

Dam safety and climate change

...in times of
energy
transition

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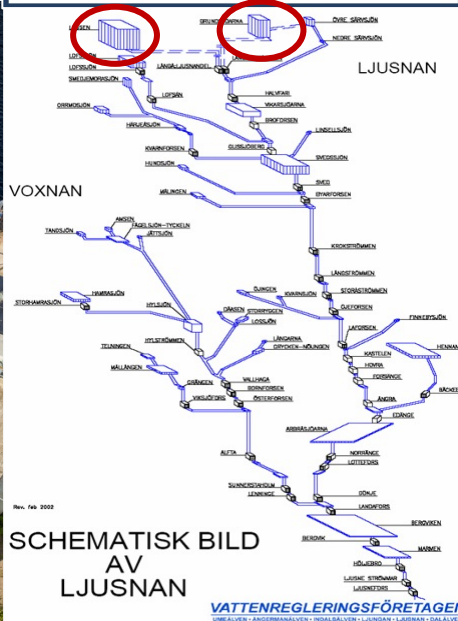
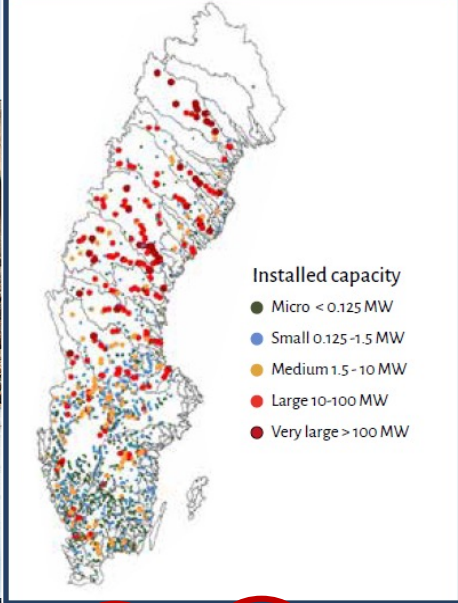
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VATTENKRAFTEN FOU-DAGAR, 2024-04-24

Content

1. Background
2. Government assignment dams & climate change
3. Recent examples from Statkraft
 - Changes in flow patterns
 - Winter discharge
4. Concluding remarks

