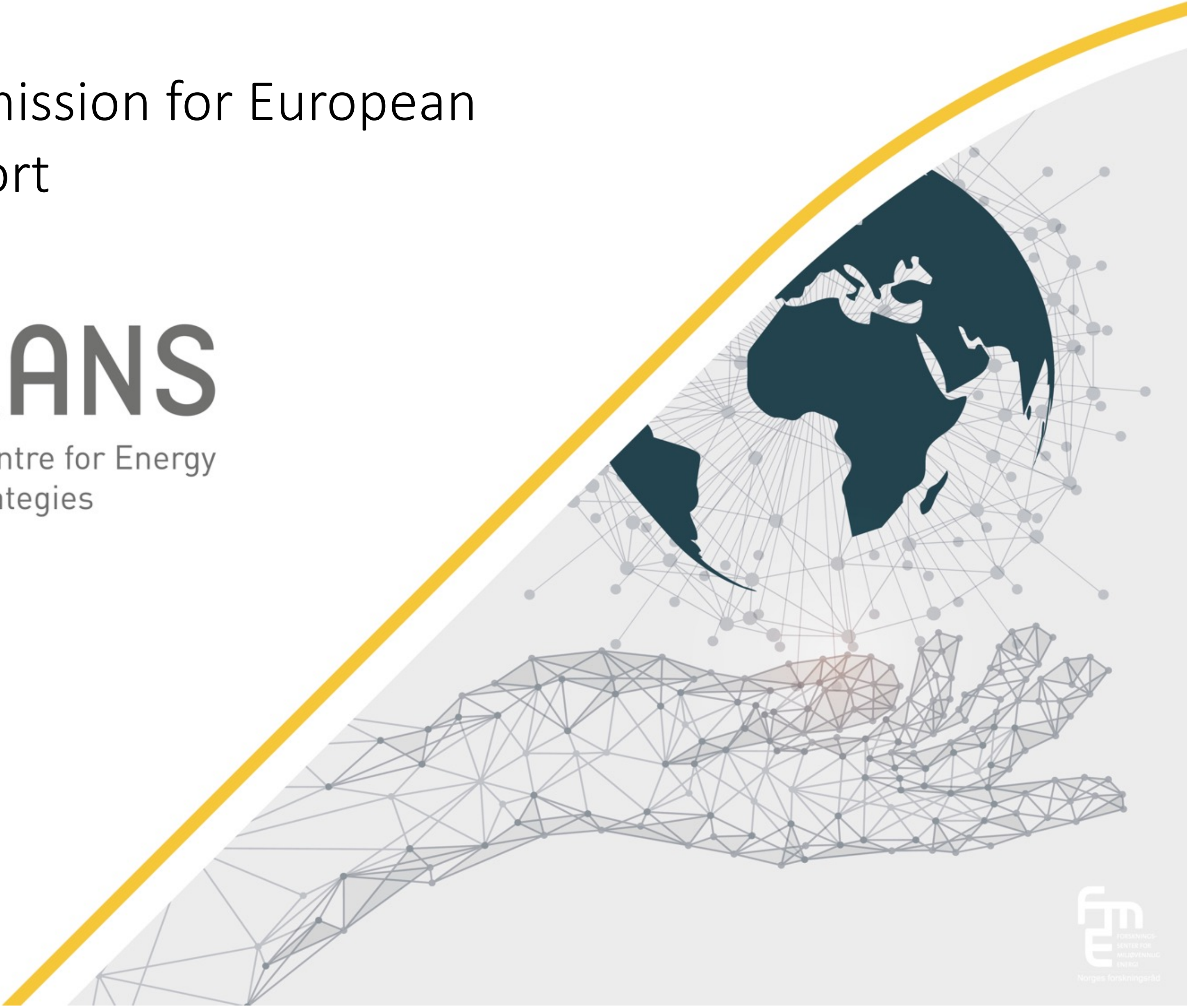
Transition to Zero Emission for European Industry and Transport

