Kraftproduksjon og -etterspørsel i Norge og Norden

Sammenstilling av scenarioer

THEMA CONSULTING GROUP

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Prosjektbeskrivelse

Dette notatet gir en oversikt over ulike scenarioer for utviklingen i kraftproduksjon og -etterspørsel i Norge og Norden til 2050. Data om forbruk og etterspørsel er hentet fra totalt 17 scenarioer, fra ni ulike rapporter og seks ulike analysemiljøer. Notatet er et vedlegg til en excel-database som inneholder det fullstendige datagrunnlaget og en mer detaljert oversikt over kilder og scenarioer.

Prosjektteam

Kontaktperson

Berit Tennbakk
berit.tennbakk@thema.no
+47 928 68 117

Bidragsytere (alfabetisk)

Lisa Zafoschnig

Om THEMA Consulting Group

Postadresse: Øvre vollgate 6
Besøksadresse: Nedre vollgate 9
0158 Oslo, Norway

Foretaksnummer: NO 895 144 932
www.thema.no

THEMA Consulting Group tilbyr rådgivning og analyser for omstillingen av energisystemet basert på dybdekunnskap om energimarkedene, bred samfunnsforståelse, lang rådgivningserfaring og solid faglig kompetanse innen samfunns- og bedriftsøkonomi og teknologi.

INNHOLD

1 INNLEDNING

Dette notatet gir en oversikt over ulike scenarioer for kraftproduksjon og -etterspørsel i Norge og Norden. Data om forbruk og etterspørsel er hentet fra totalt 17 scenarioer fra ni ulike rapporter. Kildene inkluderer analyser fra seks forskjellige aktører, blant annet offentlige aktører, konsulentselskaper og forskningsinstitusjoner. En detaljert beskrivelse og skjematisk sammenstilling av scenarioene ligger i kapittel 2, og referanselista finnes i kapittel 6.

Data ble samlet inn med en bottom up-tilnærming, ved å bruke det høyeste tilgjengelige detaljnivået for etterspørsel pr. segment og produksjon pr. teknologi. Ulike kategorier ble deretter aggregert til sammenlignbare etterspørselssegmenter og produksjonsteknologier.

> **Etterspørsel:** Kildene bruker ulike forbrukskategorier med ulike detaljeringsnivåer. Husholdninger og tjenester inneholder også oppvarming og elektriske apparater. Datasenter er regnet som industriforbruk. Med mindre petroleumsindustrien er oppgitt som en egen kategori, er forbruket her også inkludert i industri. Tap i nettet er enten oppgitt som en egen kategori eller inkludert direkte i forbrukssegmentene. Kategorien «annet» inneholder alle sektorer som ikke er inkludert i de andre kategoriene pr. kilde.
>
> **Produksjon:** De fleste kilder oppgir produksjon pr. teknologi direkte. I tilfellet kun data om installert effekt er tilgjengelig, ble produksjon beregnet ut fra kapasitet og fullasttimer oppgitt i rapporten Langsiktig Kraftmarkedsanalyse, NVE (2021). For kilder som ikke skiller mellom havvind og landvind, er summen av vindkraftproduksjonen oppgitt. Kategorien «annet» inneholder alle teknologier som ikke er inkludert i de andre kategoriene pr. kilde.

For visualiseringer av utviklingen over tid ble total etterspørsel og produksjon beregnet ut fra summen av de underliggende kategoriene. Der ingen detaljerte data var tilgjengelig, har vi rapportert oppgitt total etterspørsel og/eller produksjon.

Kraftbalansen er regnet som forskjellen mellom total produksjon og forbruk. For scenarioer der kun en av de to parameterne er tilgjengelig, er det ikke mulig å regne ut kraftbalansen.

Kapitlene 3-5 inneholder forskjellige visualiseringer av produksjon, forbruk og kraftbalanse i Norge og Norden i ulike tidsperioder. Siden noen kilder bare oppgir detaljerte data for visse regioner og/eller år, varierer antall kilder som er inkludert pr. figur.

Dette notatet er et vedlegg til databasen som inneholder det fullstendige datagrunnlaget og en mer detaljert oversikt over kilder og scenarioer.

2 SCENARIOOVERSIKT

2.1 Beskrivelse av scenarioer pr kilde

Tabell 1: Scenariobeskrivelse

Author	Scenario	Description
NVE (2020) Langsiktig kraftmarkedsanalyse	Base	**Approach:** NVE's expectations for the development in the power market until 2040, given the drivers and challenges seen in the market today. **Focus:** Highlighting uncertainty in future developments. Climate policy and technology developments are identified as the main drivers for the power market until 2040. **Demand and supply:** Fossil fuel generation will be partly replaced by generation from renewable energies though some gas generation remains in operation to ensure system stability. Power demand increases mainly in existing and new industries while residential demand is expected to decrease as energy efficiency improves. Renewable generation capacity increases by 200% with large volumes of solar PV and wind power coming into the market. In the long term, flexibility solutions in the form of batteries, DSM and hydrogen become important to balance intermittent generation.
NVE (2021) Langsiktig kraftmarkedsanalyse	Base	**Approach:** NVE's (updated) expectations of the development in the power market until 2040, given the drivers and challenges seen in the market today. **Focus:** Highlighting uncertainty in future developments. Climate policy and technology developments are identified as the main drivers for the power market until 2040. Large uncertainty is attributed to the ambitious EU climate targets and whether or when they will be achieved. **Demand and supply:** Fossil fuel generation will be partly replaced by generation from renewable energies requiring a stronger integration of the power sector with the wider energy sector. Power demand increases driven by direct and indirect electrification of sector that currently rely heavily on fossil fuels. In Norway, electrification in the petroleum, industry and transport sectors can amount to 40-60 TWh of additional demand. To maintain its surplus Norway has to build out additional renewable generation capacity, which is limited by public acceptance for onshore wind and concession processes for offshore wind until 2030. In the long term, larger volumes of weather-dependent power generation increase the need for flexibility in the system for example through DSM and batteries for short-term flexibility and hydrogen for more long-term flexibility.
Statnett (2020) Langsiktig markedsanalyse Norden og Europa	Base	**Approach:** The European energy system and with it the power sector are on a pathway towards zero emissions by 2050. **Focus:** How could the zero emission pathway affect the power system? Assumptions are based on externally available information through specific build-out plans, external forecasts and analyses, implemented political measures and a view of the power system as it is today and has been historically. Statnett performs its own calculations based on this input to verify and quantify the development of the European power market. **Demand and supply:** Power demand is expected to double, compared to today's levels driven by both direct and indirect electrification. Most power generation will stem from solar and wind, for which generation volumes are expected to increase tenfold until 2050. At the same time, all thermal power plants are expected to be decommissioned at the latest by 2050 with many exiting the market already by 2040. Significant gains in energy efficiency are also expected. With large volumes of intermittent generation, flexibility becomes increasingly important. This flexibility can be provided by DSM, batteries, hydrogen production and strengthened grid infrastructure.
	Extra High	**Approach:** The European energy system and with it the power sector are on a pathway towards zero emissions by 2050. **Focus:** How could the zero-emission pathway affect the power system? **Demand and supply:** Increased power demand in Norway from the petroleum sector, industry, data centres and hydrogen production while residual demand is assumed to be the same as in the Base scenario. All other assumptions as in Base scenario.
	Moderate	**Approach:** The European energy system and with it the power sector are on a pathway towards zero emissions by 2050. **Focus:** How could the zero-emission pathway affect the power system? **Demand and supply:** Reduced electrification of petroleum installations and a more rapid decrease in demand from petroleum activities. Coupled with increased energy efficiency this

