



Sustainable Energy
Systems 2050
NORDIC ENERGY RESEARCH PROGRAMME



norden

Nordic Energy Research

Nordic Energy Road Map 2050

Strategic Choices towards Carbon Neutrality (NORSTRAT)

SES Annual Conference 2013

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Outline of presentation

- **NORSTRAT project description**
- **Scenario description**
- **Power system analysis**
- **Large scale deployment of EVs**
- **Governance analysis**
- **Some preliminary conclusions**



Outline of presentation

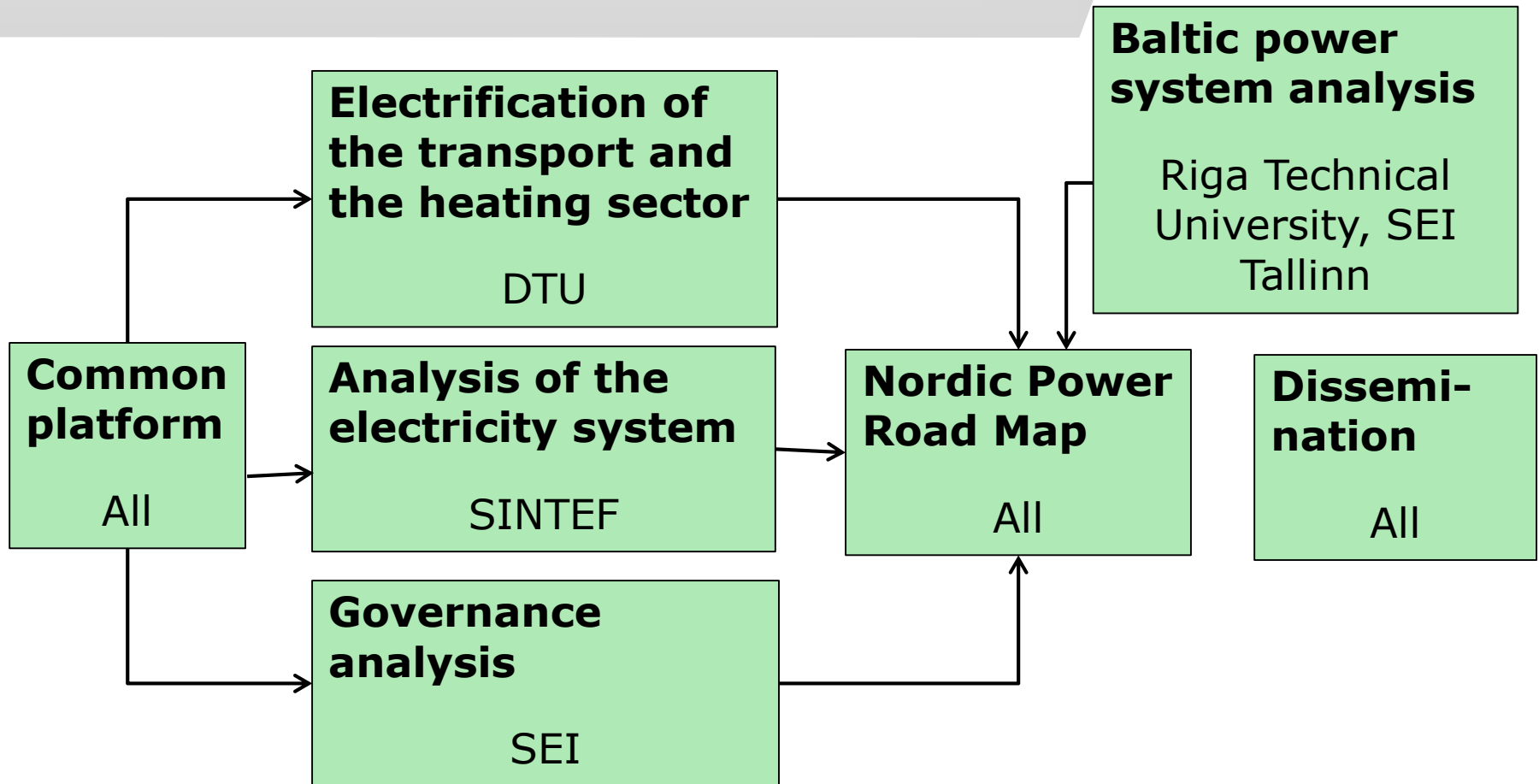
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NORSTRAT objectives