NTRANS

Norwegian Centre for Energy Transition Strategies



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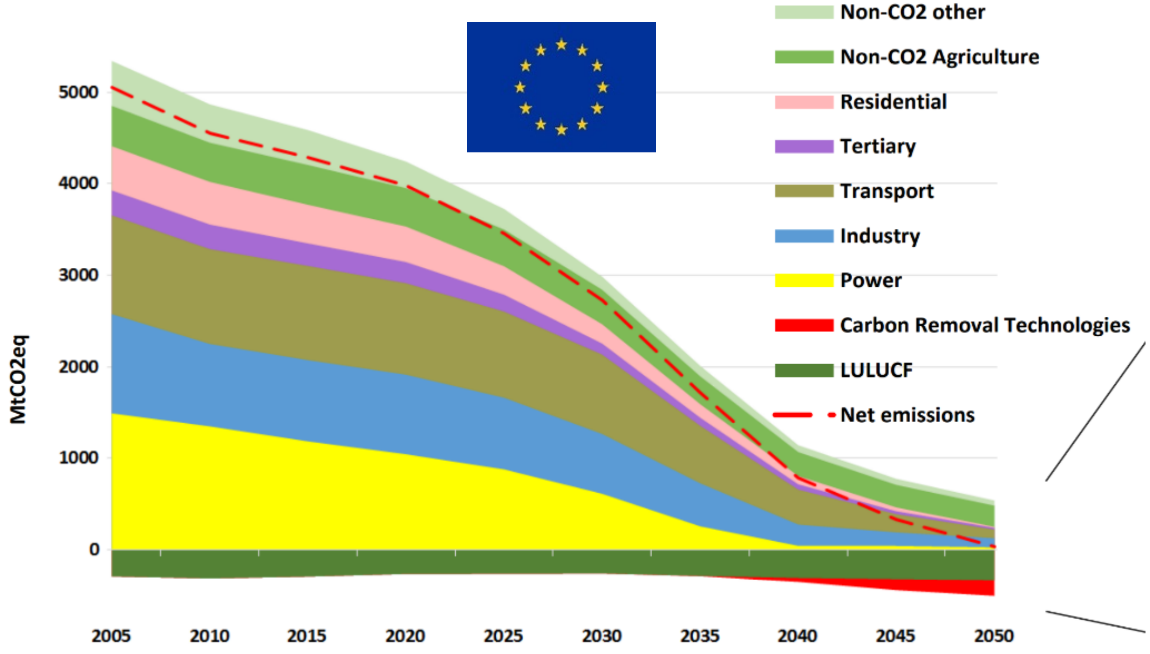
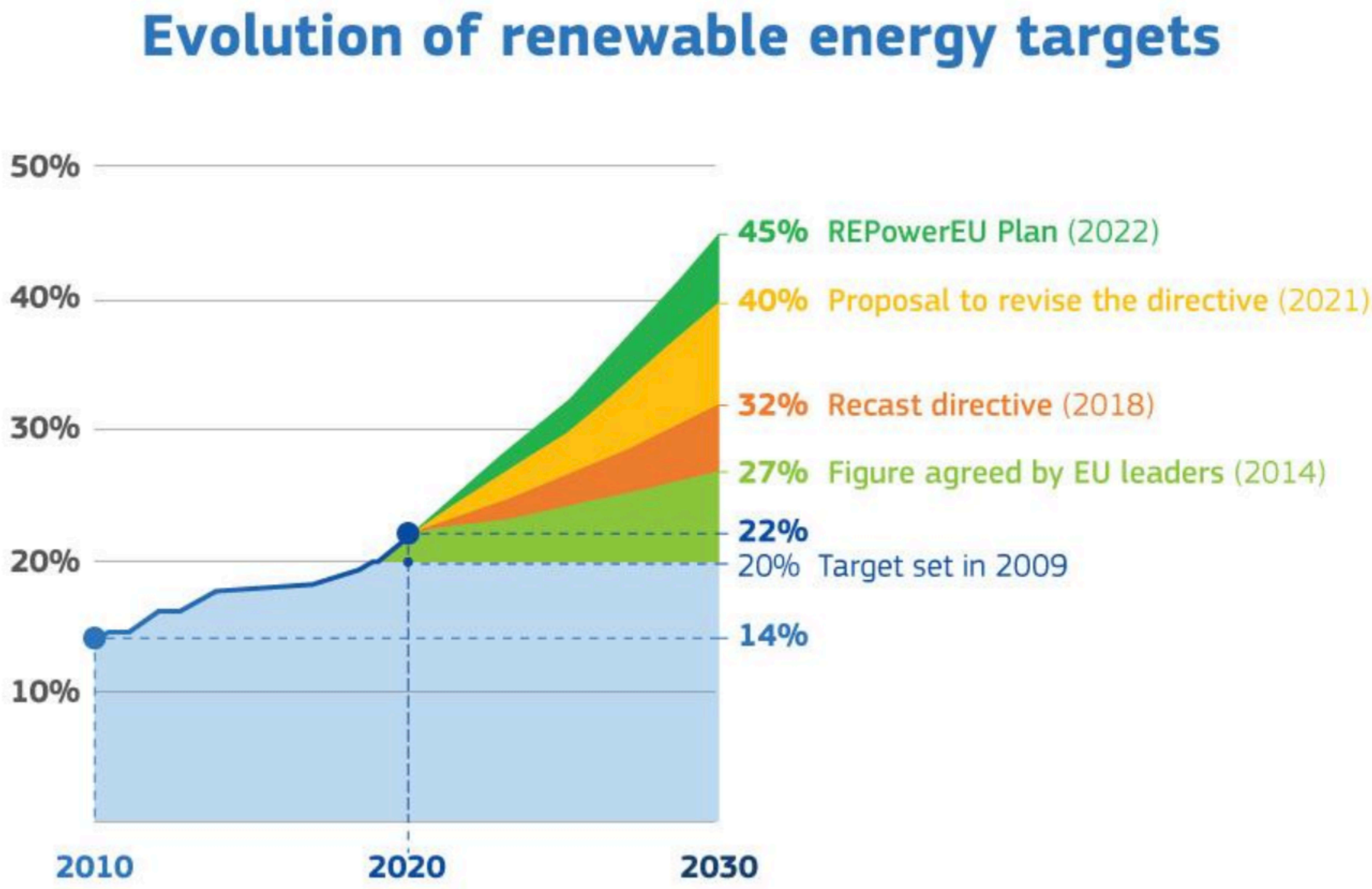
Outline

