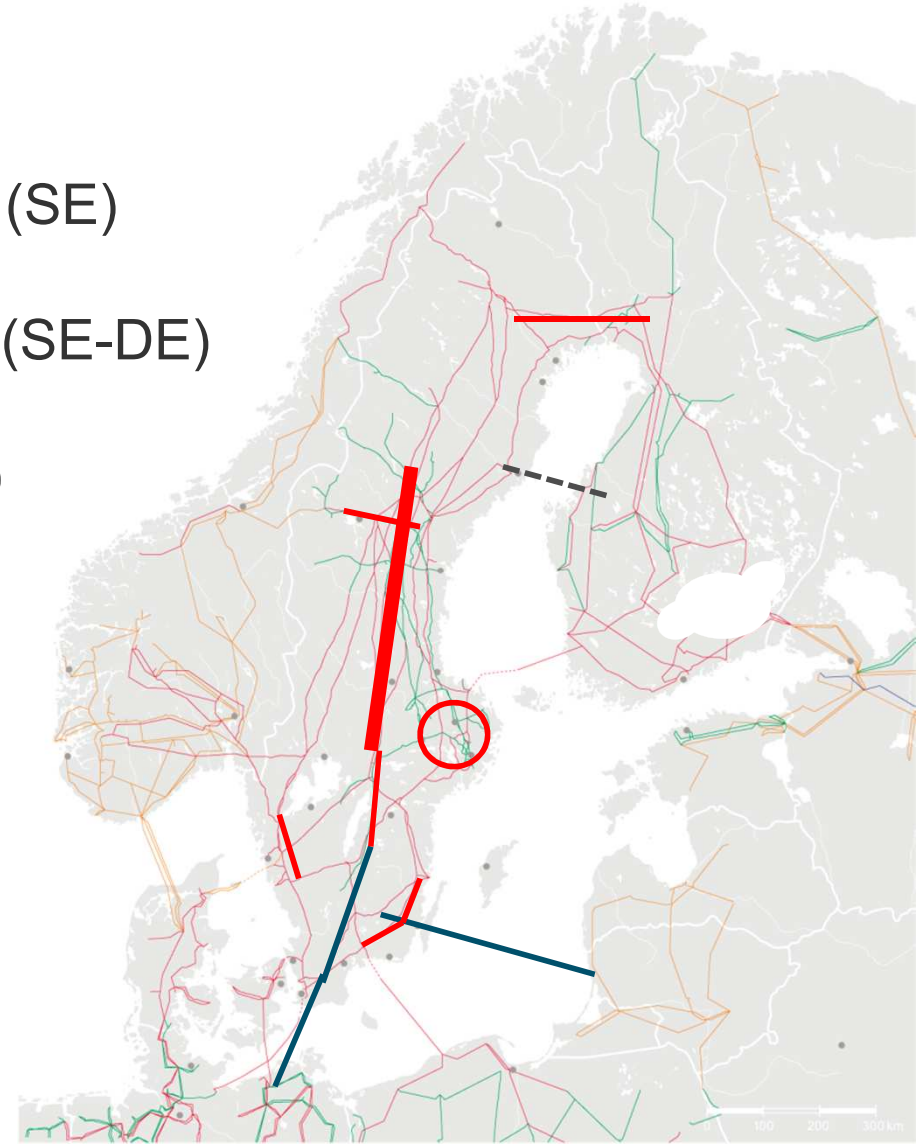
# Major projects

- SouthWest Link AC+DC VSC (SE)
- HansaPower Bridge DC VSC (SE-DE)
- 3rd AC Interconnector (SE-FI)
- Kvarken? DC (SE-FI)
- Stockholm
- Internal reinforcements
  - From the North
  - In the South