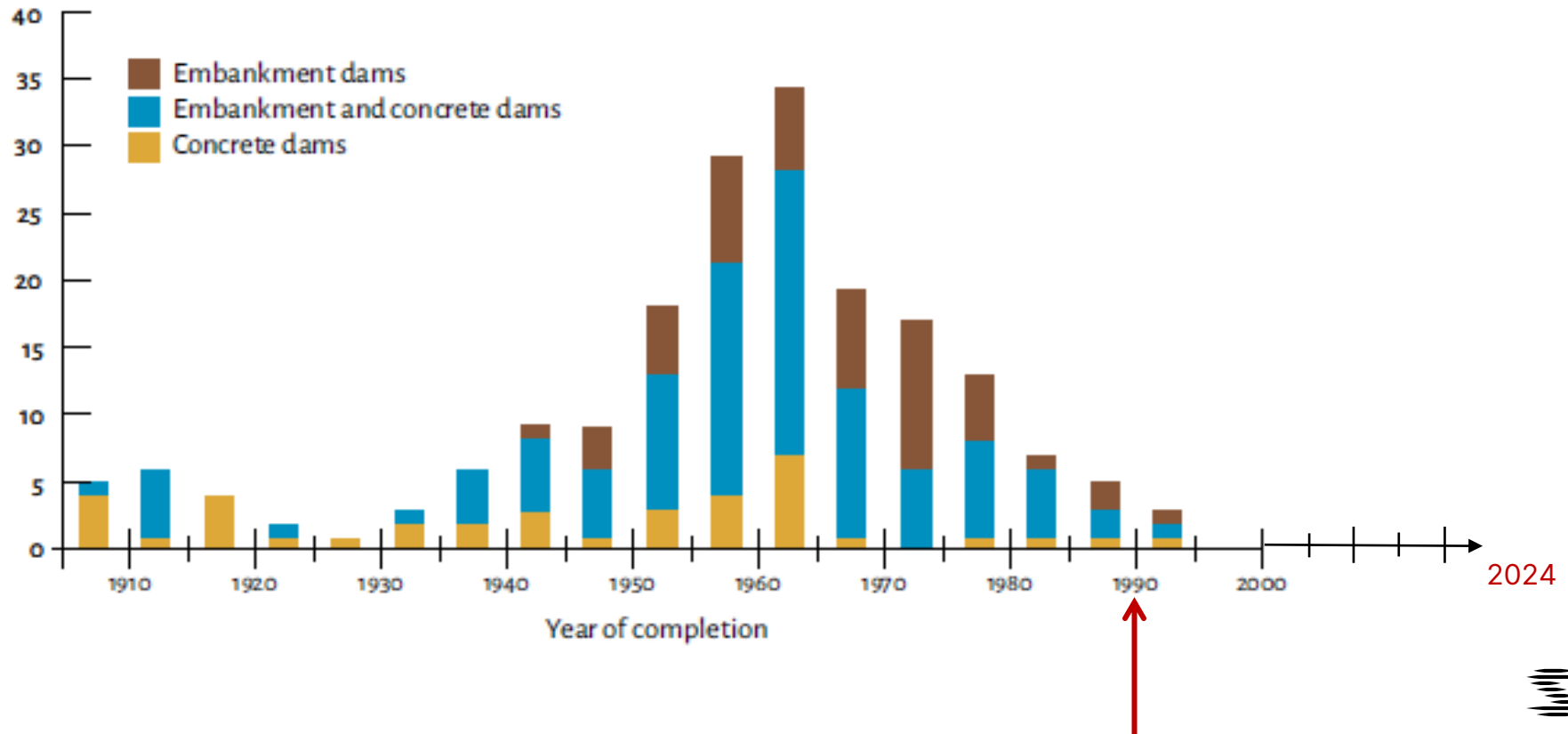




Large hydropower dams

Designed before modern dam safety framework

Number of dams



Extreme floods had been underestimated

1990 “New” design flood guidelines

- Interaction of observed extreme climatic factors & water regulation strategies
- Modelling river by river to find the most critical effect

What about climate change?

- Addressed since 2007



2. Government assignment 2022/23

Analyse impact of climate change on dam safety

- Compile current knowledge on climate change relevant to dams
- Analyze how changes in inflow and operation may influence extreme floods
- Map the vulnerability of classified dams to floods and effects of climate change
- Investigate application of national strategy for climate adaptation to dams



Team effort: authorities – industry – R&D



Read more on Svks web

[Klimatförändring](#) | [Svenska kraftnät \(svk.se\)](#)

What did we do?

- Focus on existing high consequence dams
- Compiled and made existing knowledge available
- Additional R&D studies
- Workshops with broad groups of experts

Findings

- Ongoing changes in the climate, the energy system and water use affect hydropower operation already today
- Impacts both directly on dams and their functions and indirectly via the surrounding environment



Conclusions & recommendations

Primarily already known risks that may change, get more severe, less predictable

- More weather events, unstable winters, fast variations, events coinciding
- Fast changes in energy mix, its geography and market – affect water regulation and HP operation, flexibility increasing importance, resulting in more winter discharge
- Focus remains on safe discharge; capacity, access, availability - not only extreme floods
 - Pay close attention to connection between dam safety and operation

Incorporate guidance in existing dam safety guidelines – like in design flood guidelines

- Integrate into dam owners' risk management processes
- Measures incl more maintenance, monitoring and surveillance but also adaptation of operation and design
- Strive for solutions providing extra safety margins today & facilitate stepwise adaptation in the future

