The energy system impacts of electric heating in northern Europe under variable historic weather scenarios

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Resilient energy systems (2023-2026)

The expected increase in the use of electricity for heating combined with increased shares of variable power in the energy system will imply that supply and demand and thus the prices of power in Northern Europe will become more sensitive to variability in the weather and changes in climate.

Objectives for this project:

- Quantify how variation in the weather and climate will affect the future energy system, which is largely electrified.
- Analyze potentials and barriers for solutions that can provide long-term flexibility and how different technical solutions for a decarbonised energy system are perceived and accepted.
- Identify solutions that ensure a future low-carbon energy system that are economically sustainable, socially accepted and at the same time have the capacity to solve future challenges in variability and disturbances in supply and demand.

Responsible organisation: NMBU **Projectleader:** Erik Trømborg

Partners: : CICERO, IFE, DTU (Denmark), Federal University of Viçosa (Brazil), Statnett, Statkraft, Fornybar Norge, Norsk Fjernvarme, Celsio, Tafjord Kraftvarme, Kvitebjørn Varme, Østfold Energi, NVE, NOBIO **Project-period:** 2023-2026

Project-type: Competence-building project for business

Public (governmental) fundig: 10,5 mill. NOK (1 mill. €)

Wep-page: www.nmbu.no/forside/prosjekter/resilient

Projectnumber: ES709673

Background

The Problem

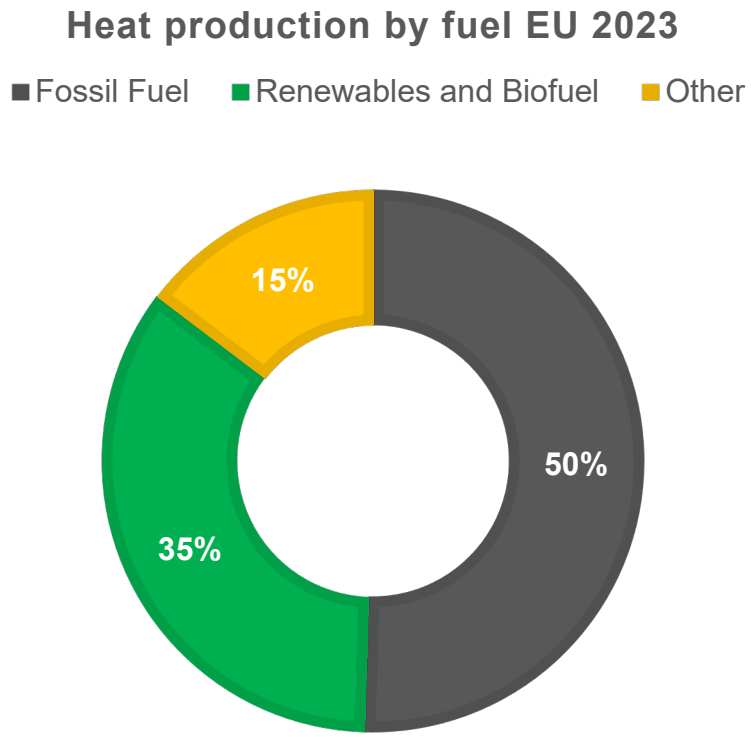
- Fossil fuels provide around 50% of the energy demand of the heating sector of EU.

The Solution

- Electrification could be the most cost-effective solution, given the limited availability of alternative renewable sources.

