The Role of Demand Response in the Future Renewable Northern European Energy System

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Background

- Significant benefits of Demand Response (DR):
  - Substituting peak power generation capacities and decreasing peak load
  - Increasing operating efficiency of transmission grids
  - Increasing the integration of high shares of VRE
  - Decreasing grid congestion
  - Providing ancillary services

- Demand response is used today to some extent, but mainly industrial consumers

Background

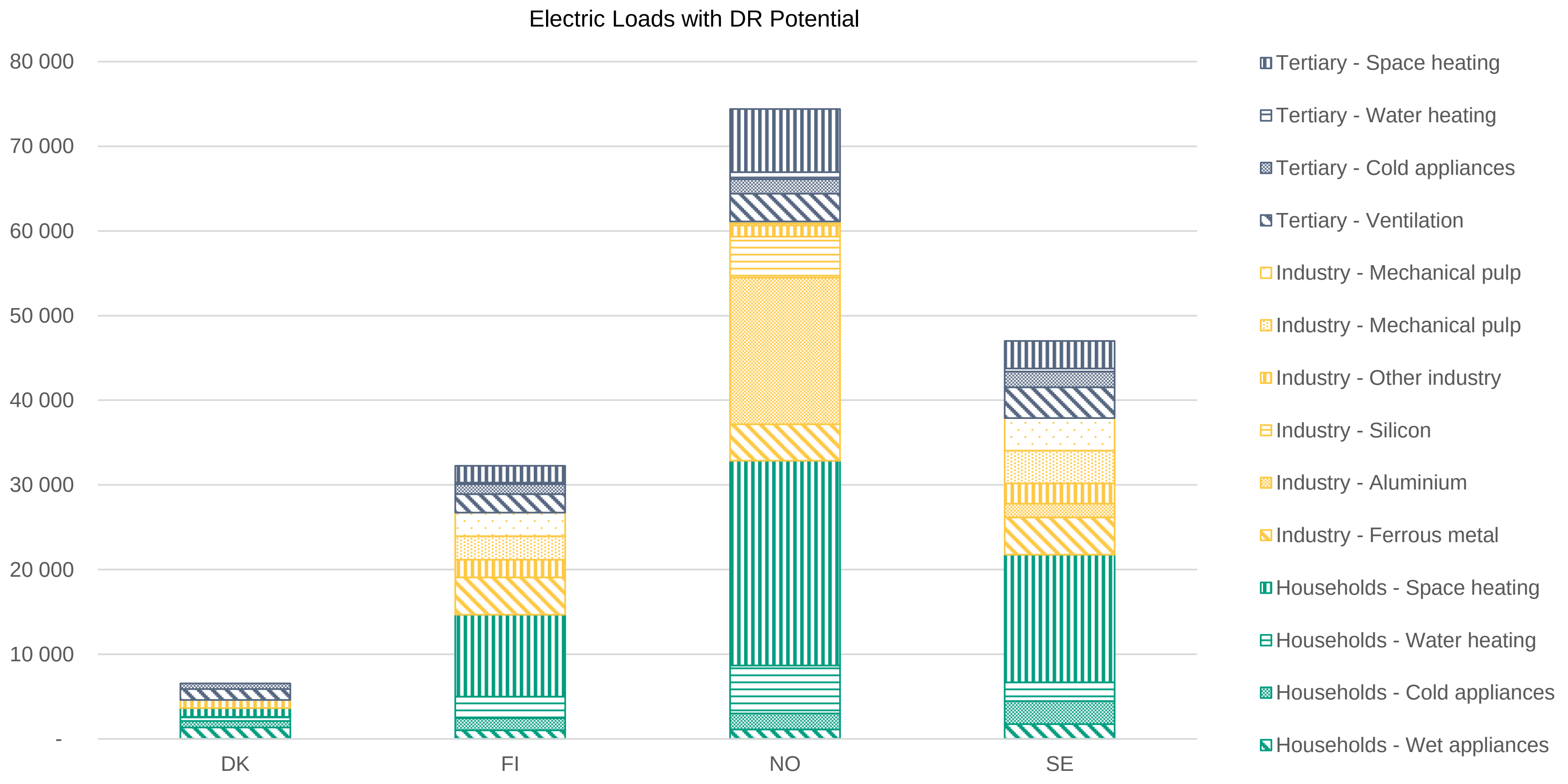
- Research on demand response has not commonly focused on:
  - Cross-country and cross-sectoral studies
  - Economic assessment
  - Parameterization of DR potentials in the Nordics