- Ambition & Policy
- Scenarios & Sectors
- The power system in Europe
- Decarbonizing industry
- Hydrogen, natural gas and renewables

With some methods and some results



REPowerEU



Evolution of renewable energy targets
50%
40%
30%
20%
10%
45% REPowerEU Plan (2022)
40% Proposal to revise the directive (2021)
32% Recast directive (2018)
27% Figure agreed by EU leaders (2014)
22%
20% Target set in 2009
14%
2010
2020
2030

Energy efficiency

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September/October 2023

The binding target will enter into force in all EU countries 20 days after the publication in the EU Official Journal.

July 2023

Binding target of at least 11.7% compared to projections of the expected final energy consumption in 2030 (2020 Reference Scenario) agreed between co-legislators.

May 2022

Proposal as part of the REPowerEU package to move to a binding target of 13% compared to projections of the expected energy consumption in 2030 (2020 Reference Scenario)

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ENTSO-E projections

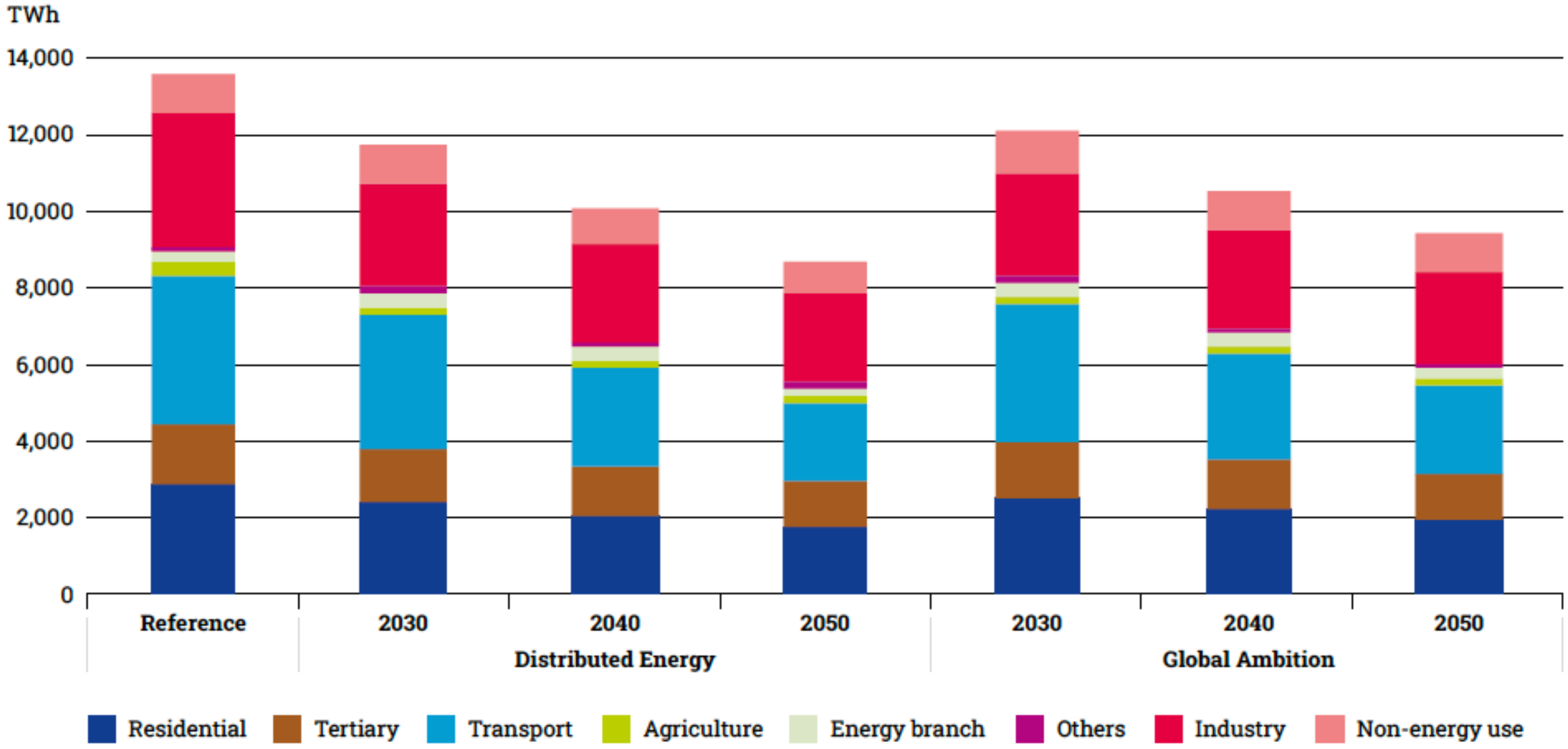

Figure 4: Energy demand per sector (energy and non-energy use for feedstock)[6] for EU27