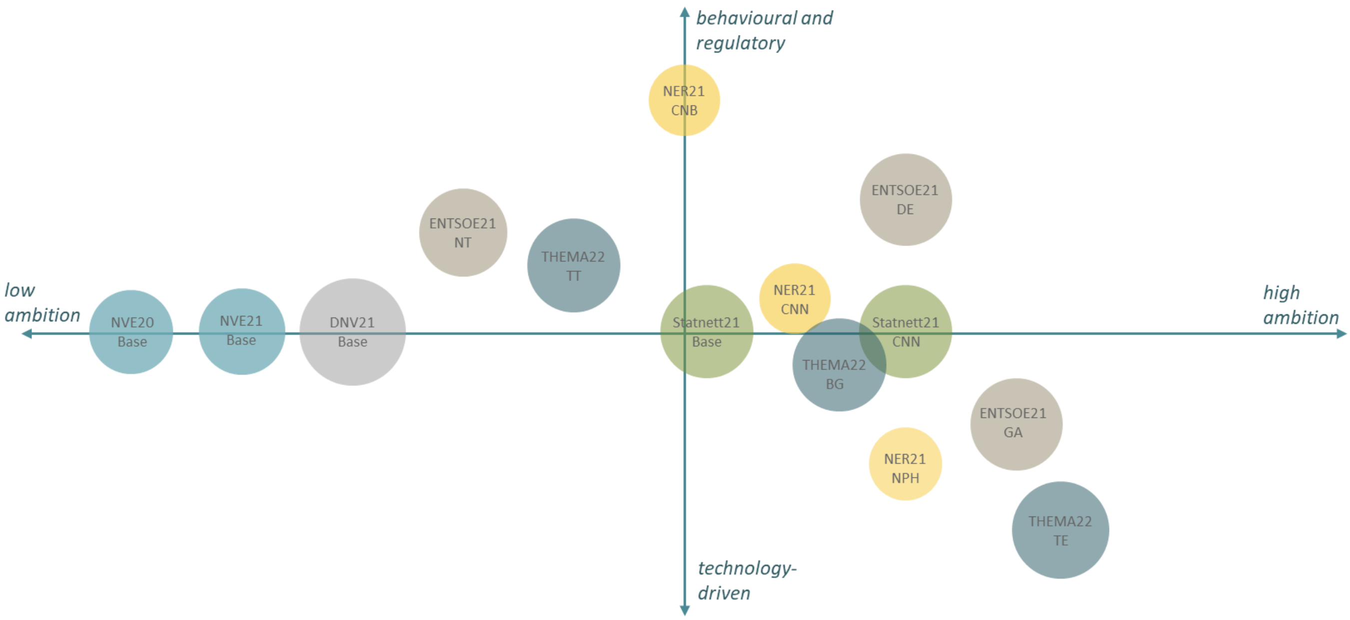
		scenario shows a moderate development of power demand in Norway. All other assumptions as in Base scenario.
Statnett, Fingrid, Svk, energinet (2021) Nordic Grid Development Perspective	Climate Neutral Nordics	**Approach:** Decarbonisation of the Nordic region based on national scenarios from the Nordic TSOs fulfilling the goal for decarbonisation in 2030–2050. Opens up a role for the Nordics as a net exporter of green products such as electricity, steel, and to some extent hydrogen. **Focus:** The impacts of high direct and indirect electrification throughout the energy systems. **Demand and supply:** With the increased electrification a large increase in electricity consumption is assumed, mainly from new consumption like electric vehicles (EVs), industry, heat pumps and P2X. In order to facilitate this electrification in the Nordic region, large amounts of renewable power production need to be built throughout the region, primarily wind, onshore and offshore and to a smaller extent photovoltaic (PV).
Nordic Energy Research (2021) Nordic Clean Energy Scenarios	Carbon Neutral Nordics	**Approach:** Pathway to a carbon neutral Nordic energy system, based on stated, but not yet implemented, national strategies and targets. **Focus:** What fast actions are required in all sectors as the amount of renewable power and heat production must increase to provide clean energy to end-use sectors. **Demand and supply:** Nordic countries in this scenario increase electricity exports to central Europe, but the amount does not increase much above current projections as electrification of Nordic heating, transport, and industry require a large supply of low carbon electricity. Biomass imports from outside the Nordics are limited to current or slightly higher levels to ensure sustainability of bioenergy use. BECCS is utilised compensate some of the most expensive CO2 emission abatement options. In addition, onshore wind development is limited below the technical potential due to social acceptability and land use issues.
	Carbon Neutral Behaviour	**Approach:** Pathway to a carbon neutral Nordic energy system, based on stated, but not yet implemented, national strategies and targets. **Focus:** Storyline motivated by strong political and citizen engagement. In this storyline, politicians and citizens adopt additional energy and material efficiency measures in all sectors that lead to lower energy demand. **Demand and supply:** Output from heavy industry decreases in this storyline by 10% in comparison to CNN from 2030 to 2050. In addition, decentralised generation technologies become much more common, further cutting the amount of energy delivered through grids. Energy demand for transport is assumed to decrease due to more efficient use of transportation modes and less but more efficient heavy transport of goods. For passenger transport national passenger km is assumed to not grow past 2030.
	Nordic Power House	**Approach:** Pathway to a carbon neutral Nordic energy system, based on stated, but not yet implemented, national strategies and targets. **Focus:** Storyline where the Nordic countries provide cheap clean energy and host more low carbon services and industries, increasing their exports of low carbon products and energy carriers, and increase the exports of carbon free steel and aluminium. **Demand and supply:** All these activities increase demand for electricity and/or other energy products. This also results in more excess heat from industry and services that is used in district heating generation. The NPH also allows for increased power transmission capacity between the Nordic countries and from the Nordics to mainland Europe as well as increased power-to-X (PtX) fuel production.
Miljødirektoratet (2020) Klimakur 2030	Base	**Approach:** Analysis of possible measures to achieve decarbonisation targets. **Focus:** Focus on individual decarbonisation measures per segment spanning from electrifications, CCS, to efficiency improvement in processes and resource use. **Demand and supply:** Electrification as a measure to reduce emissions could increase power demand significantly. No estimates were made for power generation.
DNV (2021) Energy Transition Norway	Base	**Approach:** Realistic scenario for the transition of the Norwegian energy system to 2050. **Focus:** To present a clear and solid picture of Norway's most likely energy transition through to 2050. Norway does not meet its 2030 climate targets and does not reach carbon neutrality by 2050. Norway already enjoys a low carbon intensity energy system thanks to its hydropower dominated electricity system. Most of the emissions reductions must therefore happen in the hard-to-abate sectors like oil and gas production, heavy transport, and the industry sector. Oil and gas production is expected to decline. **Demand and supply:** Renewable electricity is the key lever for reducing emissions in the main sectors of transport, industry, and oil & gas. Everything that can be electrified should be. Clean electricity is needed for making hydrogen, ammonia, and in carbon capture. factories will require a large amount of clean electricity. Total electricity supply in 2050 is expected to be 75% higher than today's production. Floating offshore wind is the key instrument for Norway to scale up electricity supply. Europe is dependent on energy export from Norway.

ENTSOE (2022) TYNDP	**Distributed Energy**	**Approach:** A pathway achieving EU-27 carbon neutrality by 2050 and at least 55 % emission reduction in 2030. **Focus:** The scenario is driven by a willingness of the society to achieve energy autonomy based on widely available indigenous renewable energy sources. It translates into both a way-of-life evolution and a strong decentralised drive towards decarbonisation through local initiatives by citizens, communities and businesses, supported by authorities. **Demand and supply:** This leads to a maximization of renewable energy production in Europe and a strong decrease of energy imports.
	Global Ambition	**Approach:** A pathway to achieving carbon neutrality by 2050 and at least 55 % emission reduction in 2030 **Focus:** Driven by a global move towards the Paris Agreement targets. **Demand and supply:** It translates into the development of a wide range of renewable and low-carbon technologies (many being centralised) and the use of global energy trade as a tool to accelerate decarbonization. Economies of scale lead to significant cost reductions in emerging technologies such as offshore wind, but also imports of decarbonised energy from competitive sources are considered as a viable option.
	National Trends	**Approach:** Scenario in line with national energy and climate policies (NECPs, national long-term strategies, hydrogen strategies, etc.) derived from the European targets. **Focus:** The electricity and gas datasets for this scenario are based on figures collected from the TSOs translating the latest policy- and market-driven developments as discussed at national level. The quantification of National Trends focuses on electricity and gas up to 2040. ENTSOG and ENTSO-E invite stakeholders to refer to the national documents to have a more energy-wide perspective. **Demand and supply:**
THEMA (2022) Market Outlook Nordics	**Best Guess**	**Approach:** Ambitious EU-wide climate targets in line with the European Green Deal and the recently published fit-for-55 package are achieved. **Focus:** Identify most likely market developments based on expected policies, market integration, technology developments, fuel and CO_2 prices, etc. **Demand and supply:** A push towards long-term decarbonisation leads to a steep increase in the RES share, achieved through a mixture of subsidies and market-driven investments. Countries become increasingly interconnected and front collaboration through joint offshore projects. Over the forecast period, the CO_2 price increases in the long term. Electricity demand increases significantly, due to electrification of the transport, industry and heating sectors as well as new industries. Hydrogen takes a crucial role in the power system of the future as a new source of electricity demand, flexibility, energy trade and power generation. To achieve net-zero emissions, further decarbonisation technologies, such as CCS coupled with bio energy or gas, are needed in the long term.
	Technotopia	**Approach:** Ambitious EU-wide climate targets in line with the European Green Deal and the recently published fit-for-55 package are achieved. **Focus:** Power market developments if the advancement of low-carbon technologies accelerates. **Demand and supply:** In this scenario, the LCOE of RES decreases faster than current expectations. These technological developments lead to more market-driven investment in RES. Hydrogen technologies for power-to-gas and gas-to-power applications become profitable earlier. The European CO2 is a less crucial driver for decarbonisation, since new cost-efficient solutions to reduce industrial GHG emissions are developed. Such technologies are expected to be available at a low cost throughout the world.
	Turbulent Transition	**Approach:** Ambitious EU-wide climate targets in line with the European Green Deal and the recently published fit-for-55 package are achieved. **Focus:** The achievement of EU's ambitious climate targets turns out to be significantly more challenging than anticipated. **Demand and supply:** Obtaining the RES share that the EU Commission envisages is not feasible, as the build-out faces substantial obstacles. Energy collaboration across European nations is less prominent, leading to less interconnection capacity and hybrid offshore projects are not developed. The establishment of a European-wide hydrogen market is never realised, so that hydrogen never becomes a commodity similar to that of natural gas today. There is a larger need for negative emissions in industry and power.

2.2 Sammenstilling av scenarioer

Figuren under viser en skjematisk sammenstilling av scenarioene som er beskrevet i Tabell 1[1] med utgangspunkt i ambisjonsnivå for utslippskutt og hva som er de viktigste driverne:

- Den horisontale aksen beskriver ambisjonsnivået for utslippskutt, med økende ambisjoner fra venstre mot høyre.
- Den vertikale aksen beskriver i hvilken grad hoveddriveren er teknologiutvikling eller atferdsendringer og incentivregulering.