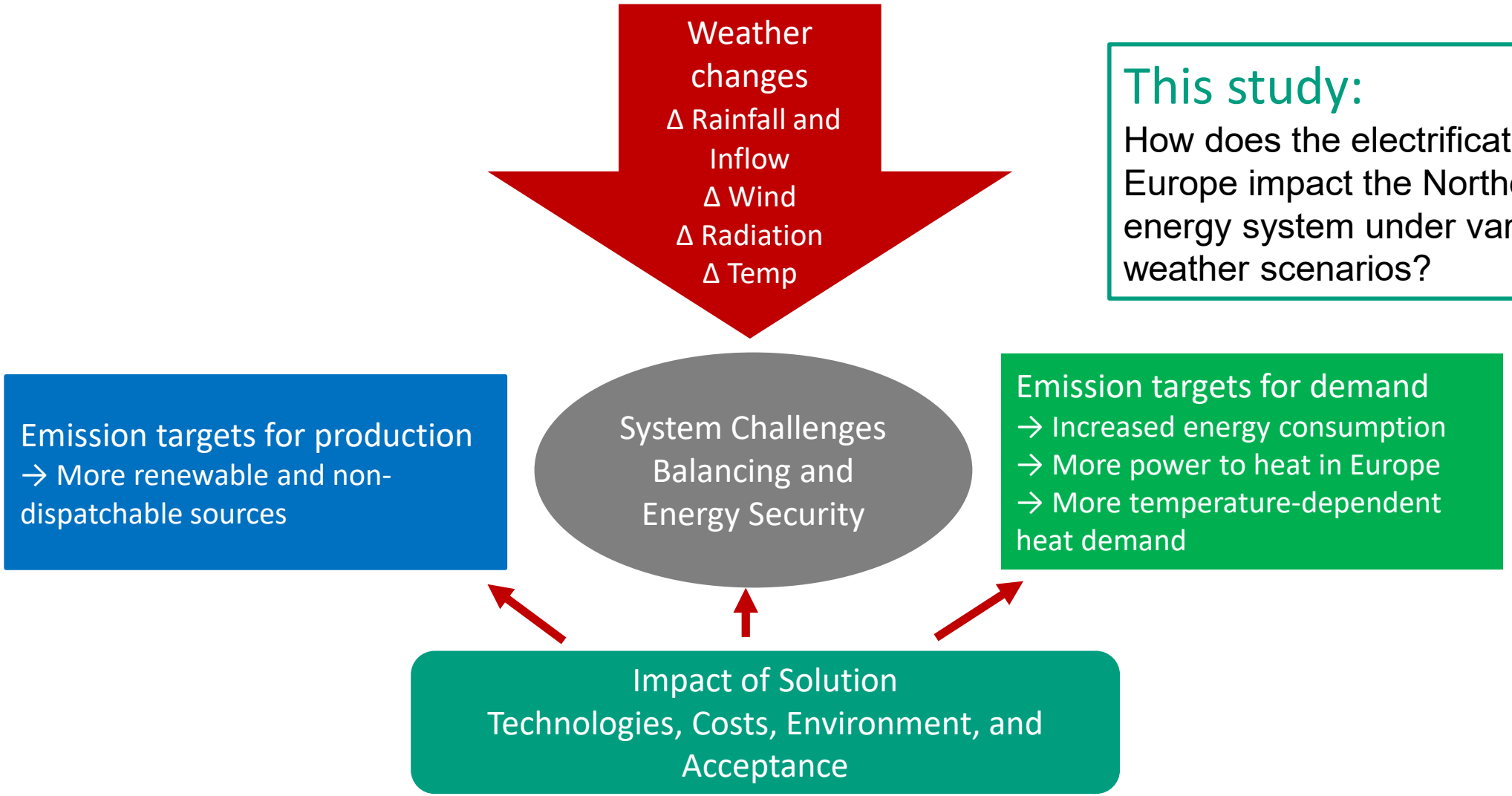
The Dilemma

- More temperature-dependent power consumption will heighten variability in the power market, affecting both short and long-term supply-demand balance.