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# A Changing Power System

> Nuclear phase out
> Before 2020, 4 units closed (of 10)
> -2850 MW

> Weather dependent generation,
> wind power

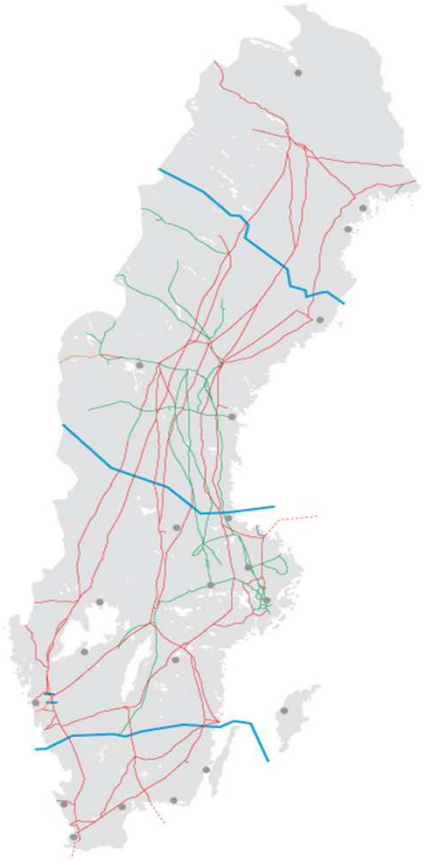
> Lack of Base Generation

# A Changing Power System

> Extensive process of change

> Conventional generation is replaced by weather dependent generation

> The robustness of BOTH the generation and the grid decreases; capacity and availability



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# A Changing Power System

- At the same time the dependency of electricity is increasing

- The level of security of supply has to be discussed
  - Risks and costs

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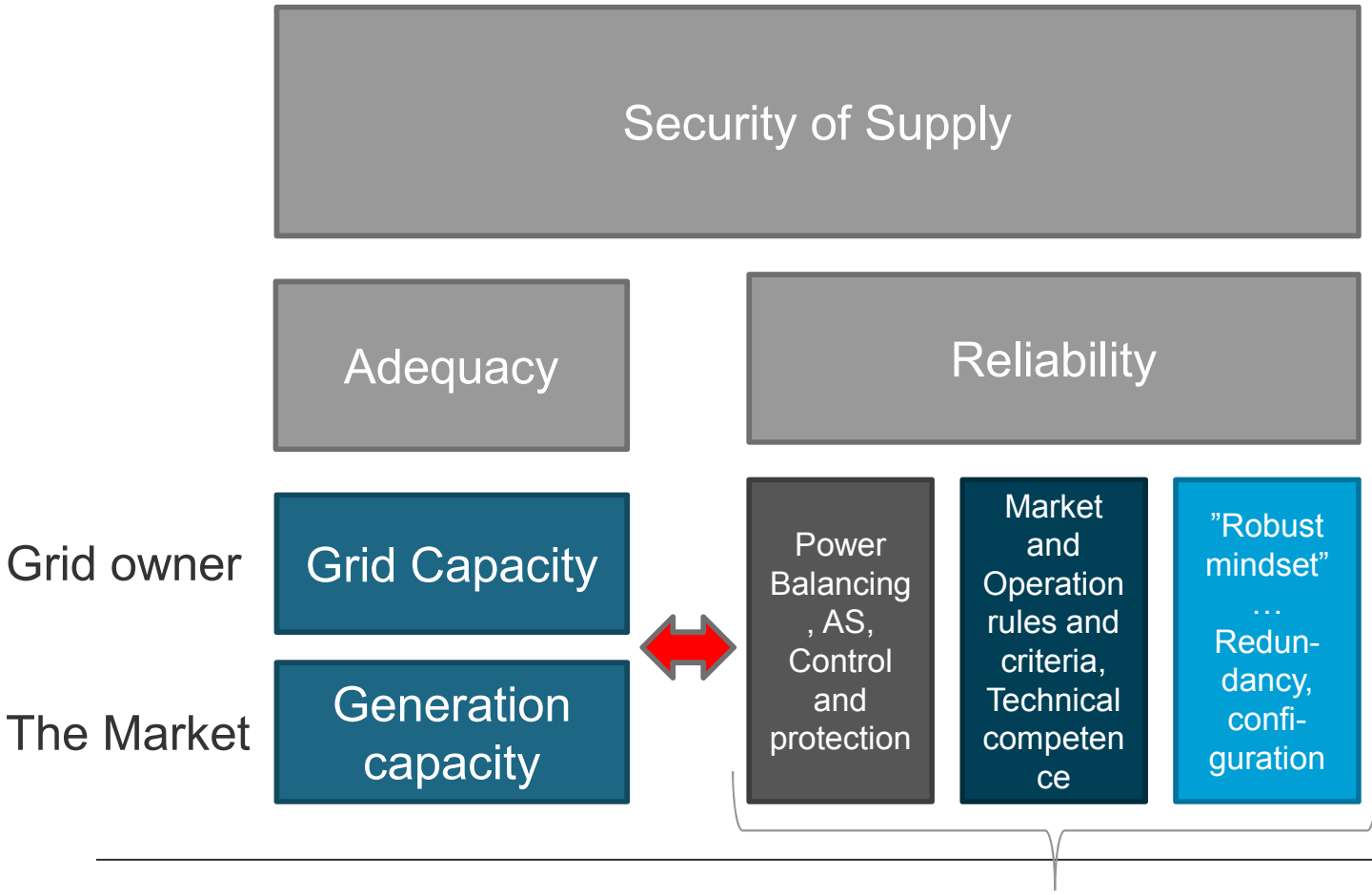
# Security of Supply