Some current observations

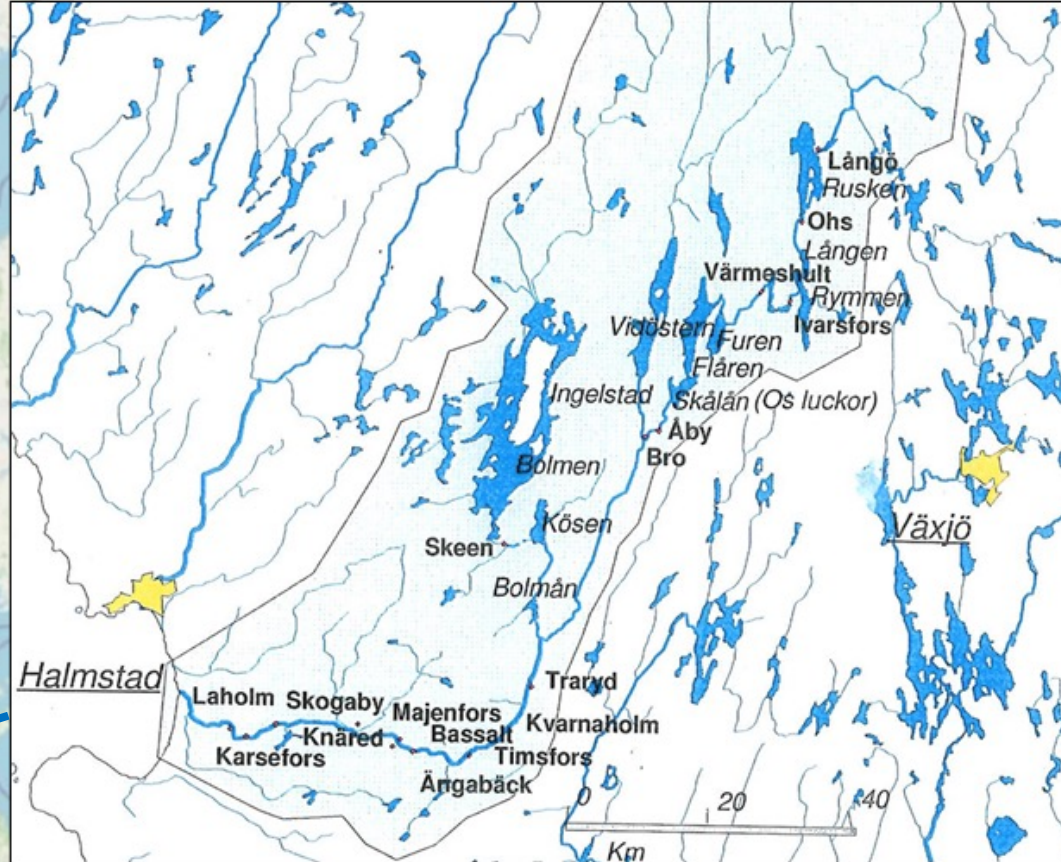
Change in flow patterns due to

- Climate change?
- Water use
- Changes in the energy market

In the South of Sweden

- More frequent dry periods in summer
- Periods of high flow and low temperatures overlapping

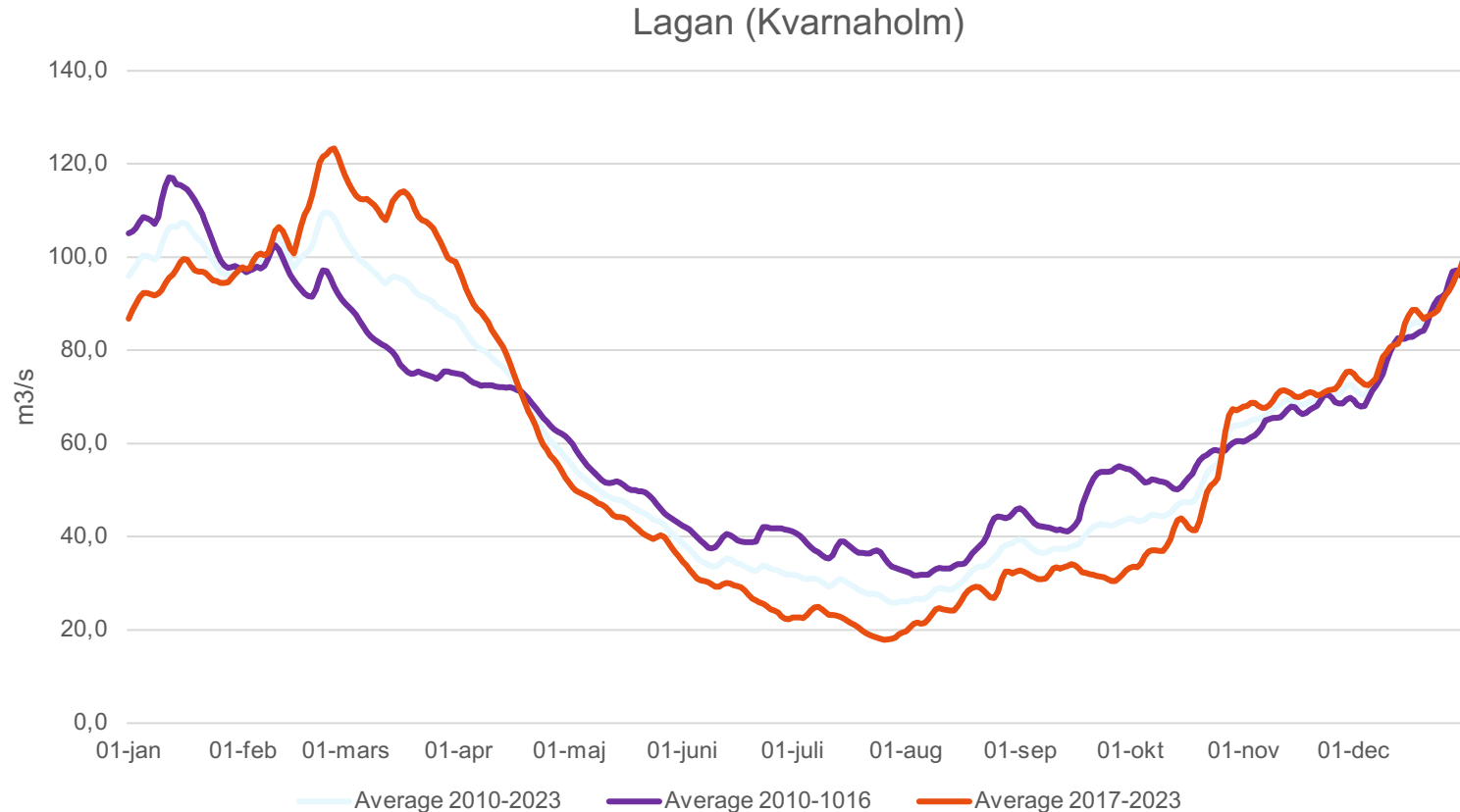
Flow regime in the south of Sweden Example from Lagan