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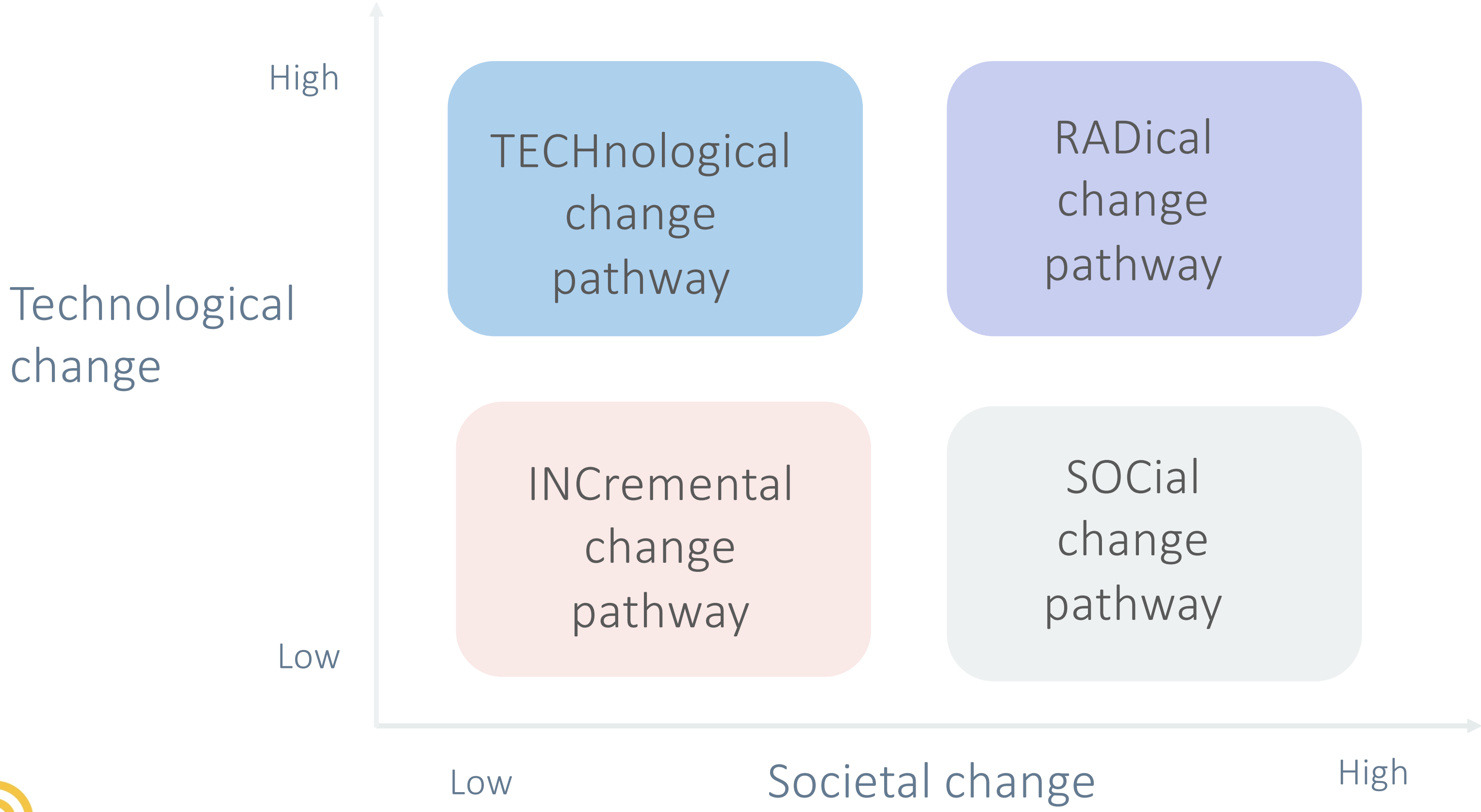
10-step methodology developed in NTRANS

1. Develop scenarios - based on socio-technical research
2. Quantify the scenarios – in dialog with partners in NTRANS
3. Analysis with NTRANS models
4. Discussion of analysis results and selection of case for in-depth analysis
5. Quantitative case study – in-depth analysis
6. Qualitative case study – in-depth analysis
7. Analysis/discussion: what are important measures to reduce bottlenecks in the transition?
8. Include uncertainty (short, medium, and long term) and bottlenecks in model analysis
9. Discuss policy implications from the model-based analysis and the socio-technical analysis
10. Summarize the research in a policy paper and a results presentation

NTRANS scenarios for Norway



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Example of assumptions

High

	Technological	Radical
	High activity/demand High wind onshore Unlimited transmission 10 % rate Municipal waste as today	**Low activity/demand** Low wind onshore No new transmission 4 % rate No waste
Wind offshore	High potential, lower cost	High potential, lower cost
Biofuel & bio coal	Expensive	Expensive
Hydrogen technologies	High learning rate	High learning rate
Blue hydrogen	Yes	No
CCS	Yes	No