## The Power System – a very complex system




Svenska kraftnät
System operator

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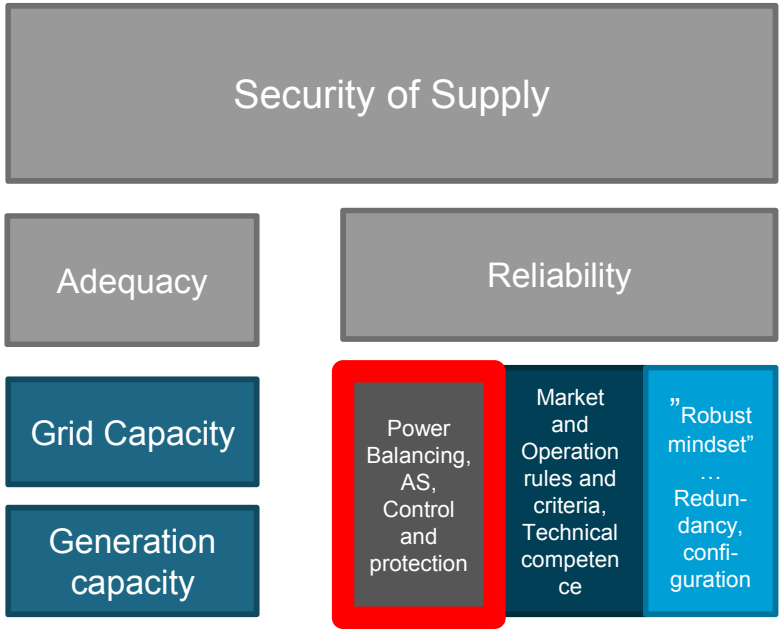
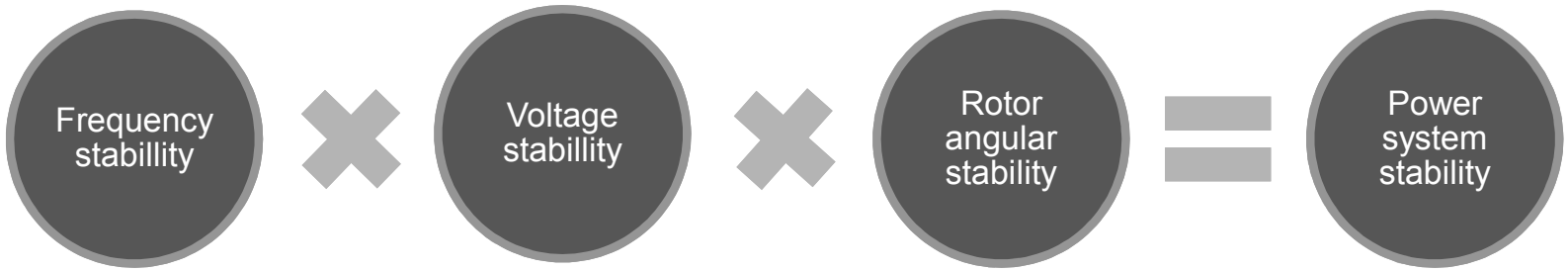
# Ancillary Services (AS) => System Stability