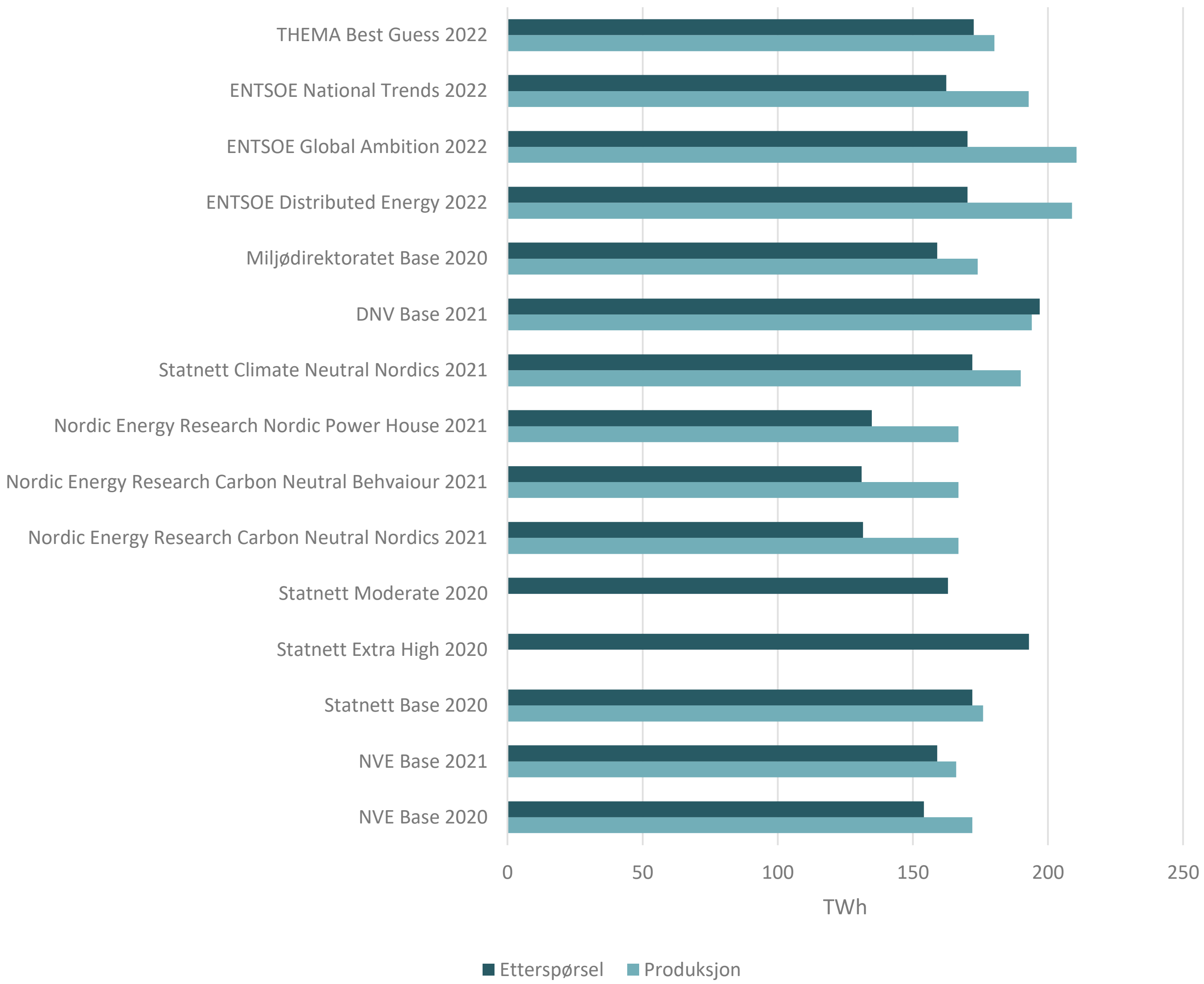


Figur 1: Skjematisk sammenligning av scenarioene. Størrelsen på boblene tilsvarer forventet kraftetterspørsel i Norge i 2030. Bobler i samme farge er ulike scenarioer fra samme kilde.

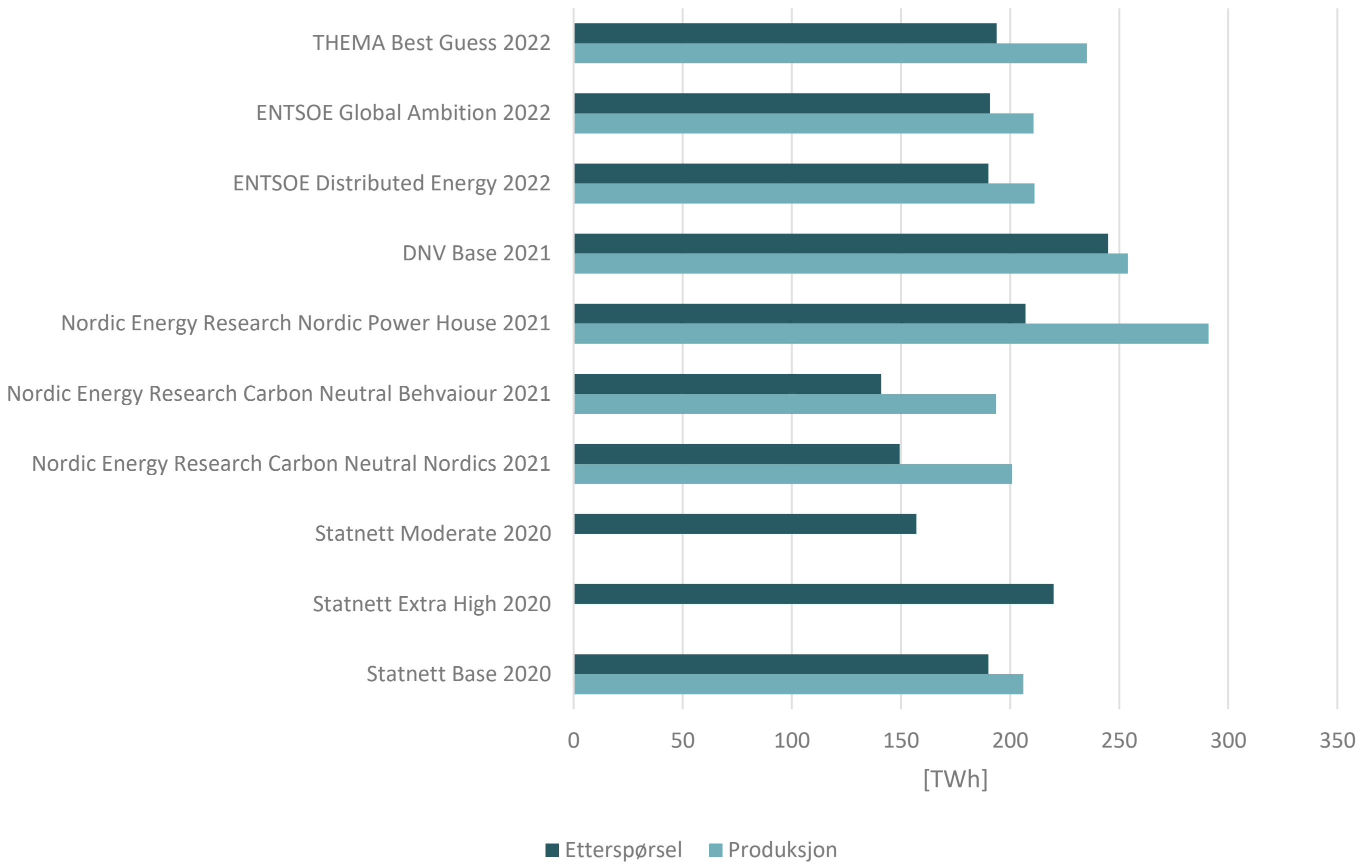
[1] Med unntak av rapporten «Klimakur 2030», Miljødirektoratet (2020) som ikke inneholder et scenario men isteden beskriver mulige tiltak