Source: Eurostat

Research Question



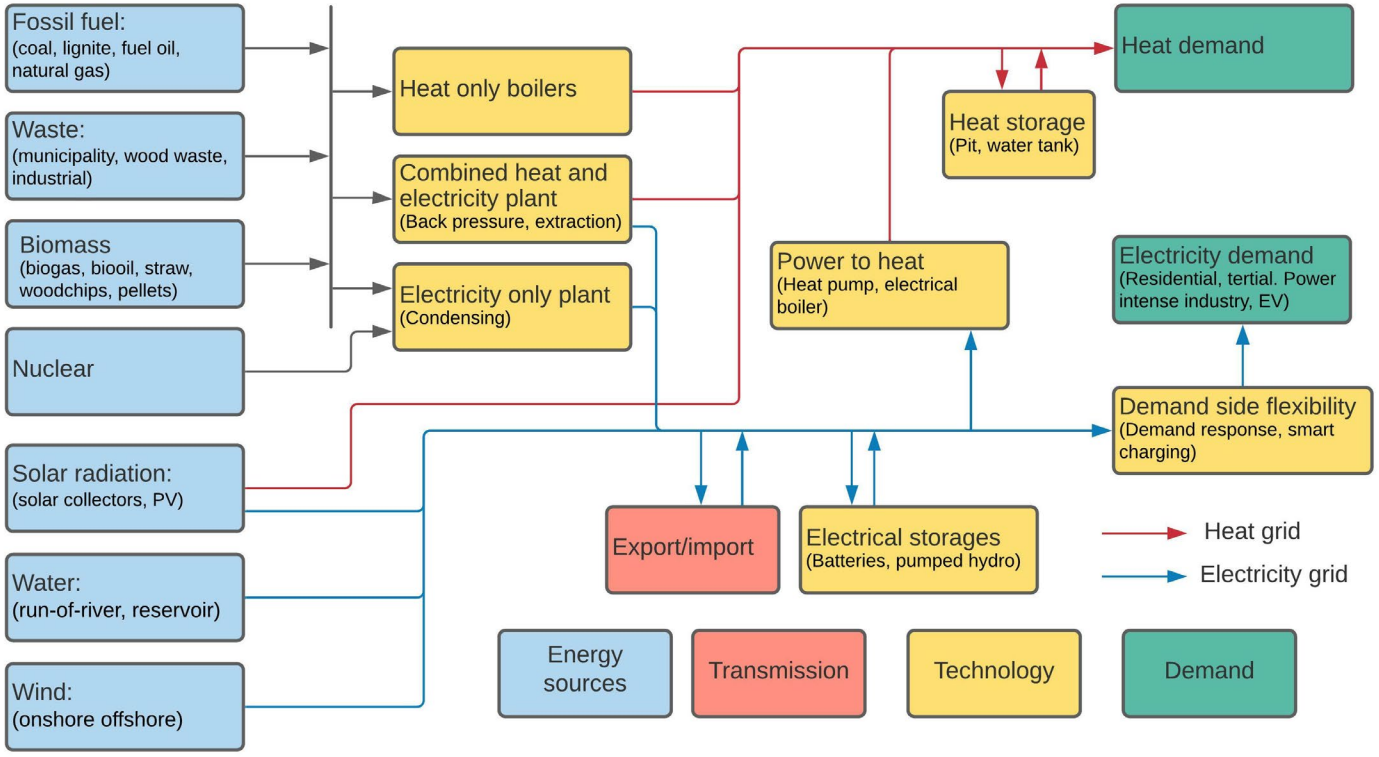
This study:

How does the electrification of heating in Europe impact the Northern European energy system under various historic weather scenarios?

Method

BALMOREL

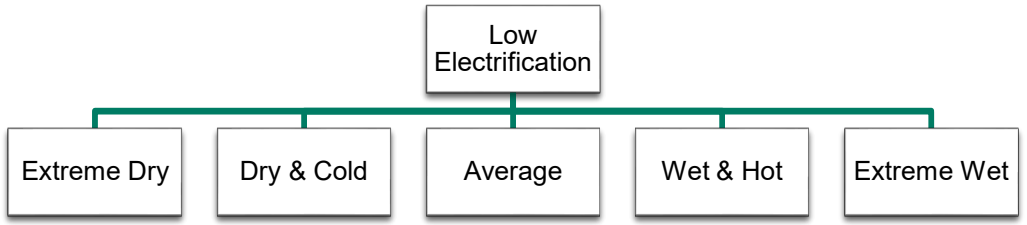
- Open-source partial equilibrium model
- High temporal resolution
- Focus Year: 2040
- Incorporates different historical weather years.
- Includes profiles for wind, solar, hydro, and heating demand, ensuring consistent historical correlations