- **Objectives:** To build knowledge about possible carbon neutral futures for an integrated Nordic power system in a time perspective up to 2050 based on qualitative scenario analysis of impacts on the electricity, the transport and partly the heating system combined with the necessary governance aspects to enable the transformation.
- **Partners:** SINTEF Energi, Stockholm Environment Institute (SEI), Technical University Denmark (DTU)
- **Related Baltic project:** Similar project for the Baltic region. Partners: Riga Technical University and Stockholm Environment Institute Tallinn.
- **Reference group:** Vattenfall, Fortum, Dong Energy, Svenska Kraftnät, Statnett, Fingrid, Energinet.dk, Danish Energy Association, Energy Norway, Enova, Vestas

NORSTRAT structure



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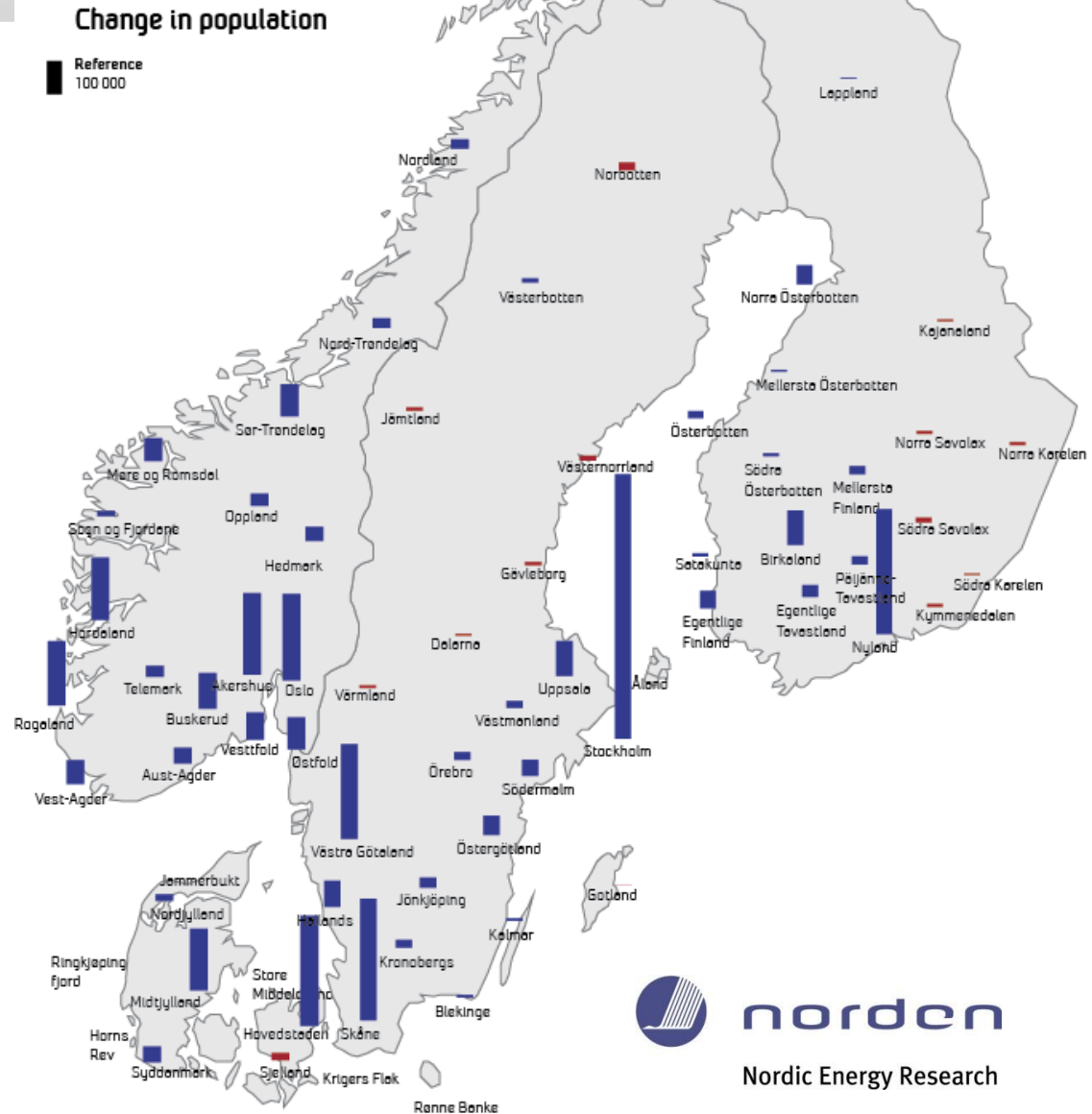