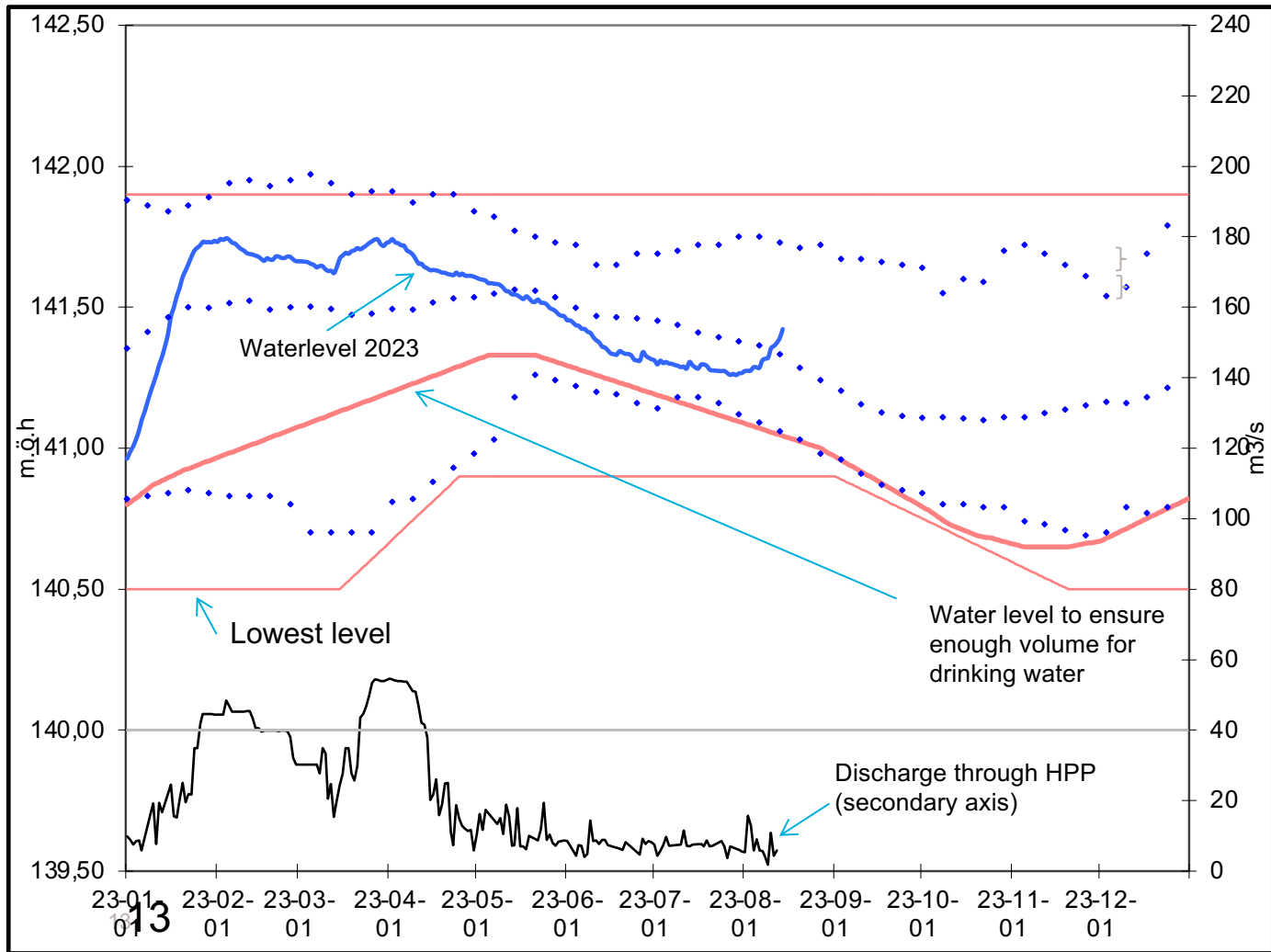


- 18 HPP
- 500 GWh/year

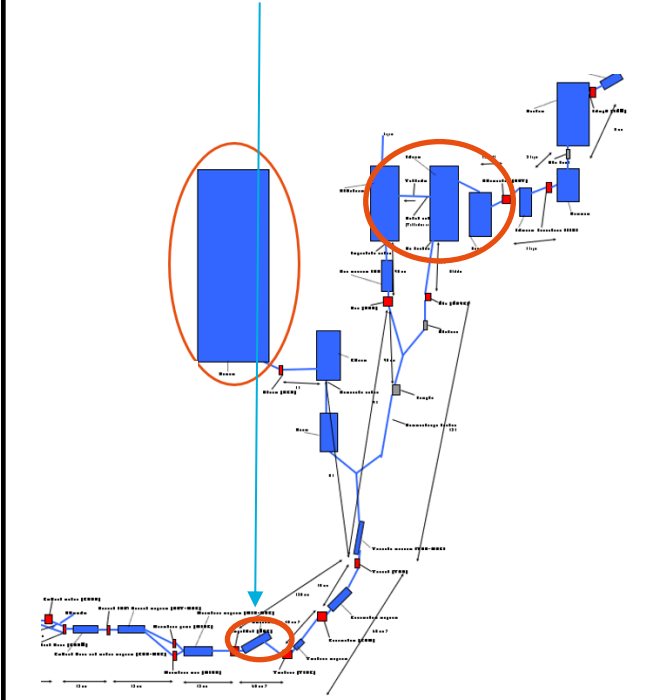
Naturalized flow (SMHI Vattenweb)

- Average 2010 – 2023
- Purple line average flow 2010 – 2016
- Red line average flow 2017 – 2023
- Trend with dryer summers and later high flow period in recent years





Upper part total reservoir volume connected to discharge in middle part of the river