Scenario

Electrification Levels

- **Base** • The present mix is maintained
- **Low** • 50% of fossil will be electrified
- **Medium** • 75% of fossil will be electrified
- **High** • 100% of fossil will be electrified



Weather Scenarios

- Extreme Dry ▪ 1996
- Dry and Cold ▪ 1987
- Average ▪ 1992
- Wet and Hot ▪ 2020
- Extreme Wet ▪ 2011

4 Electrification Levels
&
5 Weather Patterns

Total 4 X 5=20 model runs

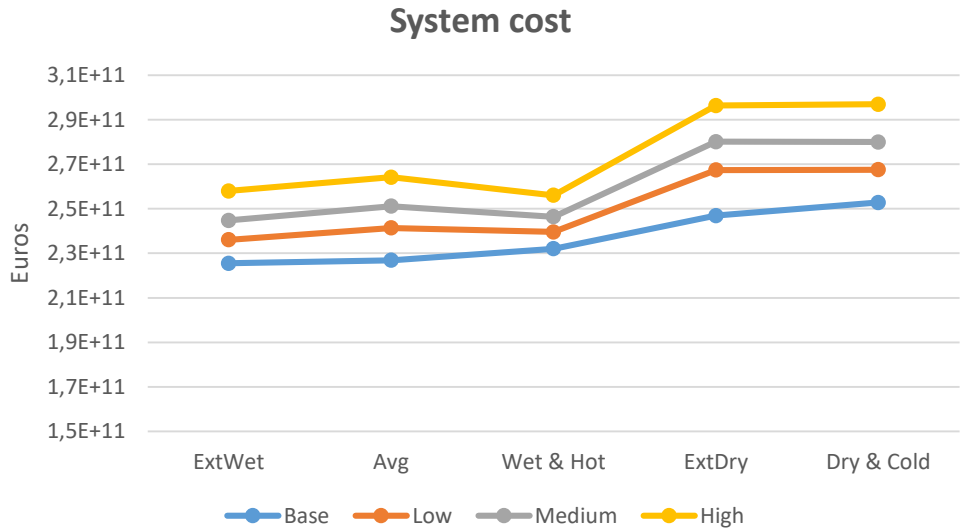
Results:

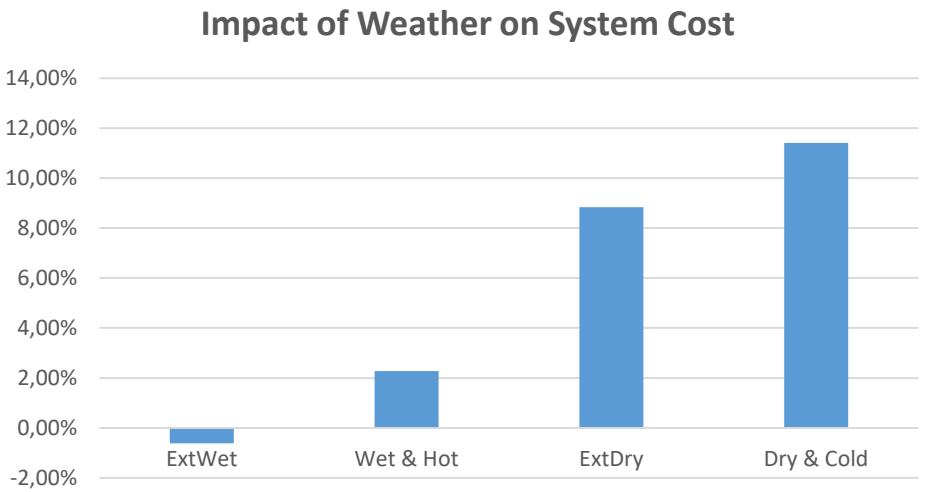
Electricity prices are more sensitive to weather changes than electrification rates.