The Nordic power system 2010 (TWh)

Energy source	Denmark	Finland	Norway	Sweden	Sum
Wind power	8	0	1	4	13
Other renewable	3	10	0	12	25
Fossil fuels	26	31	5	8	70
Nuclear power	0	22	0	56	78
Hydropower	0	13	117	66	196
Non-identifiable	0	1	0	0	1
Production	37	77	123	145	382
Consumption	36	88	130	147	401



Demographic changes to 2050 (population growth)



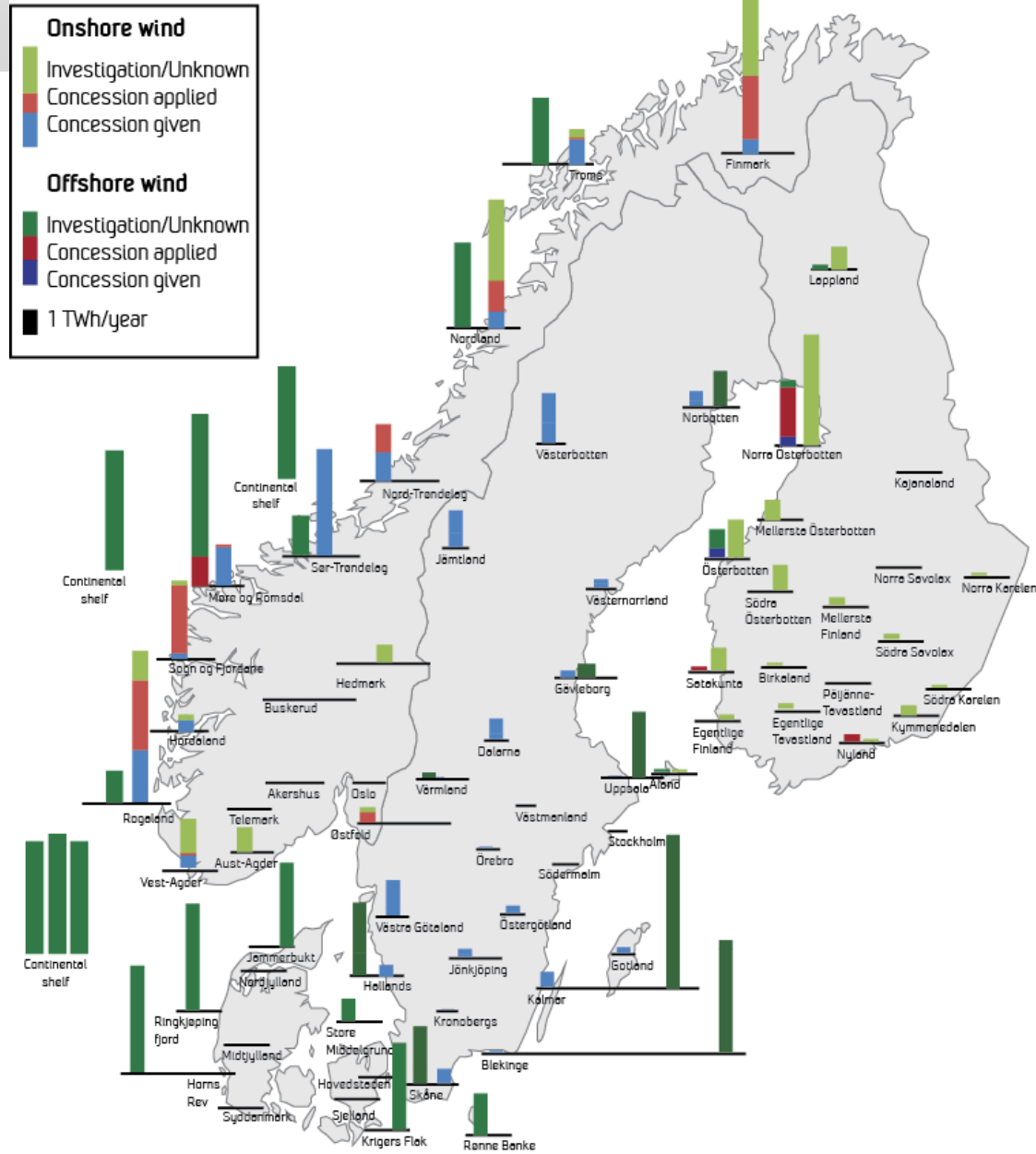
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Localization of new wind production