3 KRAFTBALANSE

3.1 Norge

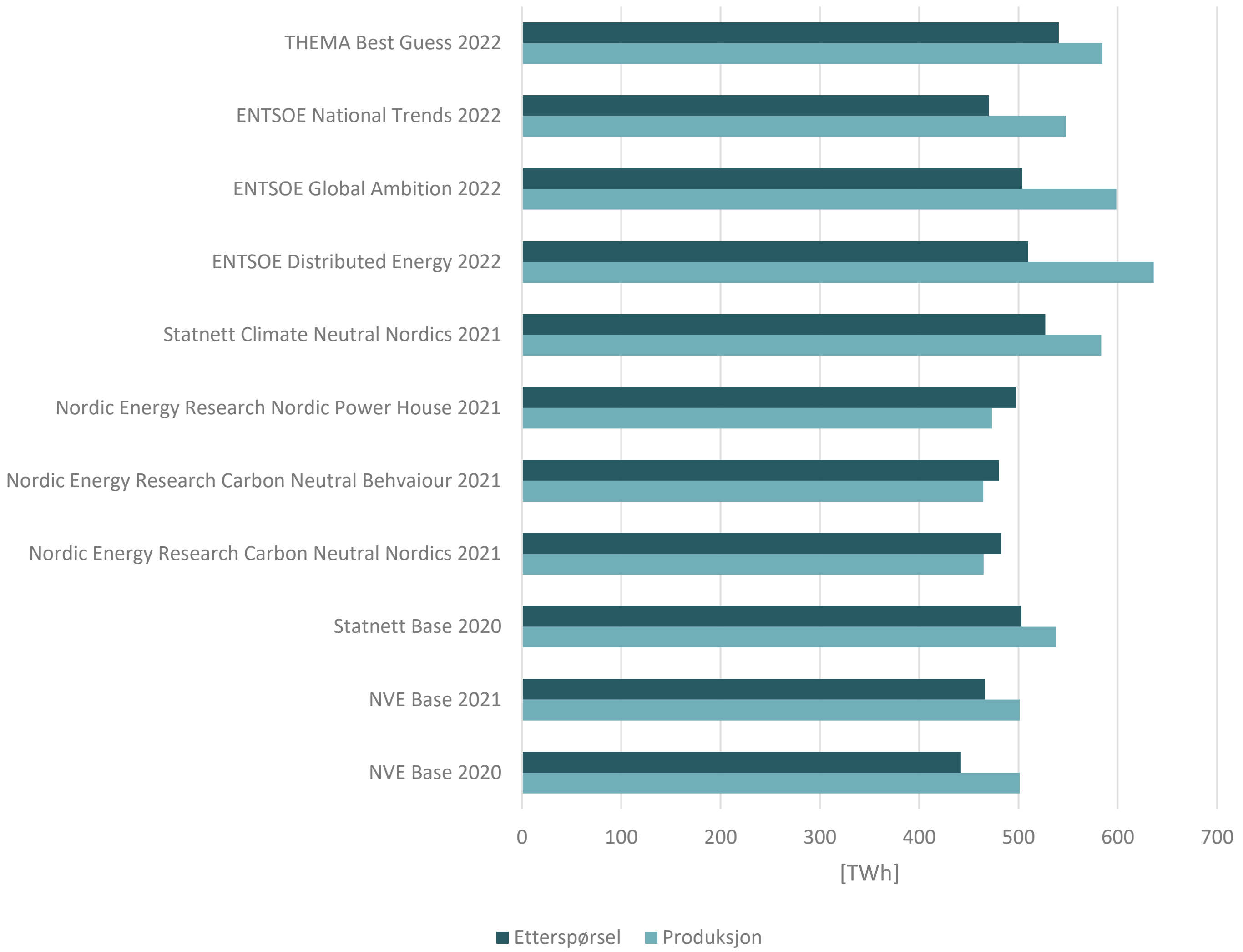


Figur 2: Sammenstilling av kraftbalansen i Norge i 2030

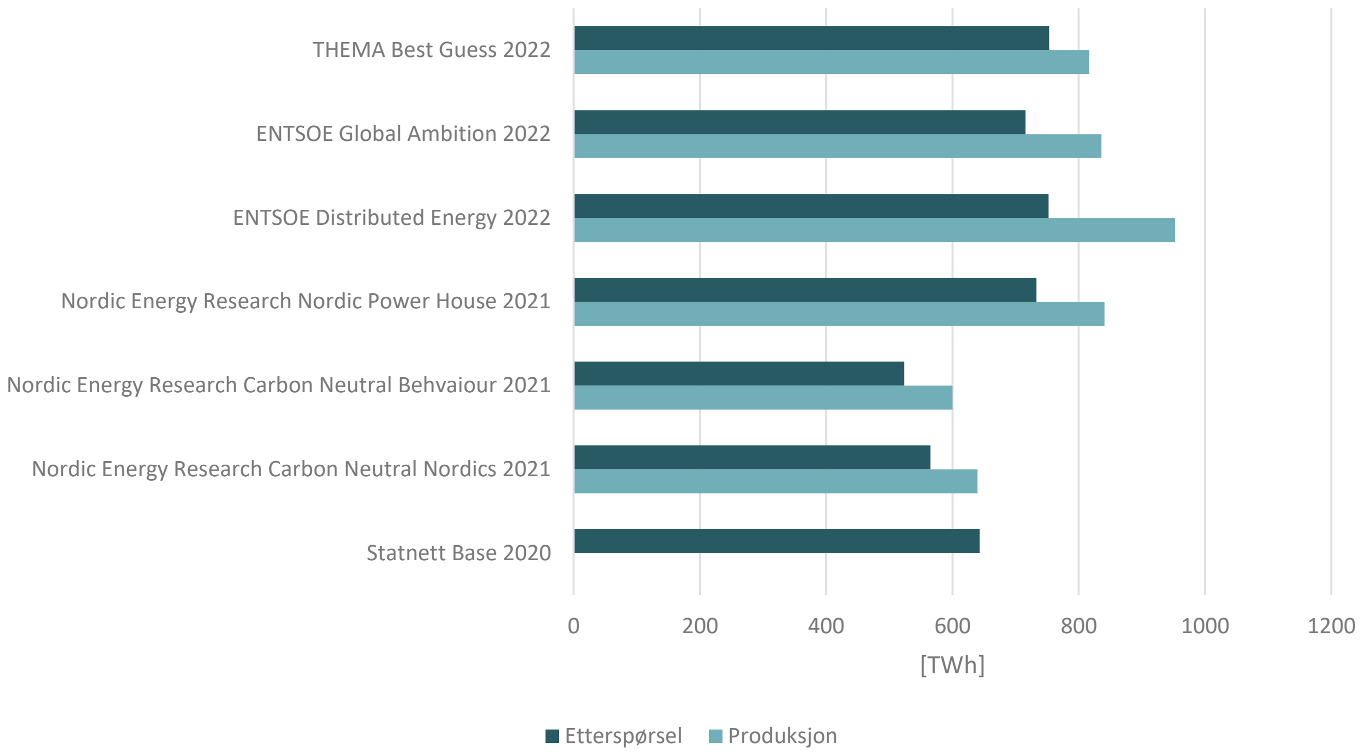


Figur 3: Sammenstilling av kraftbalansen i Norge i 2050

3.2 Norden



Figur 4: Sammenstilling av kraftbalansen i Norden i 2030

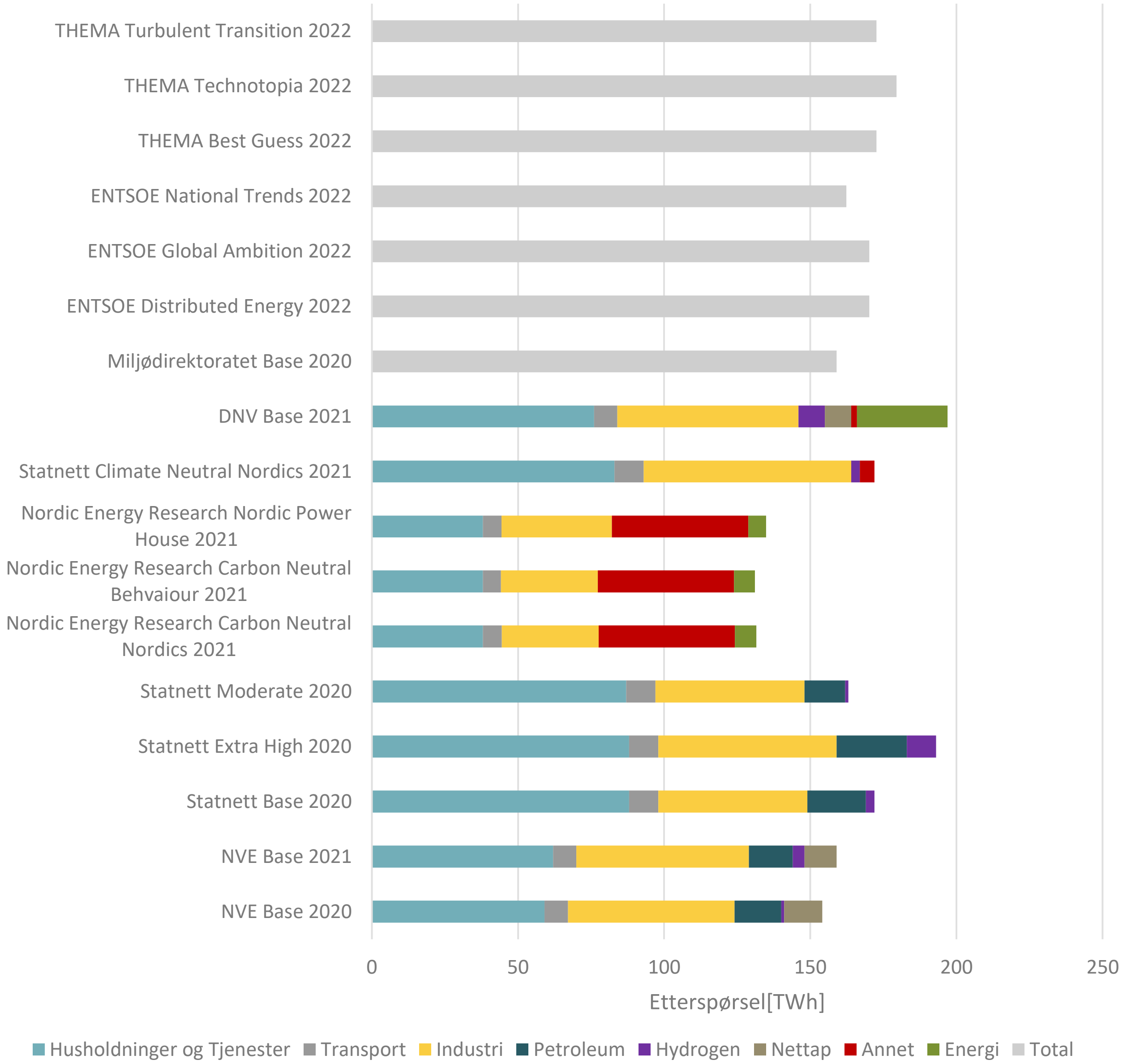


Figur 5: Sammenstilling av kraftbalansen i Norden i 2050

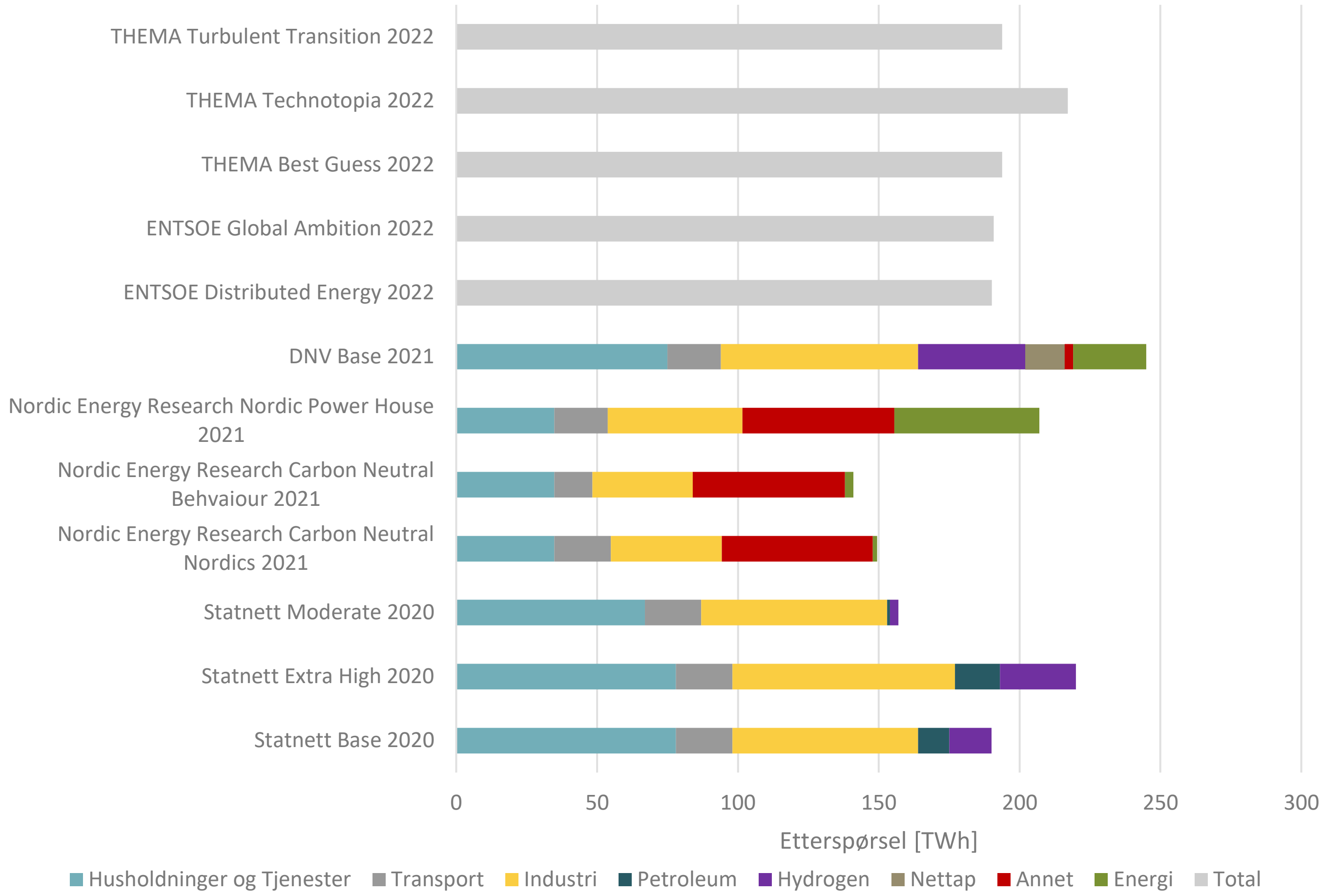