Results: System Cost in 2040

Electrification Impact: Higher electrification increase system costs indicating significant investment needs for infrastructure and generation capacity.

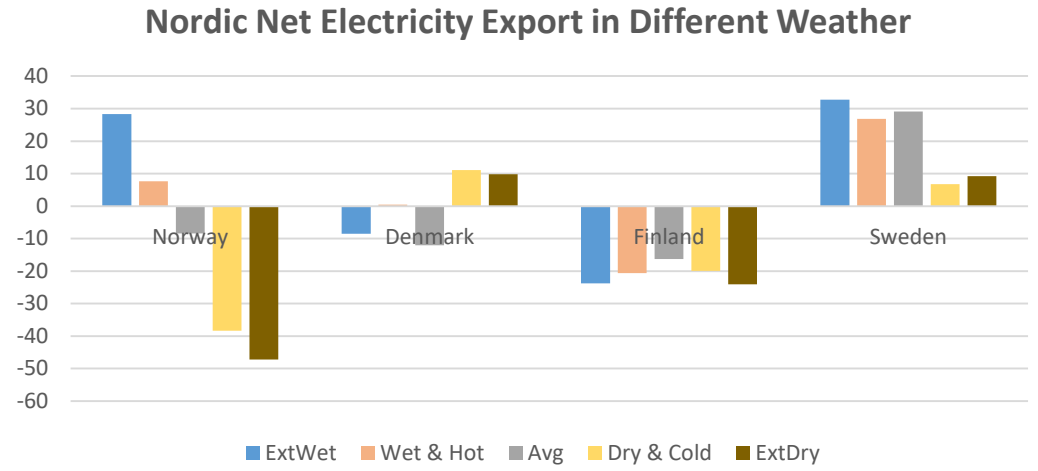
Weather Impact: System costs are highest in dry and cold conditions due to reduced hydropower and increased heating demand. Extreme wet scenarios lower system costs.