Objective

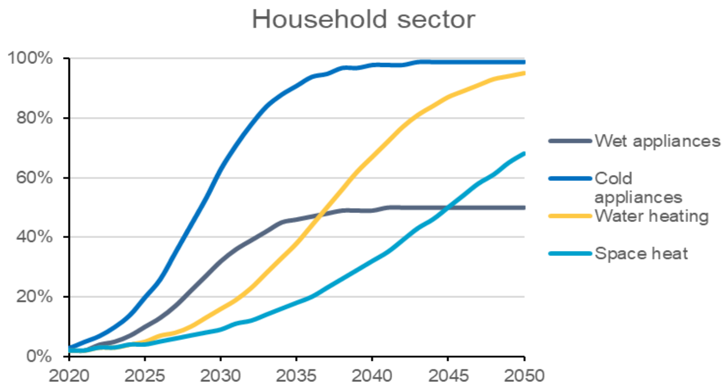
Quantify the economic potential of demand response and assess the impact of demand response for the Nordic region

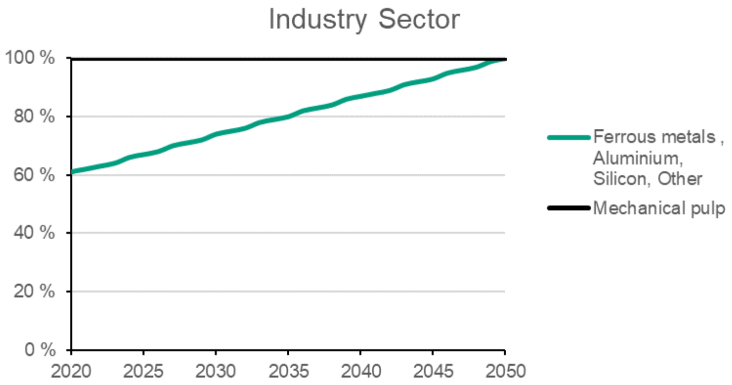
- Formulate demand response in the energy system model BALMOREL
- Assess the potential at a detail suitable to the energy system model
- Analyze results on loads shifted, generation, capacity investments and demand response revenues

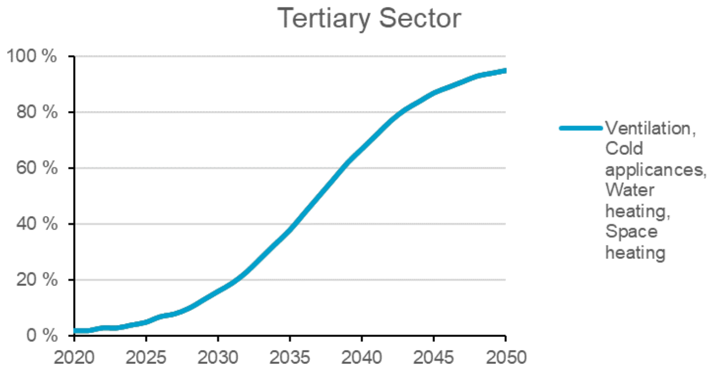
Assessing the potential of demand response in the Nordics



Adoption rates







Parameterization

Sector	DR Category	DR Type	Investment costs (€/MW)	Downshift cost (€/MWh)	Shifting time (h)	Storage (MWh/MW installed)
Industry	Aluminium	Shed		1000		
	Ferrous metal	Shed		2000		
	Silicon	Shed		200		
	Pulp and paper	Shed		200		
	Pulp and paper	Shift		10	2	
	Other	Shed		2000		
Households	Wet appliances	Shift	5000		4	
	Cold appliances	Shift	50000		1	
	Water heating	Shift	5000		6	
	Space heating	Shift	33 333			0.97
Tertiary	Ventilation	Shift			1	
	Cold appliances	Shift			1	
	Water heating	Shift			6	
	Space heating	Shift				0.97

Results

Impact of Demand Response Categories in 2030 and 2050

- Use of demand response increases towards 2050
- Demand reponse contribution is largest in households, especially in water- and space heating
- Role of industry decreases towards 2050