4 KRAFTETTERSPØRSEL

4.1 Norge

4.1.1 Etterspørsel pr. segment

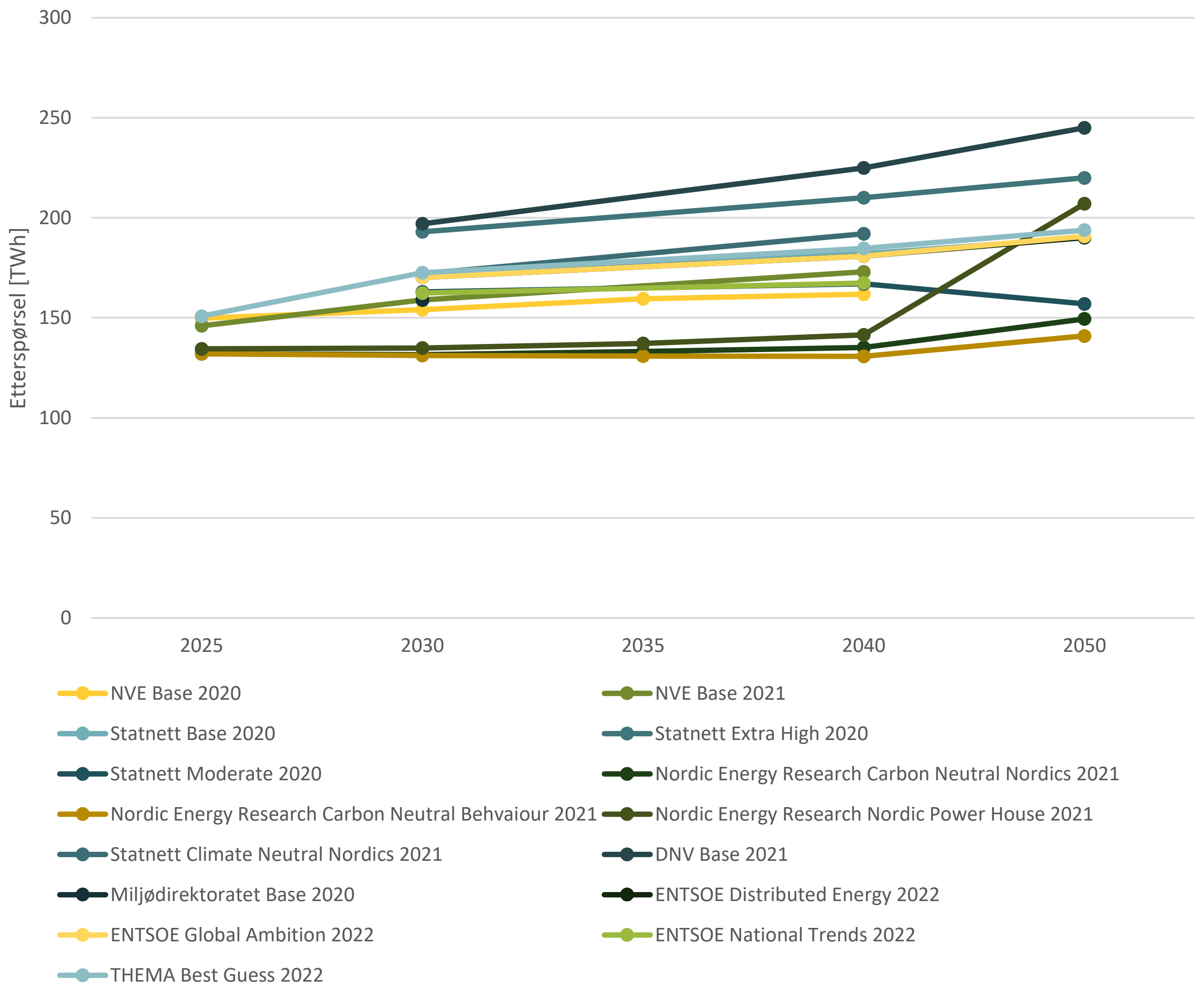


Figur 6: Sammenstilling av etterspørsel pr. segment i Norge i 2030



Figur 7: Sammenstilling av etterspørsel pr segment i Norge i 2050

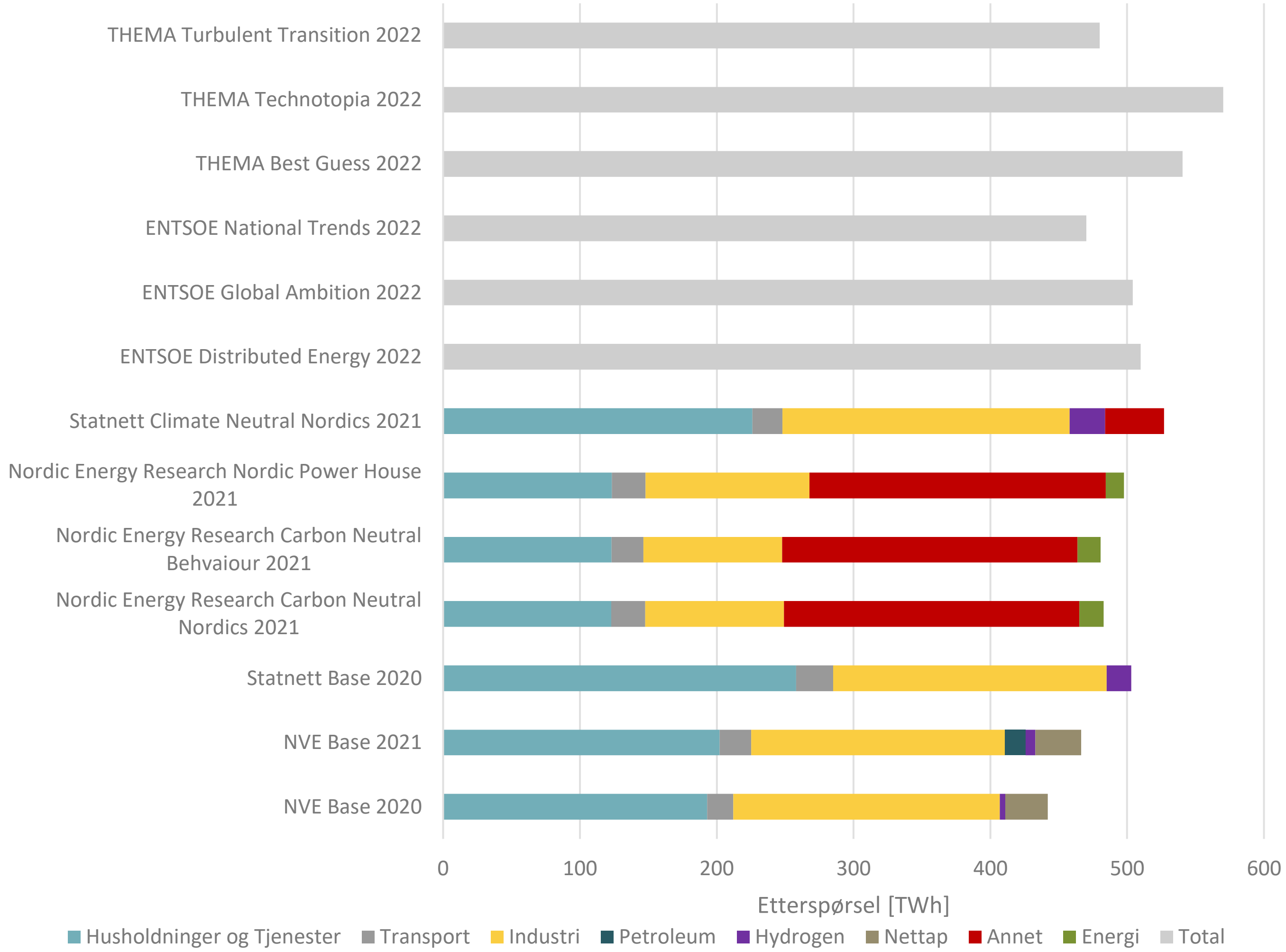
4.1.2 Etterspørsel pr. år



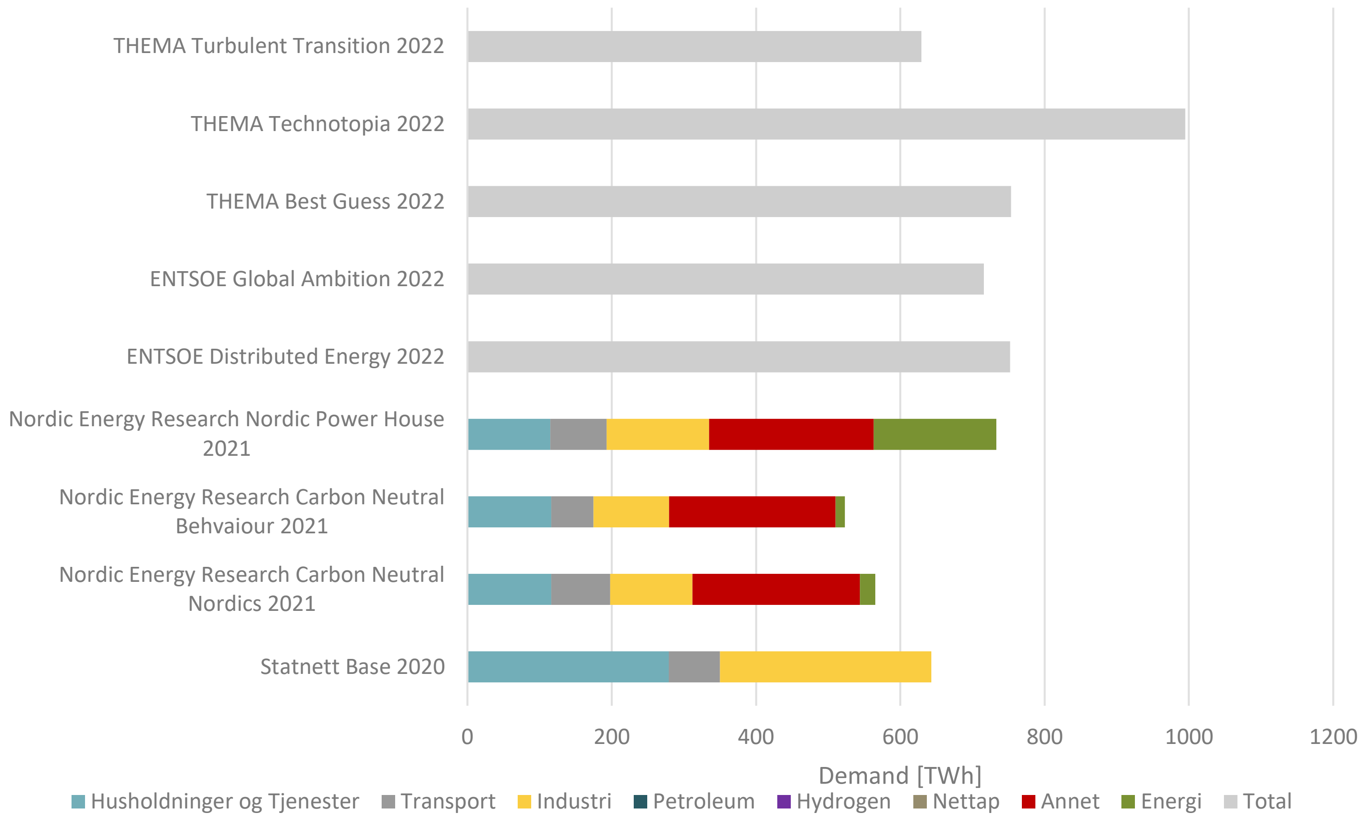
Figur 8: Sammenstilling av kraftetterspørselsutvikling i Norge, 2025–2050