Technological change

	Incremental	Society
	Medium activity/demand High wind onshore Unlimited transmission 10 % rate Municipal waste as today	**Low activity/demand** Low wind onshore No new transmission 4 % rate No waste
Wind offshore	High cost	High cost
Biofuel & bio coal	Unlimited	Unlimited
Hydrogen technologies	Low learning rate	Low learning rate
Blue hydrogen	No	No
CCS	Yes	No

Low

Low Societal change High

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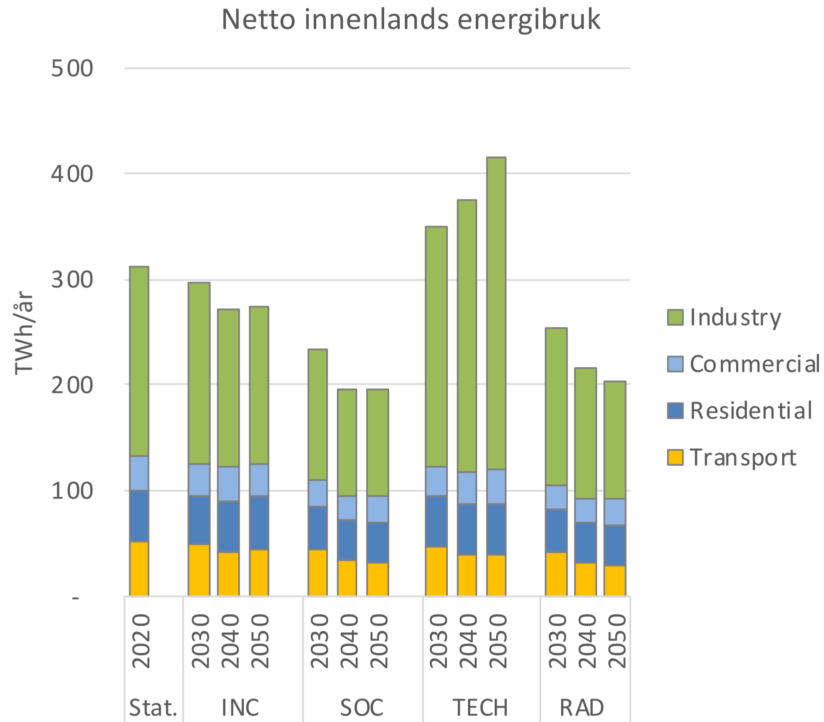
Energy use per sector

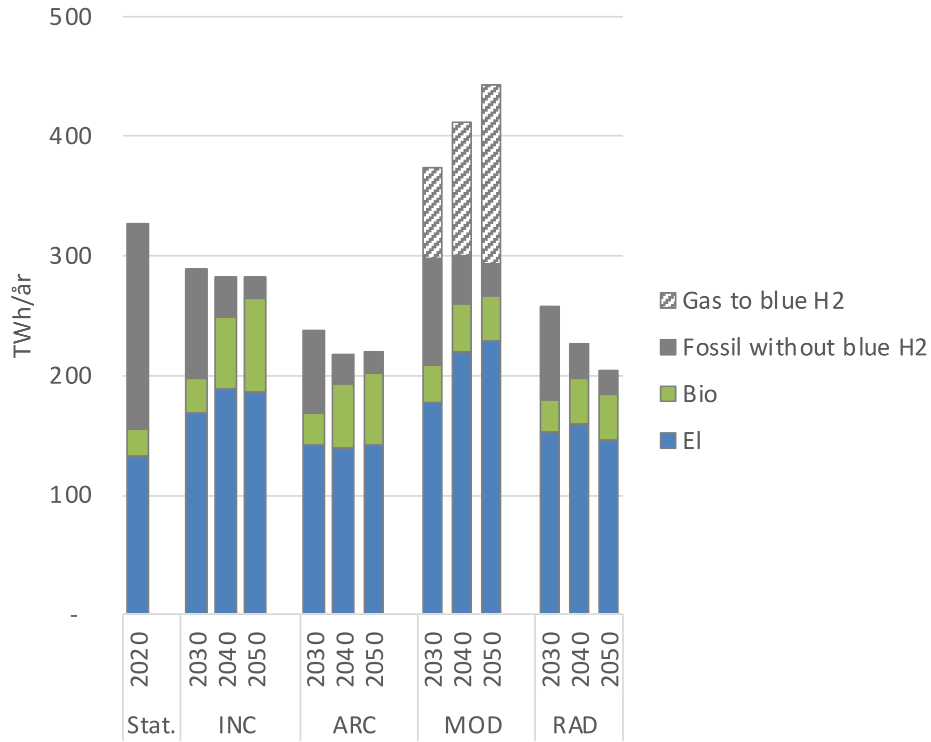
- Energy use in transport reduced in all scenarios, most in RAD and least in INC
- Energy use in buildings reduced with in SOC and RAD
- Energy use in industry incl. petroleum
  - Almost halved in SOC and RAD
  - Almost doubles in TECH