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# Inertia – Development

- Inertia decreases the impact of sudden losses of large generators/loads.
- Inertia helps to keep the grid synchronized (rotor angular stability).
- Inertia is expected to decrease between 2020-2040 to under 100 GWs
  - Yearly average from 202 GWs to 159 GWs
  - Lowest value from 121 GWs till 95 GWs

# Kinetic energy (inertia) in Sweden decreases between 2020-2040 to under 100 GWs

Simulations with lowest system inertia year 2025:

| Dim. fault [MW] | Inertia [GWs] | Lowest frequency [Hz] |
|---|---|---|
| 1600 | 95 | 48,59 |
| 1450 | 95 | 48,68 |

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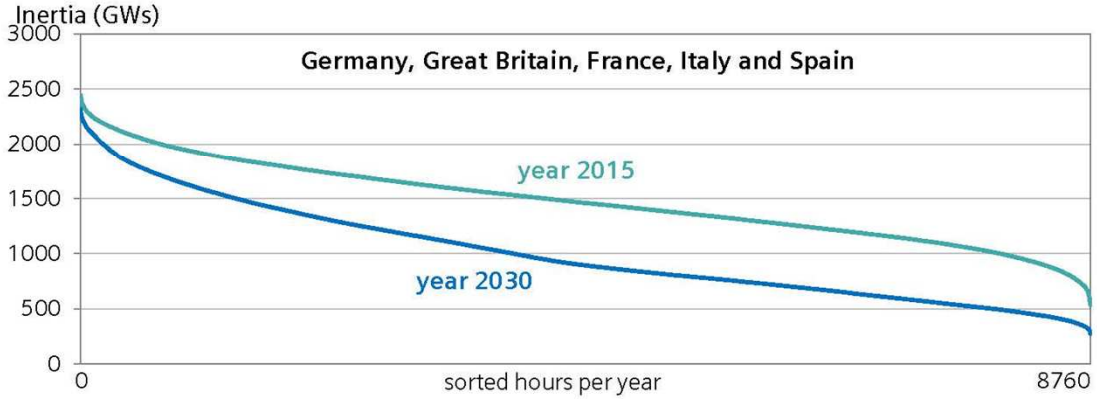
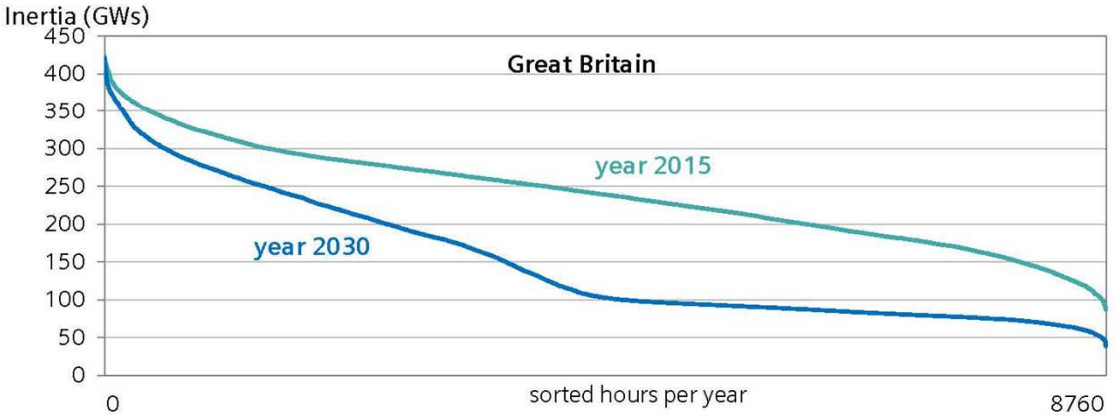
# Inertia in Germany, Great Britain, Italy and Spain
# Years 2015 (today) and 2030 (future)