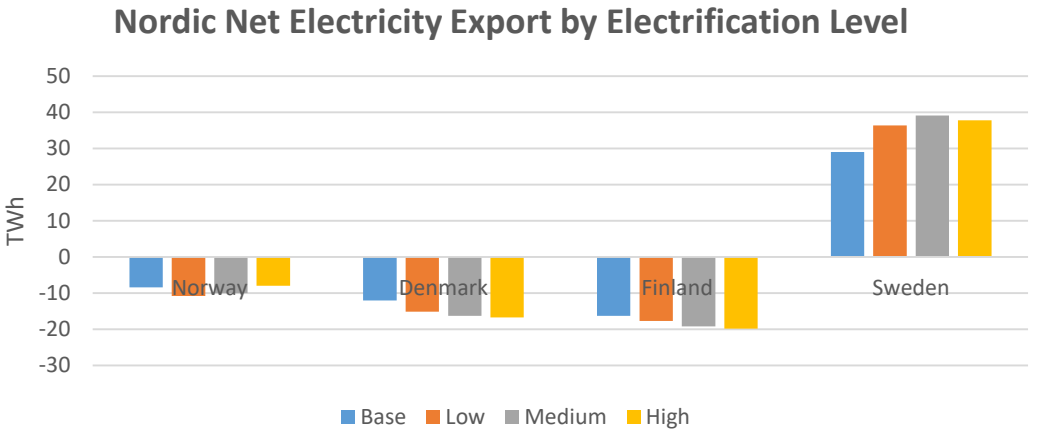




Results: Electricity Trade in the Nordics in 2040

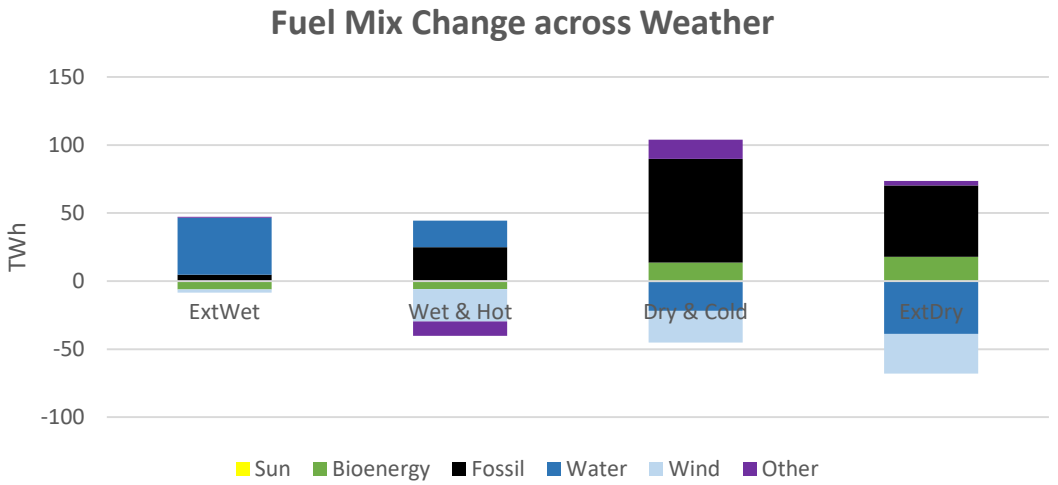
- Like Power Prices, Net Export varies significantly across weather, but slightly across electrification level
- Except Sweden, other Nordic countries become net importer in most cases
- Higher electrification slightly reduces exports as domestic demand rises.