4.2 Norden

4.2.1 Etterspørsel pr. segment

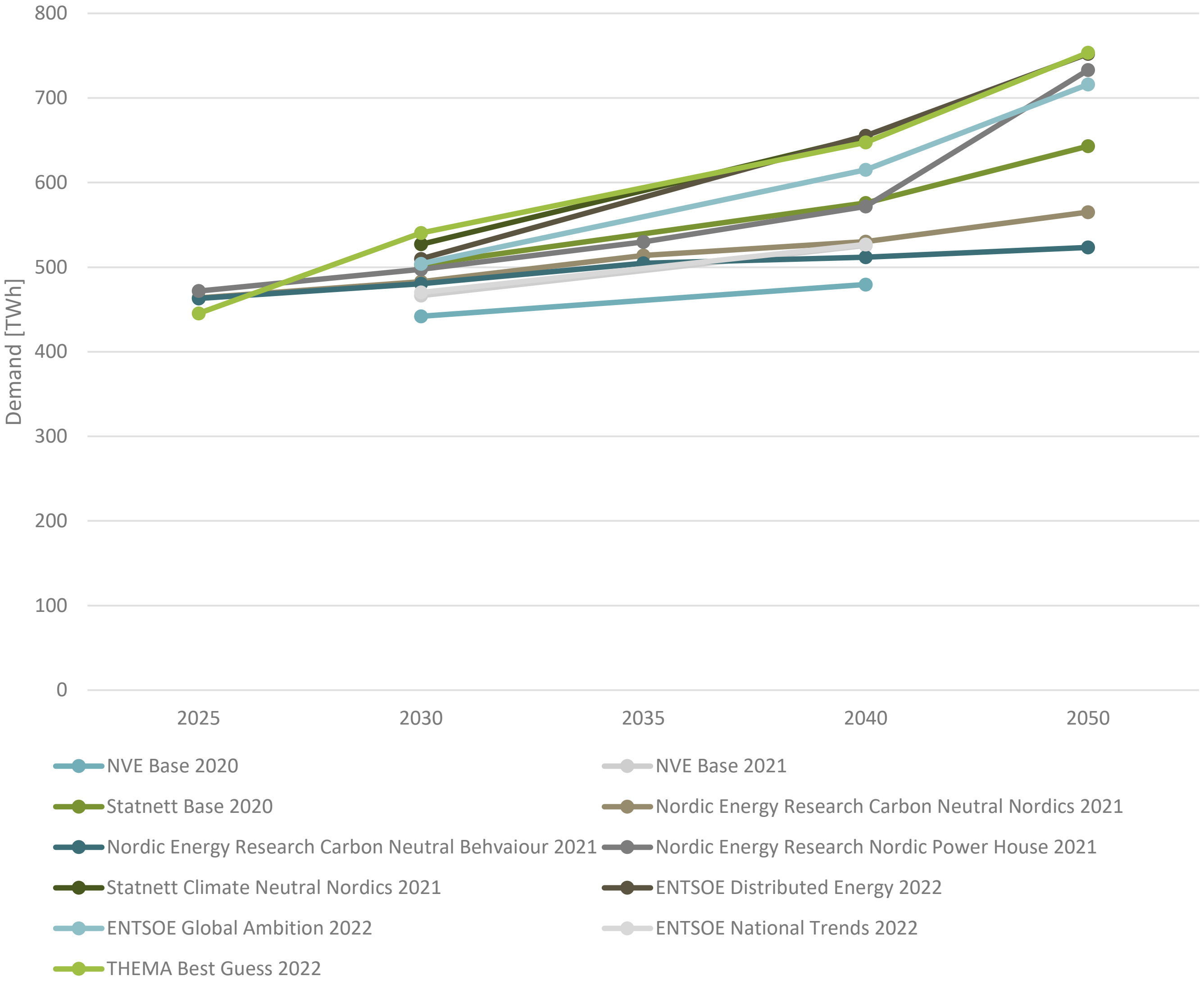


Figur 9: Sammenstilling av etterspørsel pr. segment i Norden i 2030



Figur 10: Sammenstilling av etterspørsel pr. segment i Norden i 2050

4.2.2 Etterspørsel pr. år

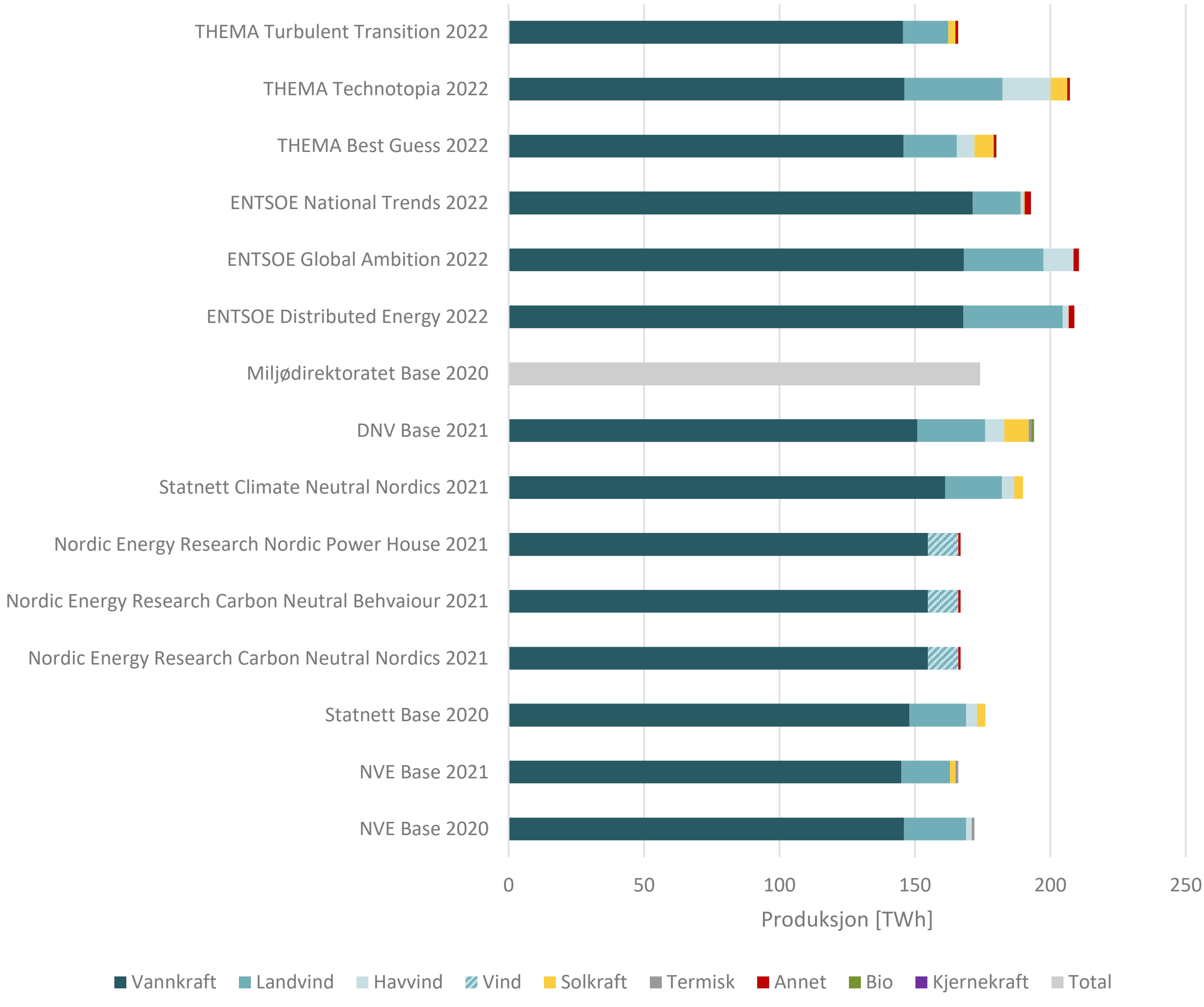


Figur 11: Sammenstilling av etterspørsel i Norden, 2025–2050

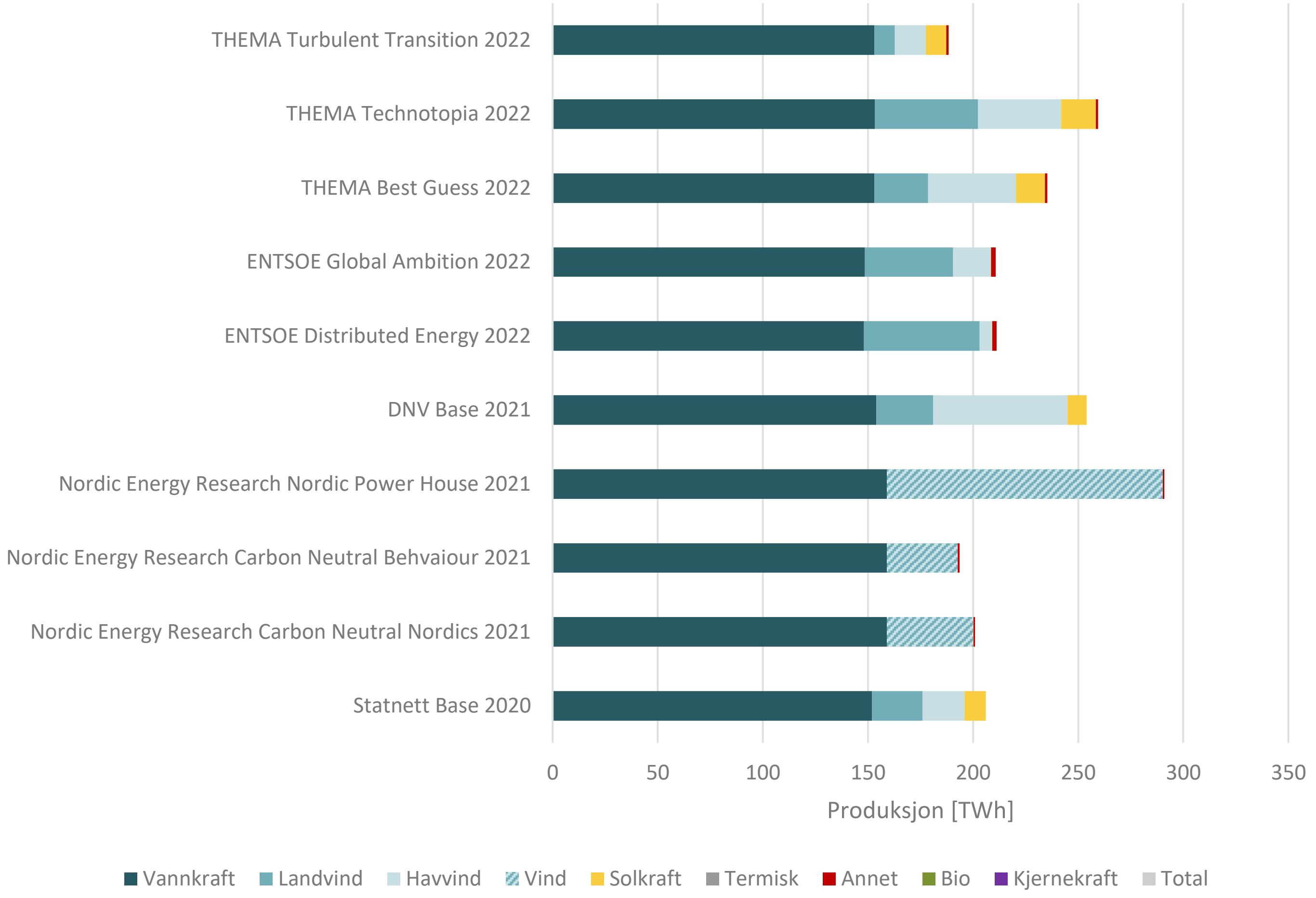
5 KRAFTPRODUKSJON

5.1 Norge