SIEMENS
Ingenuity for life







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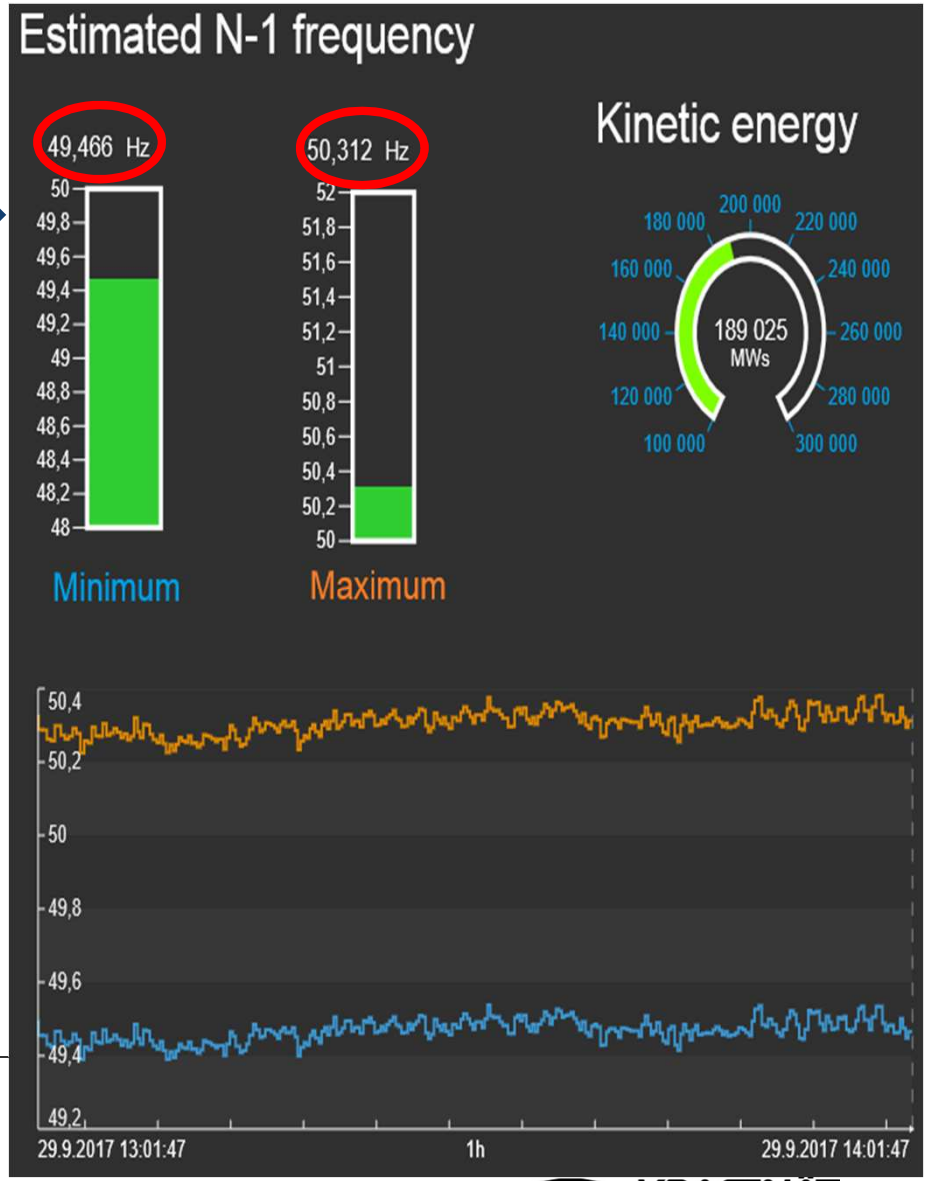
# Real time tool implemented in Svk's control room 2017:

Kinetic energy estimation

List of contingencies

Empirical regression model




**Dependent on the input.**

**Real-time values needed with data for all connected units.**

# Future Frequency Containment Reserve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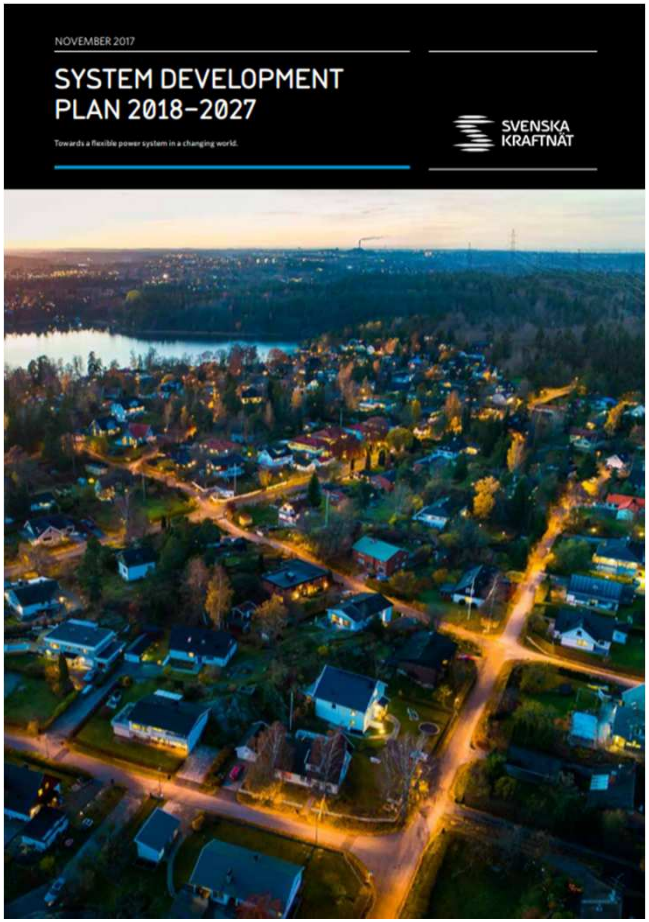
# System development plan 2018 - 2027

www.svk.se

Published 2018-02-28
(english version)

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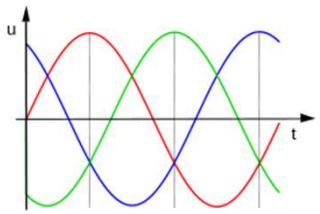
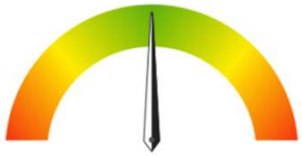
# Main challenges for the power system

## Challenges

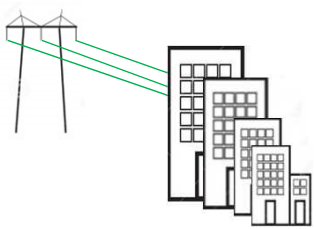
**System stability decreases by reduced interia and increased DER**



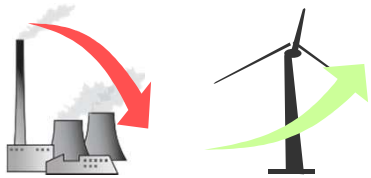

**Balancing, with less plannable resources**



**Grid capacity renewal of the grid and growing cities**



**Generation Adequacy (power) at all times**



## Solutions

**Roles and responsibilities,**

**European and Nordic cooperation - harmonization and increased interconnection**



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# New strategy to ensure the system stability

The system stability is challenged due to reduced inertia and increased DER (distributed energy resources). Thorough changes are needed, and a new strategy.

**Frequency stability**:

> Develop tools to calculate the intertia in the grid

> Develop requirements on existing and new ancillary services for primary reserves

**Voltage stability**:

> Develop new requirements on dynamic voltage control

> Increased investments in own Plants for dynamic voltage control

**Rotor-angle Stability**:

> Improve supervision of oscillations through new technology and new tools

> Develop new measures to be able to dampen power oscillations.

> Maintain short circuit power (stiff grid)

# New strategy to ensure the balancing on the energy market

The balancing must handle a lower amount of plannable production – more flexibility will be needed at all levels. Svenska kraftnät is developing a new balancing concept together with Statnett och Energinet.