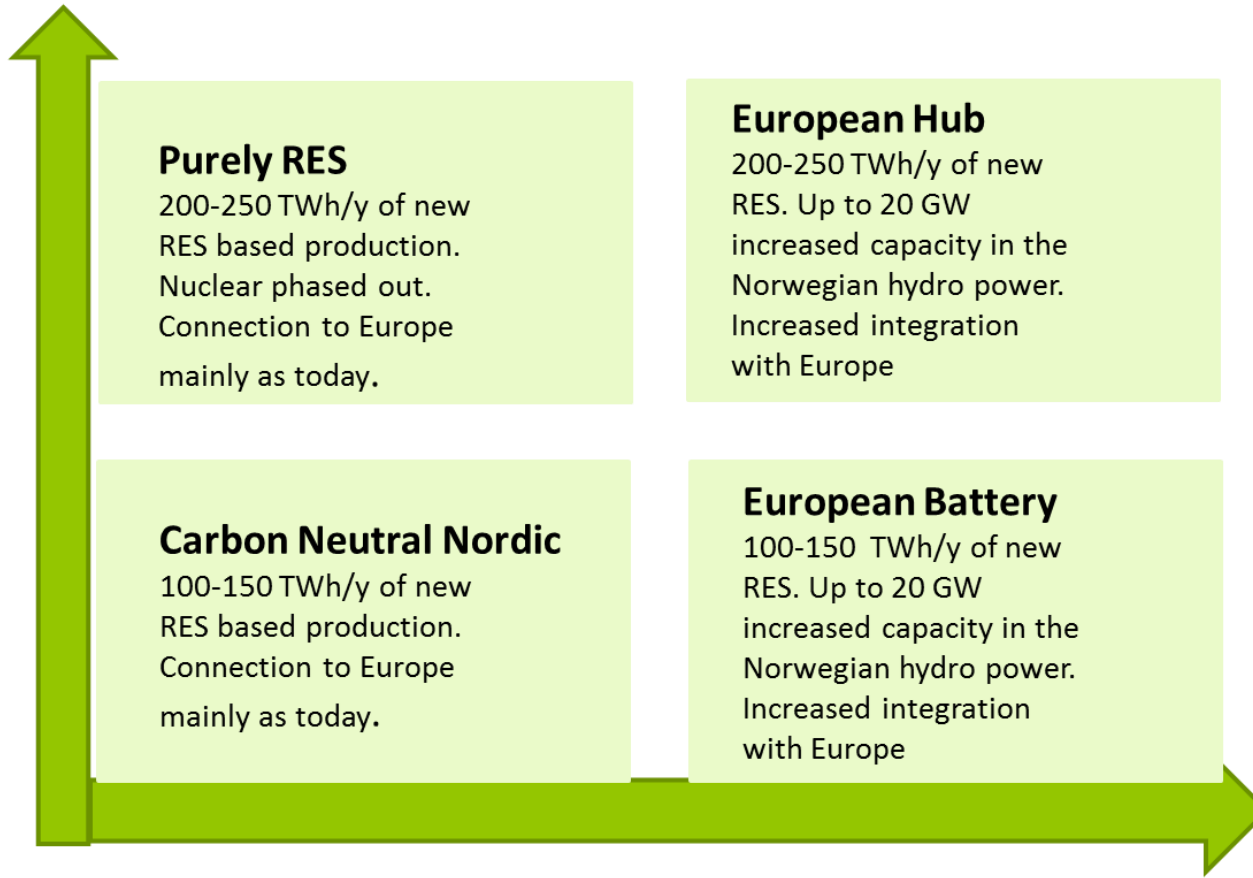
"Potential" for increased power production Nordic region

TWh/year	Onshore wind		Offshore wind		Bio		Hydro		PV		TOTAL
	2025	2050	2025	2050	2025	2050	2025	2050	2025	2050	
Denmark	0	0	18	50							68
Finland	6	6	0	8	13						33
Norway	15	10	10	40			10	20			105
Sweden	20	30	10	40	16					5	121
	41	46	38	138	29	0	10	20	0	5	
TOTAL	87		176		29		30		5		327