			Total downshifts (GWh)		Net downshift in peak hour (relative to peak load)	
Sector	DR Category	DR Type	2030	2050	2030	2050
Industry	Aluminium	Shed	4	-	0.2 %	0.0 %
	Silicon	Shed	2	2	0.2 %	0.0 %
	Pulp and paper	Shed	4	4	0.7 %	0.6 %
	Pulp and paper	Shift	123	92	1.3 %	0.8 %
	Other	Shed	0	-	0.0 %	0.0 %
Households	Wet appliances	Shift	864	899	0.5 %	0.8 %
	Cold appliances	Shift	312	136	0.1 %	0.0 %
	Water heating	Shift	1 099	4 048	0.4 %	4.5 %
	Space heating	Shift	1 327	5 706	1.3 %	7.0 %
Tertiary	Ventilation	Shift	183	954	0.3 %	0.7 %
	Cold appliances	Shift	89	529	0.1 %	0.1 %
	Water heating	Shift	120	653	0.1 %	0.2 %
	Space heating	Shift	910	3 925	0.4 %	3.9 %
Total			5 036	16 949	5.3 %	18.6 %

Power generation

- Not clear that demand response supports variable renewable energy
- Baseload generation increases with demand response
- Demand response is not seen to help reduce fossil fuels

POWER GENERATION IN THE NORDIC COUNTRIES (GWH)

	2030		2050	
	DR	NODR	DR	NODR
Biogas	177	225	5 110	6 087
Biomass	32 625	33 100	29 641	30 259
Municipal Waste	8 092	8 093	9 662	9 662
Wind	112 200	117 471	161 135	158 152
Solar PV	762	762		
Hydro	228 680	228 680	228 680	228 680
Nuclear	71 981	69 530	15 138	14 830
Fossil Fuels	2 168	2 044		
Battery Storage				347

Investment in new generation capacity

- Lower investment into flexible backup generation
- No investment into Battery storage
- Higher onshore wind investment

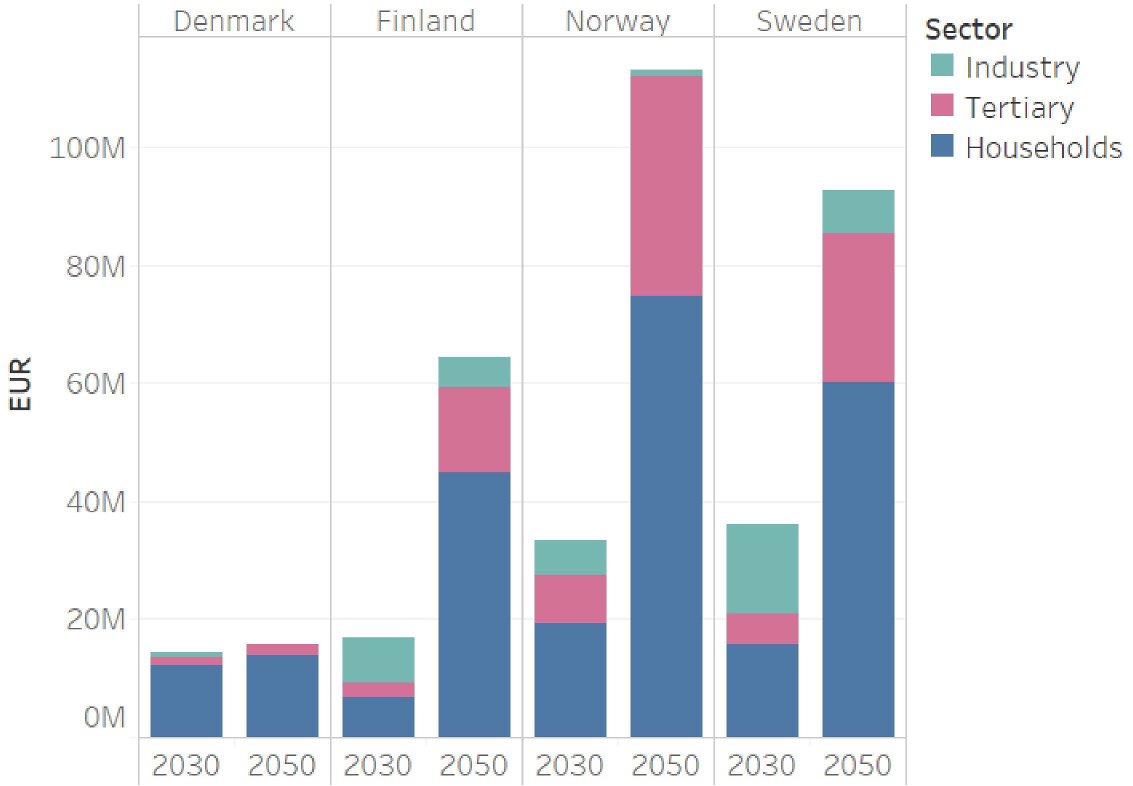
CAPACITY INVESTMENT IN THE NORDIC COUNTRIES BETWEEN 2030 AND 2050 (GWH)