**System design and development**:

> Reservation of transmission capacity to enable increased exchange of balancing services across borders.

> Identify barriers and challanges for commercial demand response and energy storage. →Pilot projects are already under way.

**Planning and operation**:

> Increased collection of real time data from the grid and from the production plants.

> Develop supporting tools, and an improved system overview and **MACE control** (Modern - Area Control Error in each LFC control block).

**Settlement**:

> The lenght of the settlement period is reduced to 15 minuter for more efficient balancing

> New improved price signals to the market by using marginal costs for calculation of the imbalance price. New price = Price cap on day-ahead market €3000 / MWh



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# Grid development

**Connection:**

> The energy system migration drives a lage increase in wind farm connections, especially in the north of Sweden.

**Market integration**:

> Increased need of interconnections between the Nordic countries, and between the Nordic countries and Europe.

**System improvements:**

> Large consumption increases in the metropolitan regions, driven by both general growth, but also specifically by data centres being established, require extensice investments in the grid

> Increased tranmission capacity north to south is required as the nuclear power is phased out.

**Reinvestments**

> Grid development is also driven by the need for reinvestments. The oldest parts of the Swedish grid are approaching the end of their technical lifetime and large parts of the grid will need to be renewed in the next few decades.

# Grid development

**Legislation challanges:**

> The long lead times in the permit processes for new transmission lines.

> Deficiencies in general regional planning that do not take into account that, for example, the establishment of new residential areas or industries also will require reinforcements of the electricity grid.

**Outage planning**

> Many planned outages must be made on power lines in the transmission grid due to the new investments and reinvestments. These will lead to reduced trade capacity for the electricity market.



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# The changing energy system creates challanges for the future generation adequacy

**Reference Scenario ”The Power system in 2040”**:

- A reference scenario until the year 2040 has been developed with the objective to illustrate and indicate the system challenges.
- In the scenario there is a risk of a yearly returing lack of power (MW) in southern Sweden, around 400 hours in 2040.
- Svenska kraftnät is investigation if increased consumption flexibility, energy storate or new flexible production can contribute to the power adequacy.

# The changing energy system creates challanges for the future generation adequacy.

Continued:

**Svenska kraftnäts responsibility and contribution to the long term generation adequacy**

Svenska kraftnät is not responsible for maintaining the generation adequacy (power) in the grid. But we contribute indirectly to strengthen it anyway as part of our mandate to promote an ”open Swedish, Nordic and European market for electricity”. Examples:

- **Building connections** to our neighbouring countries to strengthen the connection to the European power system.
- **Implementing the flow-based method** for capacity calculation. This method better represents the physical flows in the grid and leads to market solutions that better supports system operation.
- **Implements a deepend European integration** on the intraday electricity market, which is beleived to give the market actors a better possibility to trade themselves in balance.
- **Pricing of the strategic reserves** is raised to the price-cap level on the day-ahead market €3000 per MWh. The new price reduces the strategic reserves impact on the market and promotes more demand response being made available on the market.



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# Clear roles and responsibilites in the power system is vital in order to meet the challenges.

At present there is not a uniform enough picture of the roles and responsibilities on the electricity market in order to ensure the security of supply in the long term.

**Svenska kraftnäts role as grid owner, and System Operator**:

> As grid owner Svenska kraftnät is responsible for that the main transmission grid has adequate transmission capacity.

> In the role of System Operator Svenska kraftnät ensures the power balance at every moment of operation

**Uncertainties regarding the security of supply**:

> There is no dedicated actor with the responsibility for the security of supply in the pwer system, and there is no decided National target for the security of supply.

> There is no actor who is directly responsible for building enough new production to meet the demand in the long term.

> Svenska kraftnät means that the goverentment should decide on a national target for security of supply.

**Changes in other's roles on the electricity market**:

> The Distrubution System Operator (DSO / Regionnätsägare) role must be reviewed and developed to include more System Resposibility.



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# European and Nordic cooperation – Harmonization and increased interconnection

International climate policy and European energy policy has a growing effect on the power system and Svenska kraftnäts business.