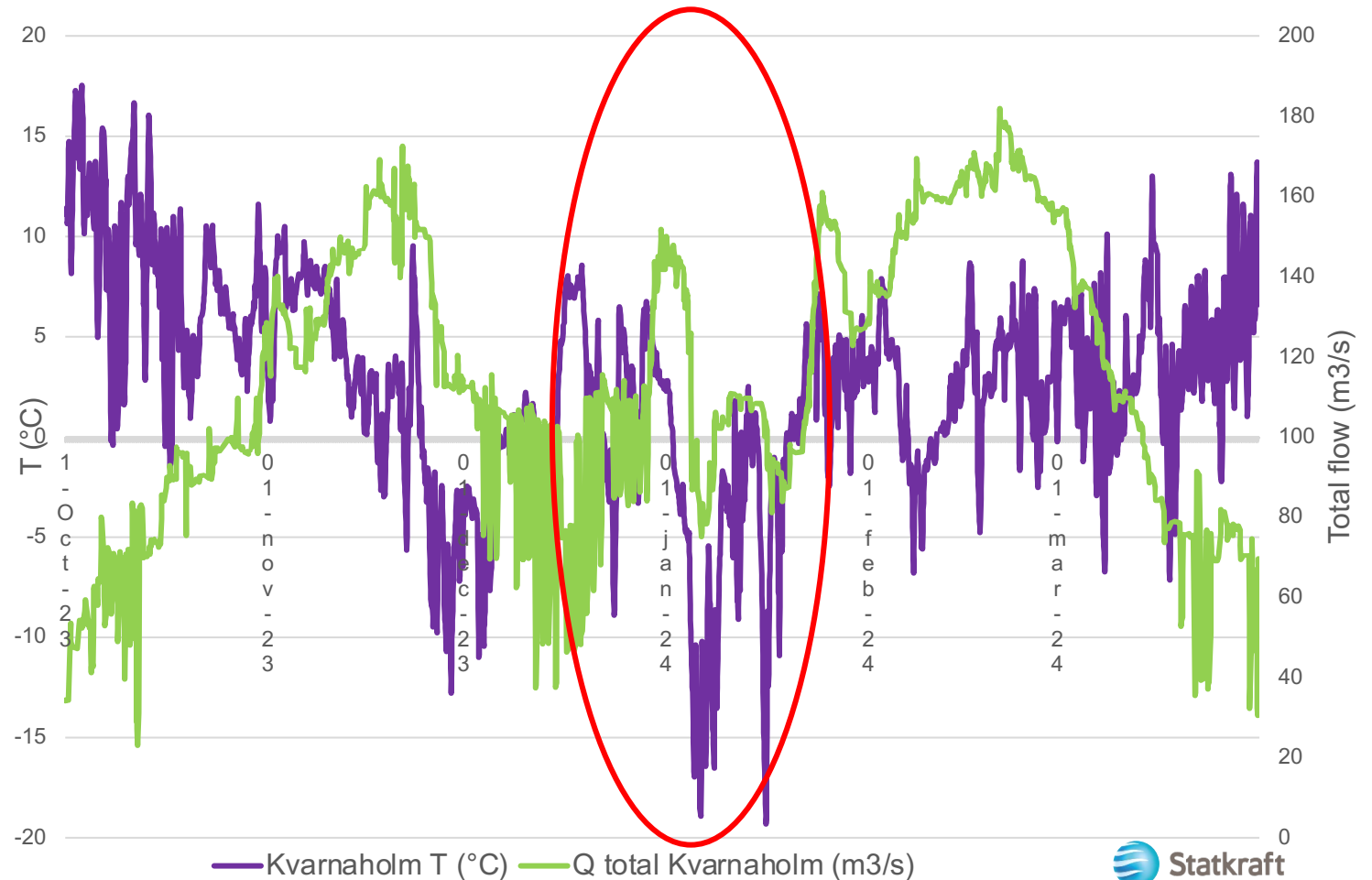
Consequences/measures

- Some examples:

- Need to retain more water in the reservoirs to have enough volume to ensure drinking water → less margin to reduce floods, may influence design flood
- Changing of regulation in the whole river system
- WFD – New concessions only for hydro power
- Greater value of hydrological and meteorological data to get more accurate data for modelling and to observe and be prepared for extremes