NORSTRAT scenarios

Volume of new RES in the Nordic region



RES – Renewable Energy Sources

Integration between the Nordic region and the rest of Europe

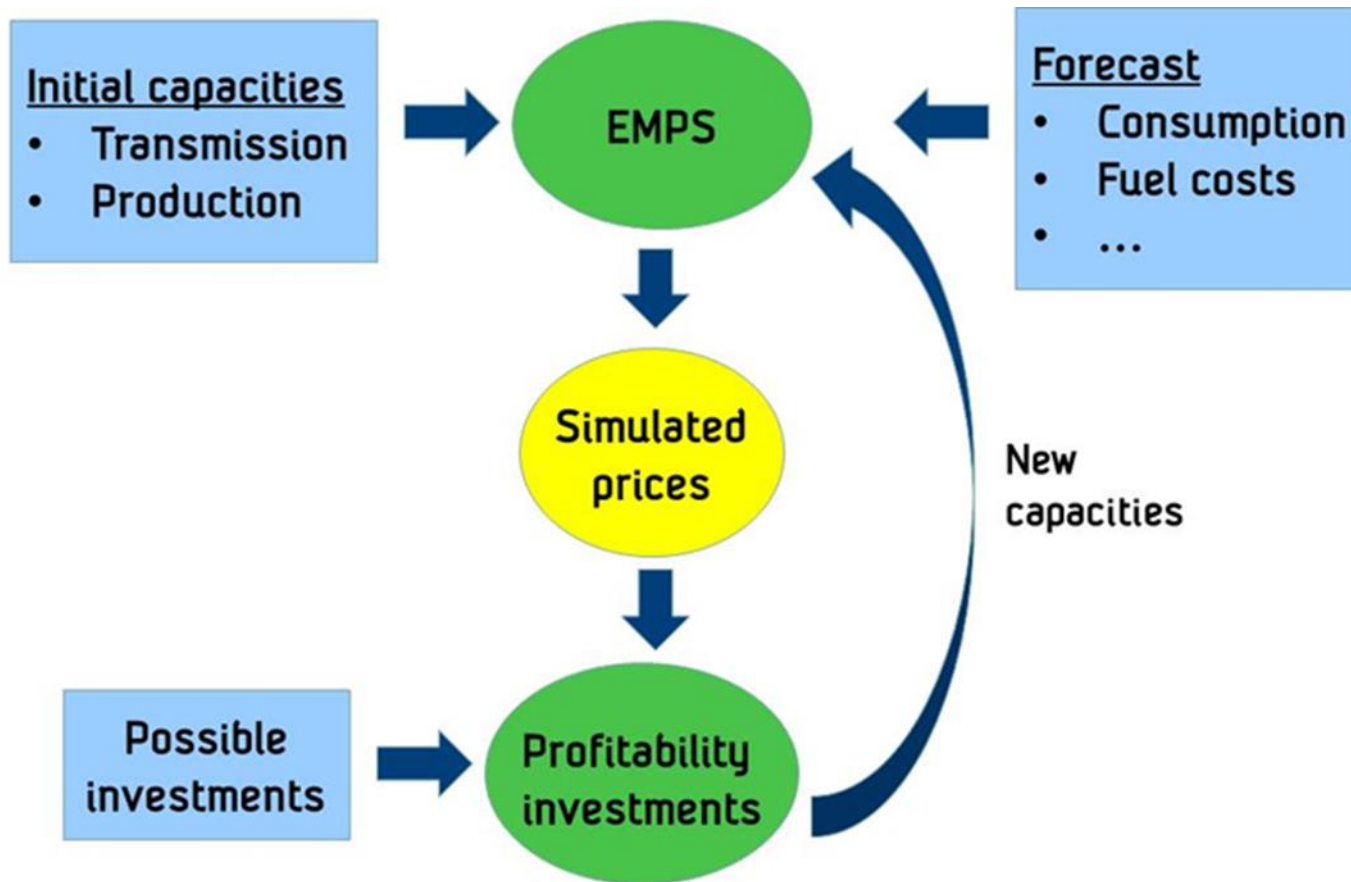


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Investment algorithm (for analysis of profitable increases in transmission capacities)