Svenska kraftnät needs to conform to European legislation in the form of Grid Codes and Comission guidelines, which overrules the National legislation.

The European Grid Codes are to a large degree already decided and are being implemented.



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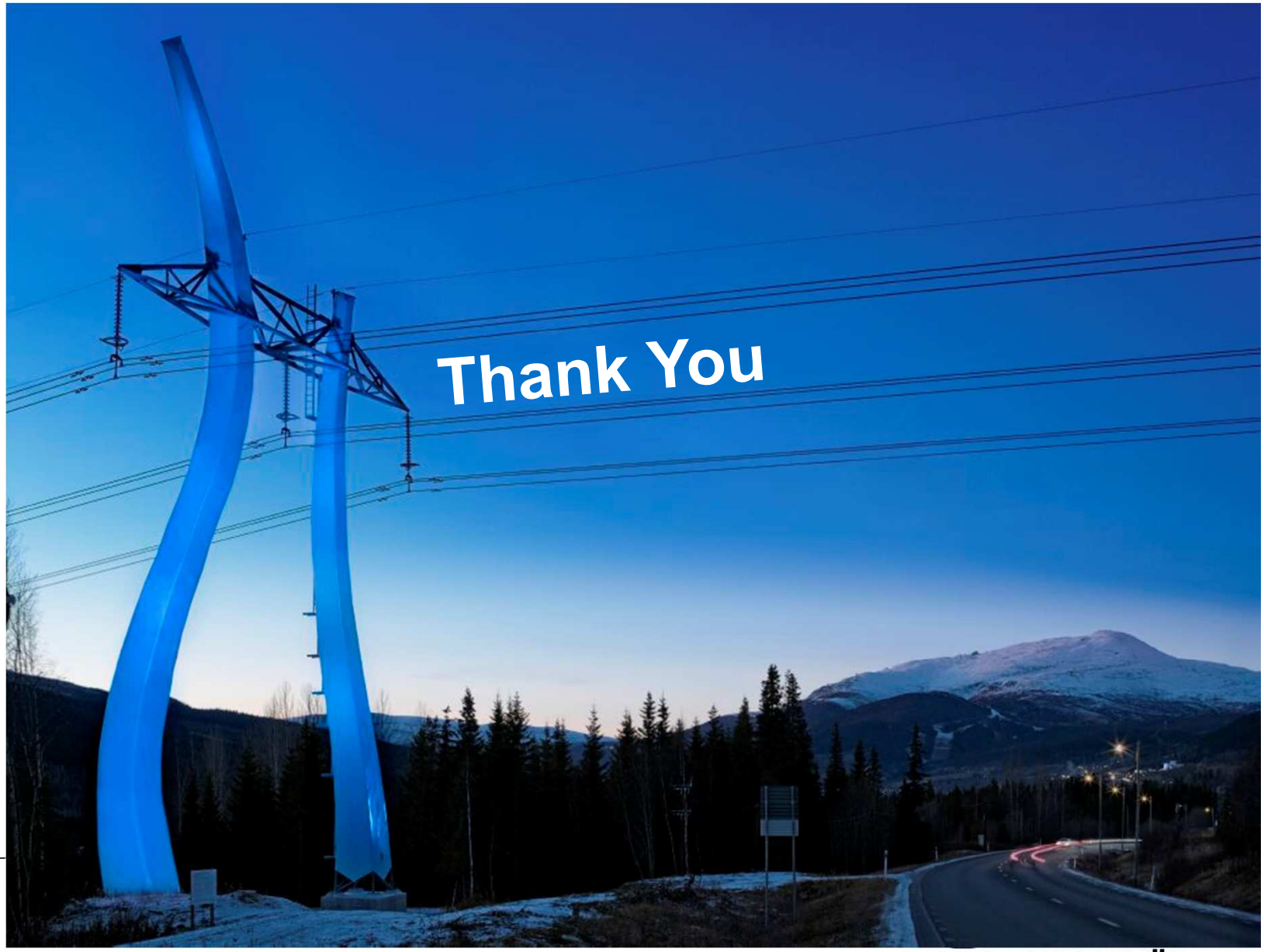


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