Flow and temperature Lagan (Kvarnaholm)

- October 2023 – April 2024
- Purple line shows temperature
- Green line shows total flow (secondary axis)
- Several occasions with high flow and dropping temperature



Lagan (Kvarnholm)

High flows in combination with cold weather

May cause problems to regulate the gates



Lagan (Timsfors)

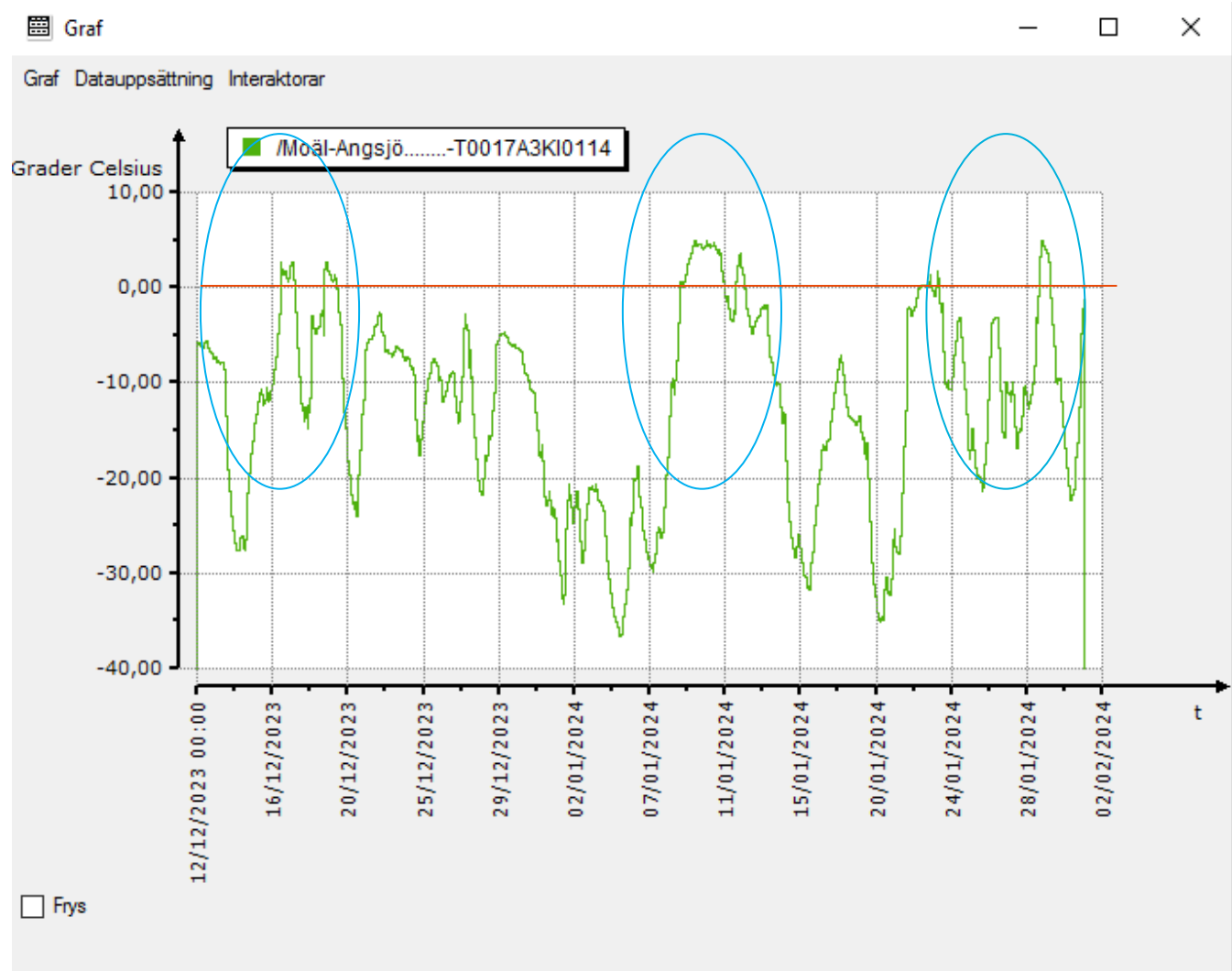
Building of ice in front the pillars during discharge through gate