TSO data model for the Nordic region

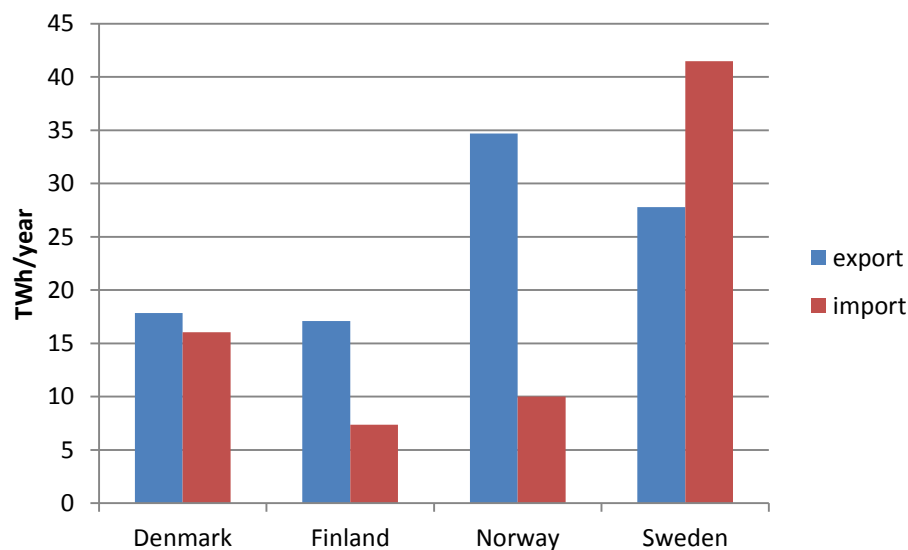
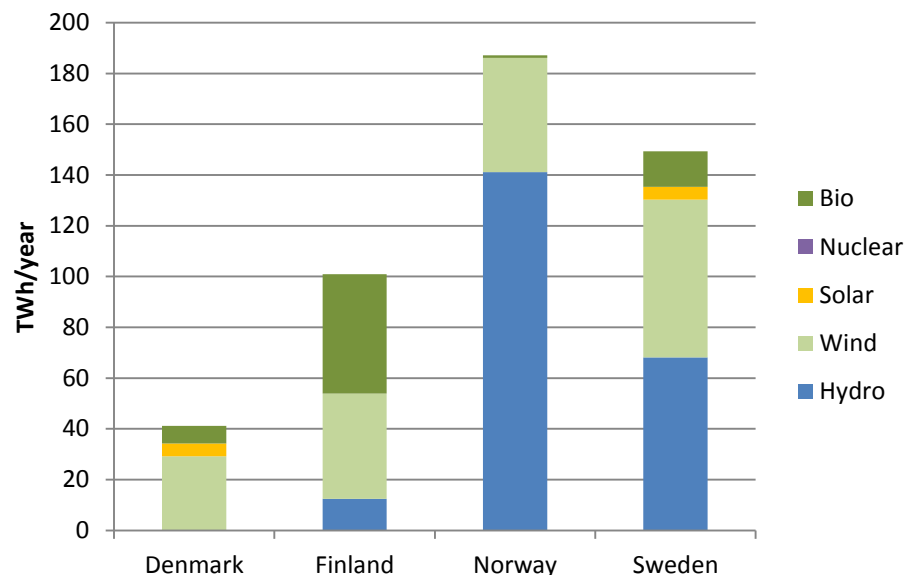




Purely RES 2050

(preliminary results)

FINNMARK	TROMS	150
FINNMARK	FIN-NORD	350
TROMS	SVER-SNO1	650
HELGELAND	SVER-SNO2	1200
MORE	NORDVEST	500
MORE	NORGEOST	1200
VESTSYD	JYLL-NORD	150
TELEMARK	NORGEOST	1400
NORGEOST	SVER-SNO3	50
SVER-SNO1	SVER-SNO2	650
SVER-SNO1	FIN-NORD	150
SVER-SNO2	SVER-SNO3	4250
SVER-SNO3	SVER-SNO4	800
SVER-SNO4	DANM-OST	400
FIN-NORD	FIN-SYD	50
HALLINGDAL-	SVER-SNO3	1350
SVER-SNO3	FIN-SYD	550
SVER-SNO3	JYLL-NORD	150
Total	MW	14000