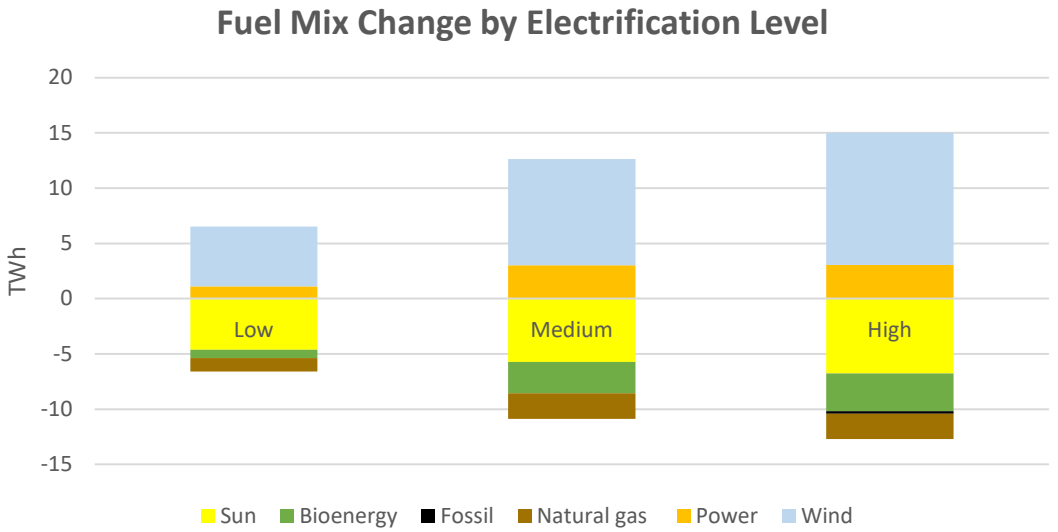




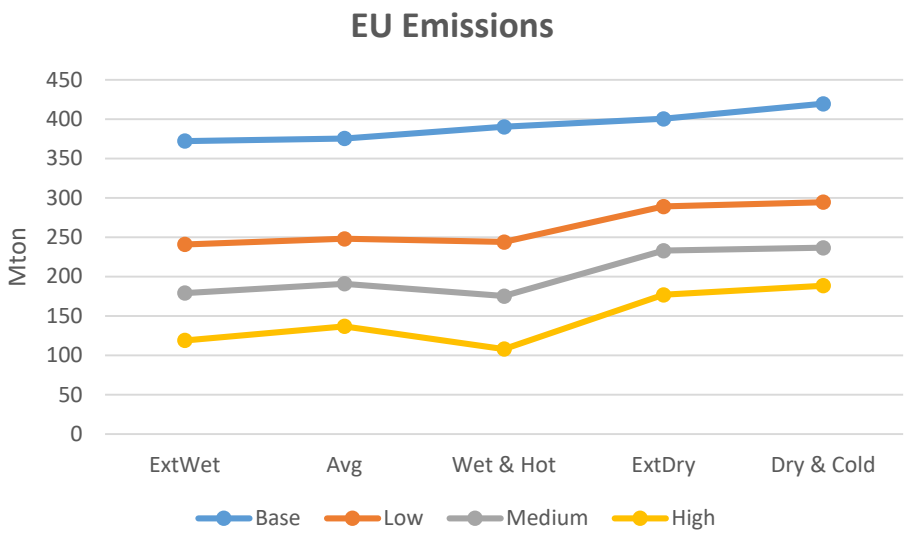
Results: Fuel Production mix in Nordics in 2040

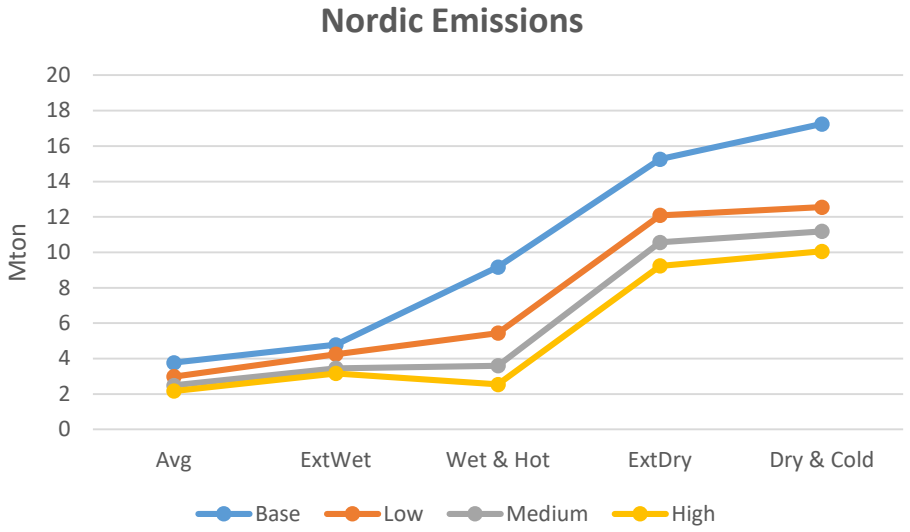
- In Dry Seasons, Hydro electricity is replaced by Natural Gas plants
- Production from solar and onshore wind remains similar across weathers.
- With more electrification, more wind power is harnessed than solar





Emissions in 2040





Higher electrification decreases emissions in all weather scenarios

In Dry seasons, more emissions occur due to more reliance on Natural Gas plants

Full electrification can cut down more than 50% emissions in the EU

Key Takeaways

- ☑ Electrification is essential to reduce heating sector emissions.
- ☑ Higher electrification raises system costs but reduces power price.
- ☑ Energy systems are more sensitive to weather changes than electrification levels.
- ☑ Dry and Cold seasons pose significant challenges in the Nordics due to reduced hydropower production and increased heat demand.
- ☑ Increased heating demand poses a greater challenge than extreme dry seasons.

Thank You!