5.1.1 Produksjon pr. teknologi

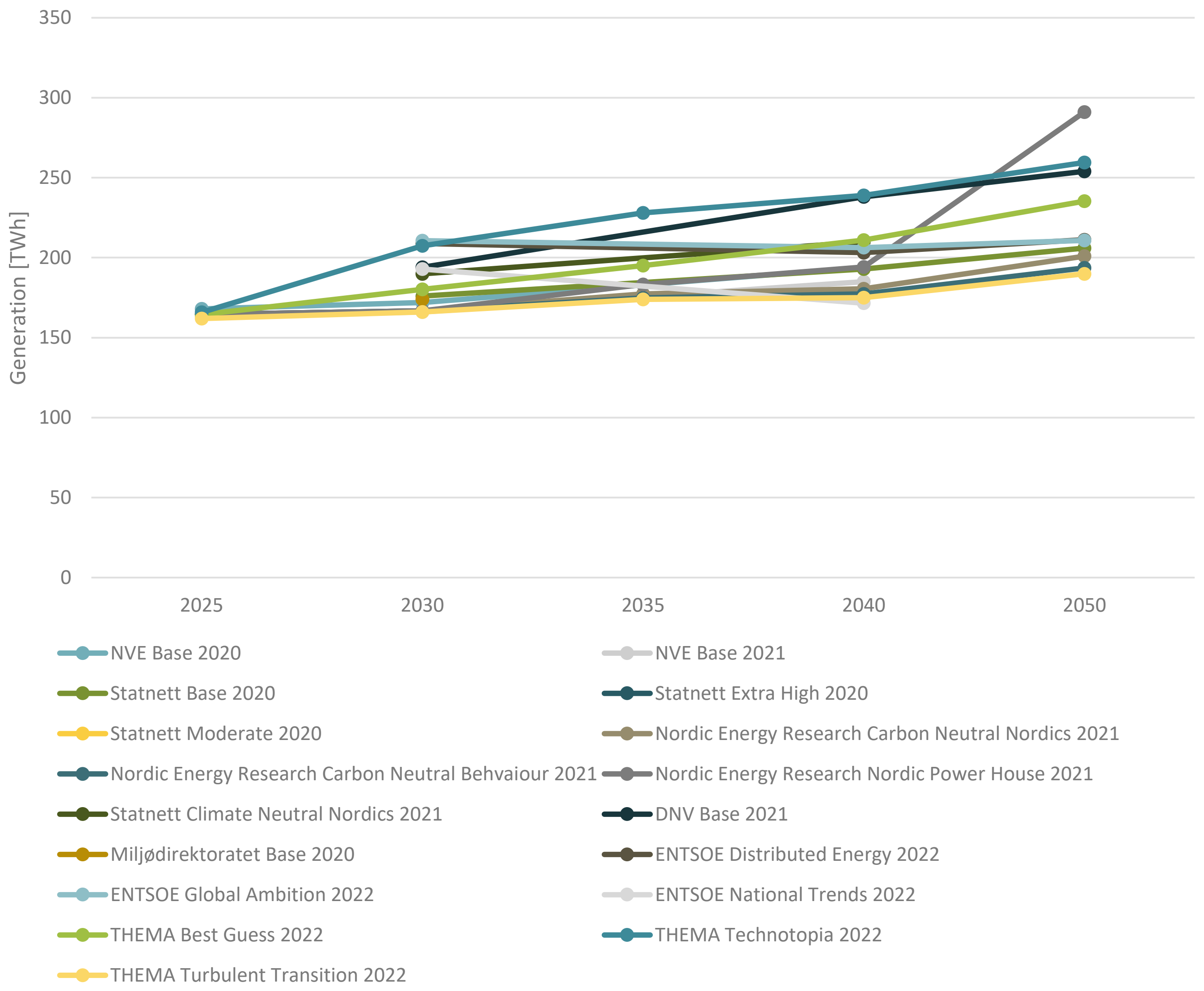


Figur 12: Sammenstilling av produksjon pr. teknologi i Norge i 2030



Figur 13: Sammenstilling av produksjon pr. teknologi i Norge i 2050

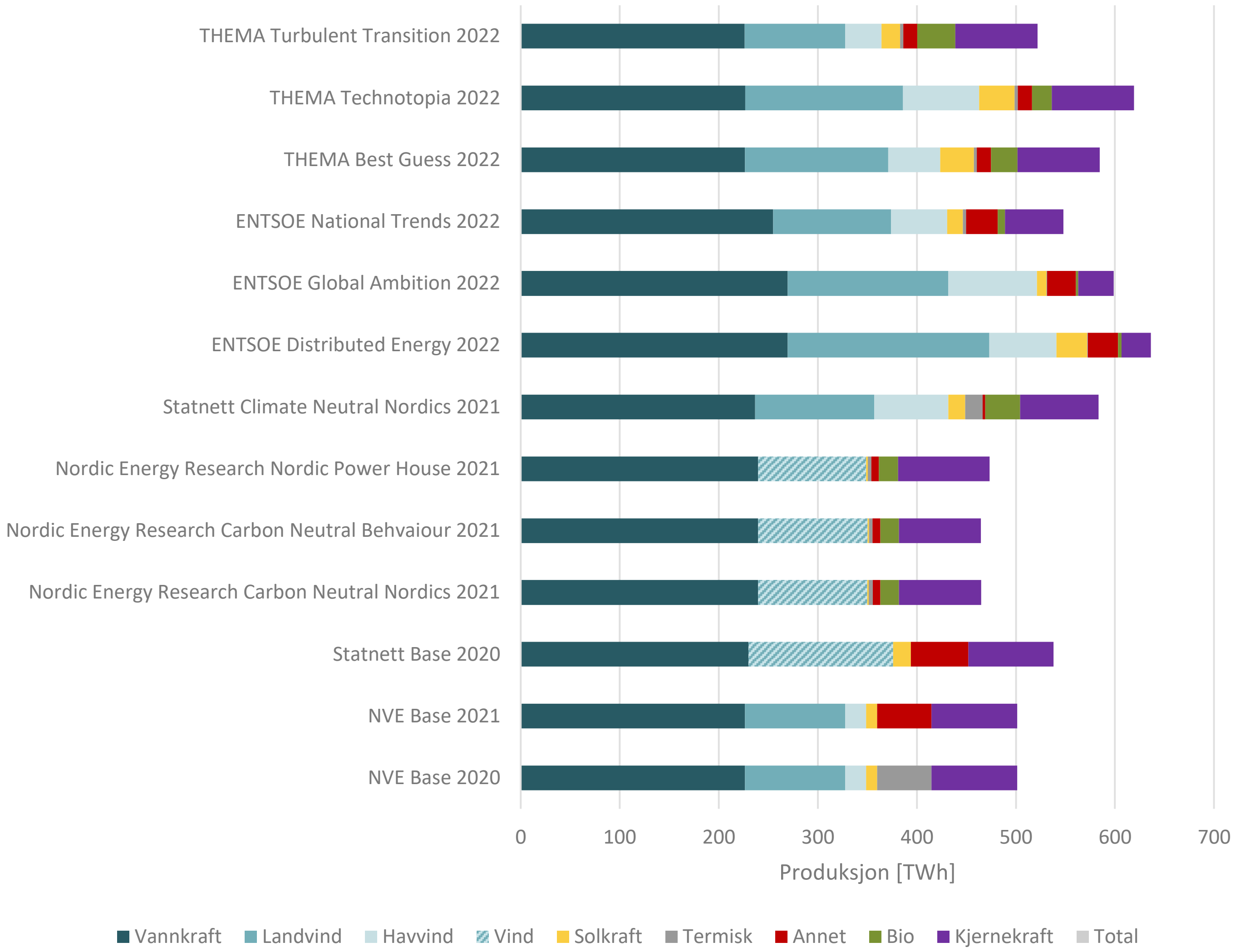
5.1.2 Produksjon pr år



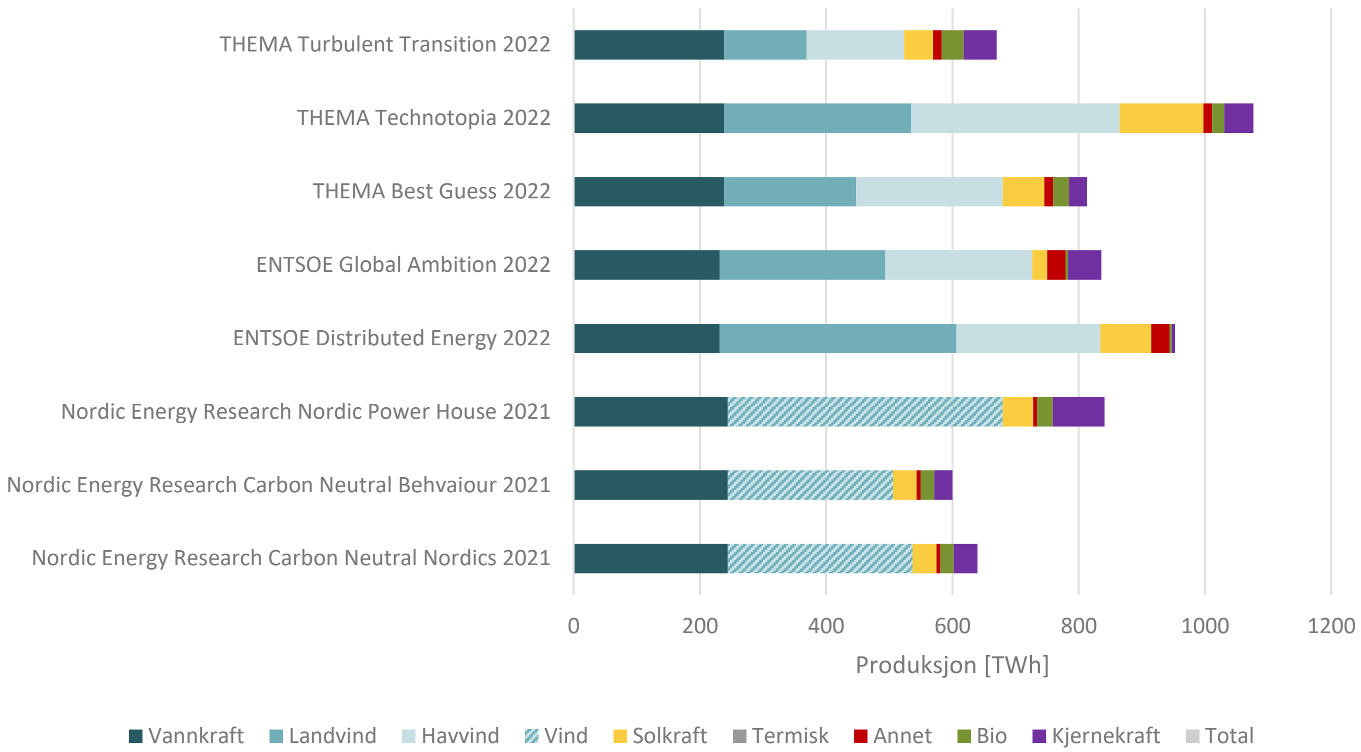
Figur 14: Sammenstilling av produksjon i Norge, 2025–2050

5.2 Norden

5.2.1 Produksjon pr. teknologi