	Scenario	
	DR	NODR
Battery storage	0	212
Gas turbine	0	367
ICE	3 916	5 002
Steam turbine subcritical	6 429	6 589
Offshore wind (far)	2 340	2 340
Offshore wind (near)	1 140	1 140
Onshore wind	44 836	44 099

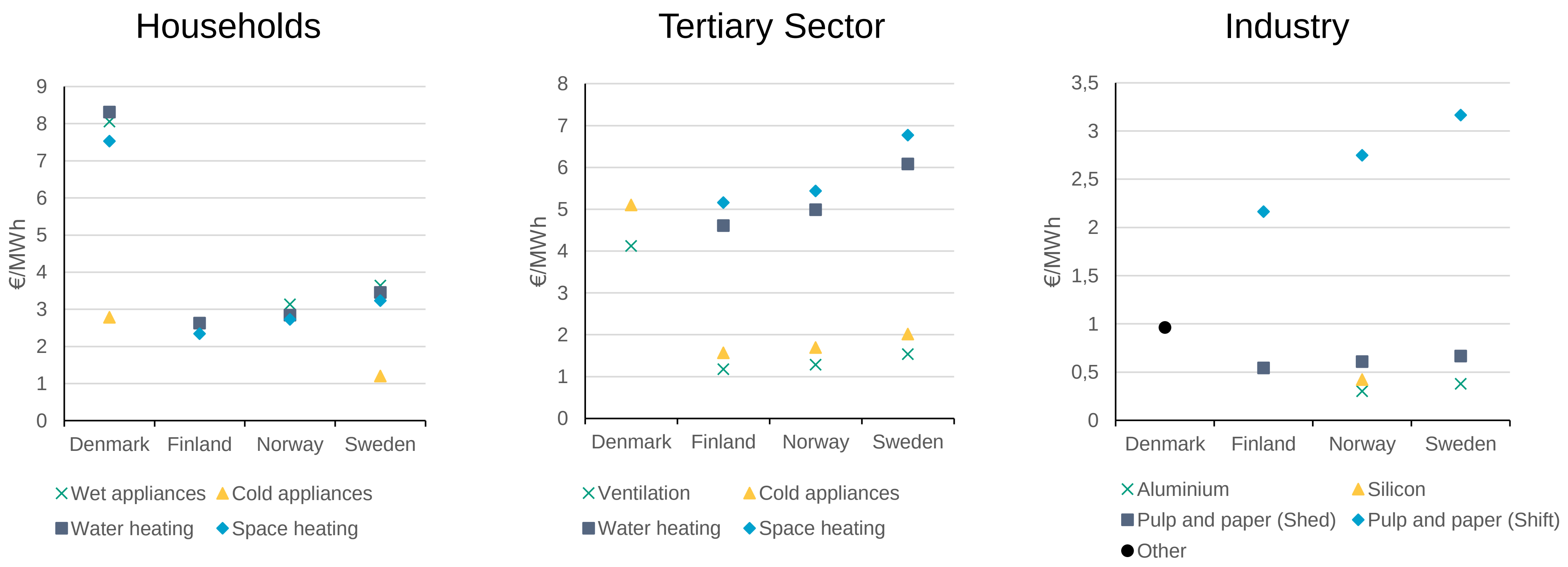
Demand response revenue

- Revenue in this study is defined as the arbitrage value of buying power in hours with lower power prices and selling in hours with higher prices

- Norway, Sweden and Finland profit from high demand response availability for space and water heating in households and tertiary sector



Revenues per unit (2030)



Conclusion

- Highest potential for demand response is in the household sector in the Nordics
- Largest potential for peak reductions comes from electric space and water heating
- Demand response generates the highest revenues in Norway, Sweden and Finland
- Denmark has the highest revenues per unit as the region is less flexible
- Demand response reduces the need for flexible back up generation
- Not clear that demand response supports renewables or decreases emissions

Thank you!