Unstable winters – not possible to build stable surface ice to reduce problems



In the north

- Temperature December 2023 – February 2024
- Several occasions with changes from -20 or -30 °C to well above 0 °C within 24 hours



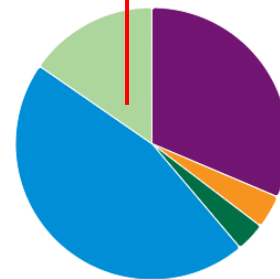
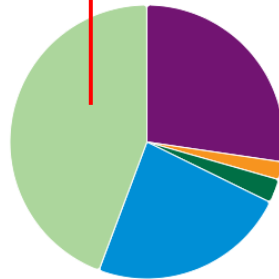
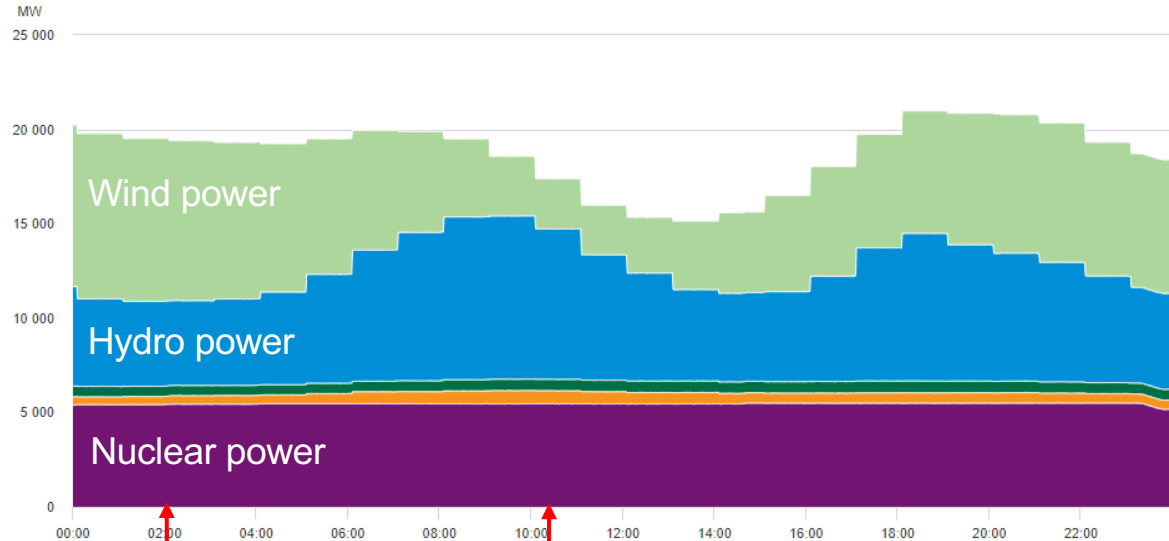
Consequences/measures