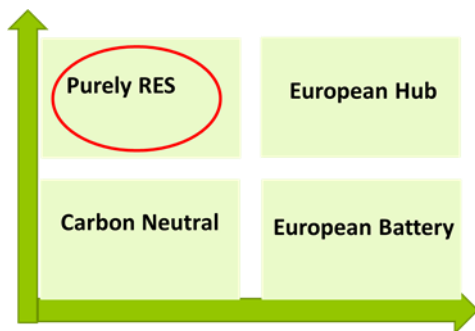
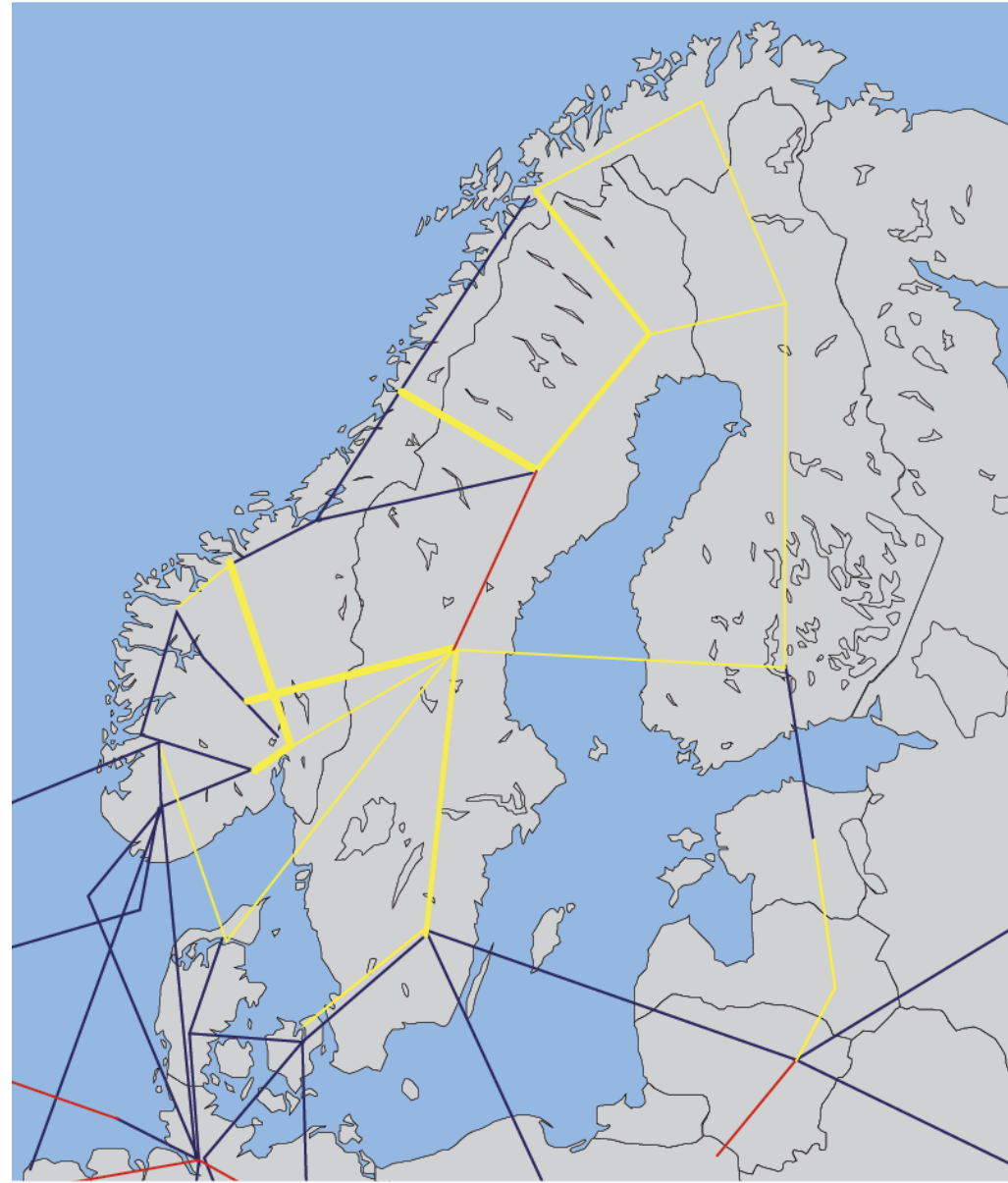


Purely RES 2050 Increases in transmission capacities (preliminary results)

Max Yellow line: 2000 MW

Red line are 10 times a yellow line

Blue line: no increase



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Demand Study on Large Scale Deployment of EVs in Nordic Region

- Study Scope:
 - Private Passenger Cars
- Energy Consumption Rate:
 - 150 Wh/km
- Driving Pattern:
 - Fulfill the Current Driving Requirement