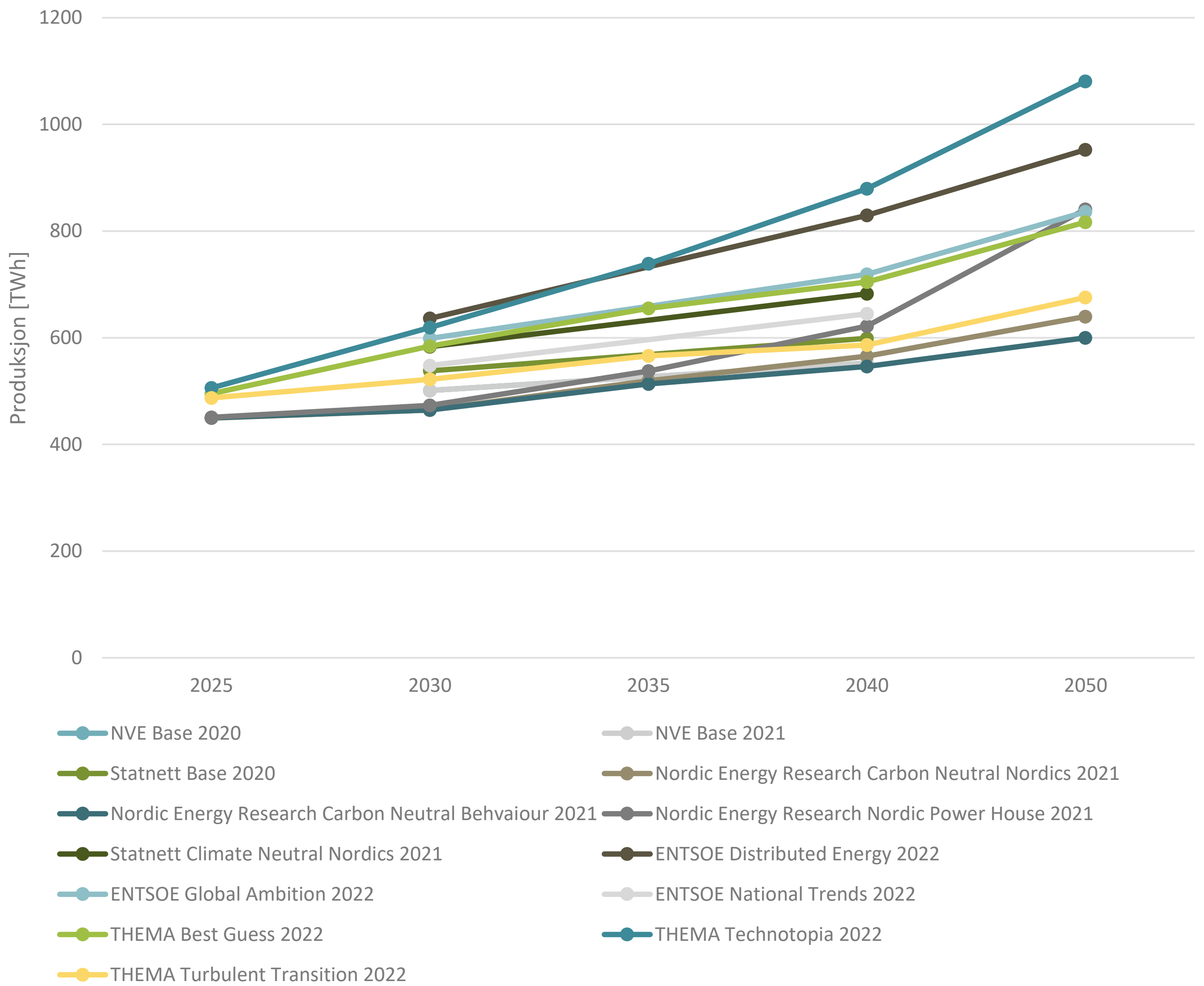


Figur 15: Sammenstilling av produksjon pr. teknologi i Norden i 2030



Figur 16: Sammenstilling av produksjon pr. teknologi i Norden i 2050

5.2.2 Produksjon pr. år



Figur 17: Sammenstilling av produksjon i Norden, 2025–2050

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THEMA Consulting Group

Øvre Vollgate 6

0158 Oslo, Norway

www.thema.no

Berlin-kontor

Albrechtstraße 22

10117 Berlin, Germany