- Some examples:

- Identified need to install an extra flood gate in some stations
- Observations and forecasts: water temperature, hydrological and meteorological
- More maintenance: remove vegetation in summer and ice in winter
- Need to consider other type of flood gates and perhaps more efficient systems to keep the gates free from ice

A changing energy market.. (example from 12:th of April 2024)

- Comes with new challenges
 - High (or low) and fluctuating power demand
- Changes in regulation of hydropower in both long and short term



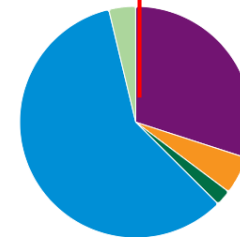
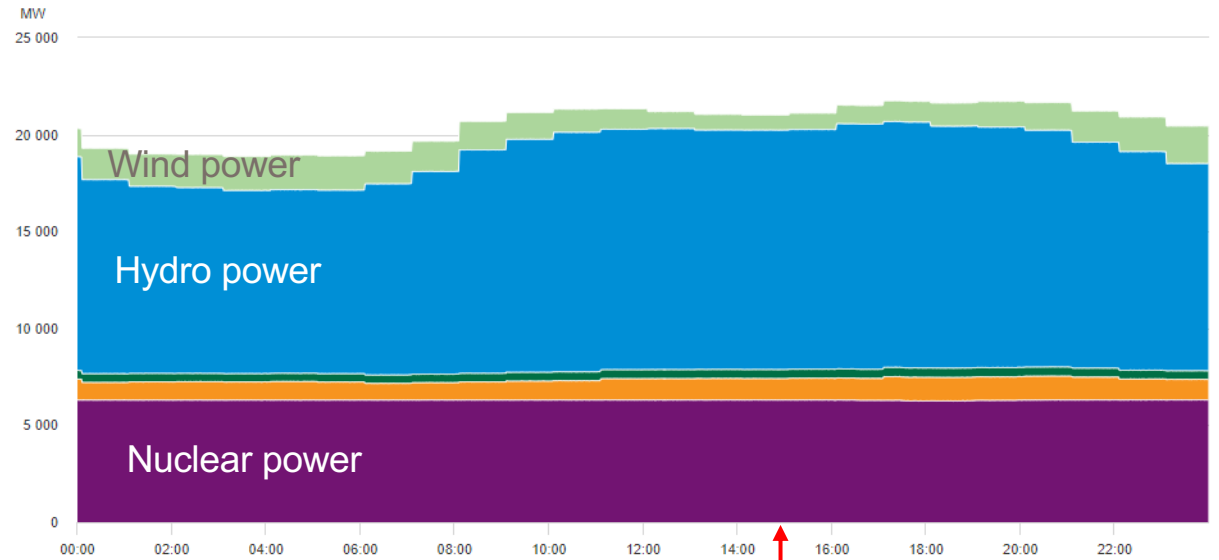
● Kärnkraft: 27,3%
● Värmekraft: 2,1%
● Ospecificerat: 2,8%
● Vattenkraft: 23,4%
● Vindkraft: 44,3%

● Kärnkraft: 31,4%
● Värmekraft: 4,0%
● Ospecificerat: 3,5%
● Vattenkraft: 45,8%
● Vindkraft: 15,3%

<https://www.svk.se/om-kraftsystemet/kontrollrummet/>

A changing energy market.. (example from 6:th of January 2024)

- Very little wind
- High and varying energy demand



● Kärnkraft: 30,0%
● Varmekraft: 5,3%
● Ospecificerat: 2,2%
● Vattenkraft: 58,8%
● Vindkraft: 3,7%

<https://www.svk.se/om-kraftsystemet/kontrollrummet/>

Problems with winter spillage



- Turbine unavailable
- Spillage to get the water trough
- Around $-30\text{ }^{\circ}\text{C}$ ($-37\text{ }^{\circ}\text{C}$)
- Building of ice and eventually breakdown of the gate
- See www.swedcold.se for more details

Concluding remarks

- Challenges with spillage in cold conditions → increased maintenance
- The trend noticed in the south of Sweden will probably start occurring further north in time
- Change in the market → change in production pattern and reservoir use
- Several things occurring at the same time → uncertainties and need of margin
- Inflow forecast calibrated on historical data/measurements. More difficult to predict both meteorology and inflow in a changing climate
- The need and value of measuring hydrological and meteorological parameters increases
- Already noticeable effects
- The dams are designed to handle extremes. Community and infrastructure more vulnerable
- We continue cooperation and information exchange between industry, authorities, and R&D

Tank you for your attention!



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