Annual Electricity Consumption of EVs in Nordic Region

EV Penetration Level	Denmark East [GWh]	Denmark West [GWh]	Sweden [GWh]	Norway [GWh]	Finland [GWh]
100%	2650	1952	6565	5413	7634
70%	1855	1366	4596	3789	5344
50%	1325	986	3283	2707	3817



EV Charging Analysis in Nordic Region

- **Dumb Charging (All-Day)**
- **Dumb Charging (At Home)**
- **Timed Charging (Initiating After 21:00 When Parked)**
- **Spot Price Based Charging (All-Day)**
- **Spot Price Based Charging (At Home)**



Peak Electrical Charging Load of EVs in Nordic Region

[1phase-10A Charging]

[MWh/h]	Denmark	Sweden	Norway	Finland
Dumb Charging (All-Day)	1124	1398	1140	1397
Dumb Charging (At Home)	1220	1590	1127	1531
Timed Charging	3312	3904	3424	4133
Spot Price Based Charging (All-Day)	3442	4113	3665	4355
Spot Price Based Charging (At Home)	3434	4108	3510	4346

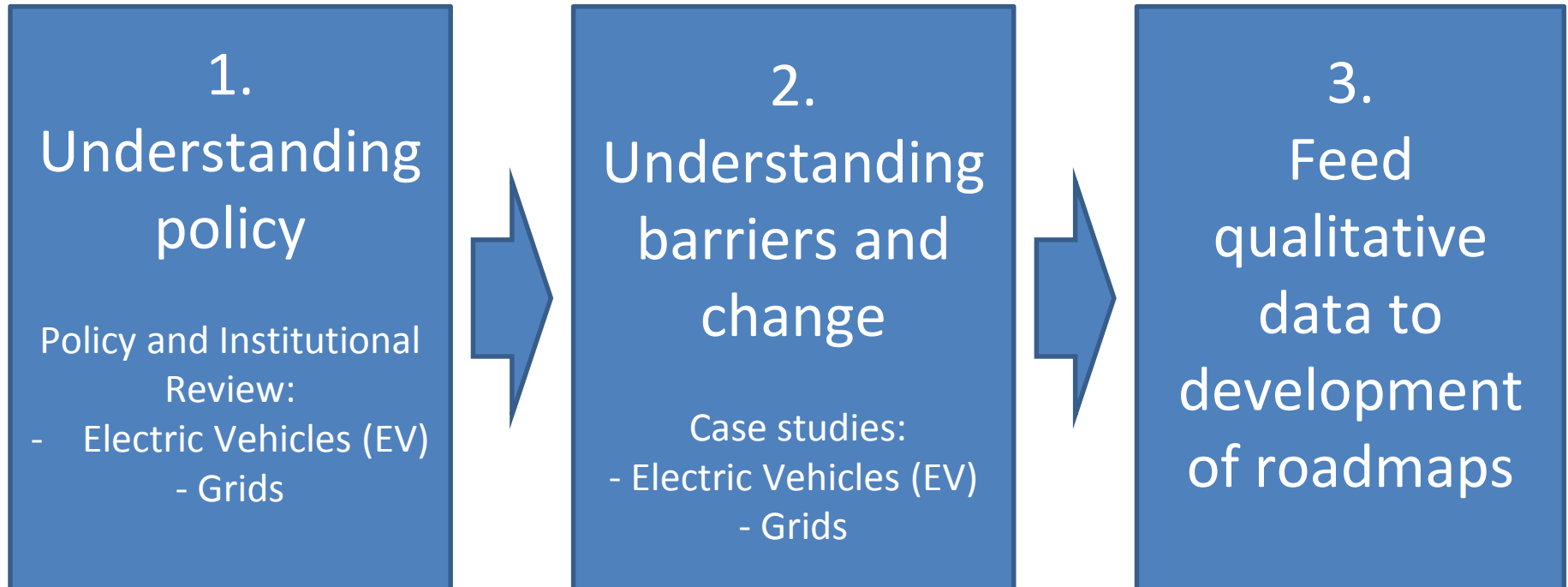


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Governance analysis



Preliminary conclusions

- **The Nordic region has renewable resources to develop a power production without CO2 emissions.**
- **The Nordic region also has RES to phase out nuclear in addition to fossil production, but huge volumes of new RES based production have to be deployed.**
- **The profitable increases in high voltage transmission capacities are “limited”**
- **Electrification of all private passenger cars in the Nordic regions increases the power demand per year with 25 TWh/y (150 Wh/km)**
- **The increases in peak load is 5-15 GW dependent on charging profile (1 phase – 10 A charging)**