Technoloy change	Low	Low	High	High
Societal change	Low	High	Low	High

Net domestic energy use

- Electricity consumption increase in all scenarios
- Bio: increases compared to 2020, mostly used in INC
- Natural gas: used in production of blue hydrogen in TECH
- Still some use of fossil energy in industry in all scenarios



Technology change	Low	Low	High	High
Societal change	Low	High	Low	High

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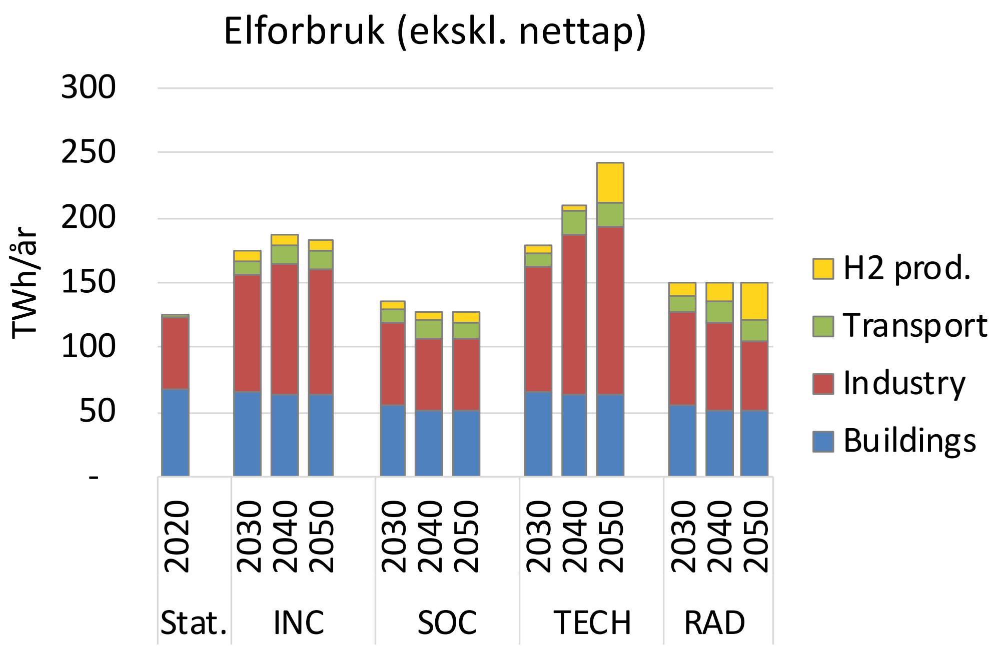
Electricity consumption

- Total use of el. in 2050
  - Cøose to 250 TWh in TECH
  - Today's level in SOC
- Use of el. in industry:
  - Highest increase in scenarios with low societal change
  - Today's level in 2050 in scenarios with high societal change
- Use of el in transport and for hydrogen:
  - Highest increase in scenarios with high technology change



Technology change	Low	Low	High	High
Societal change	Low	High	Low	High

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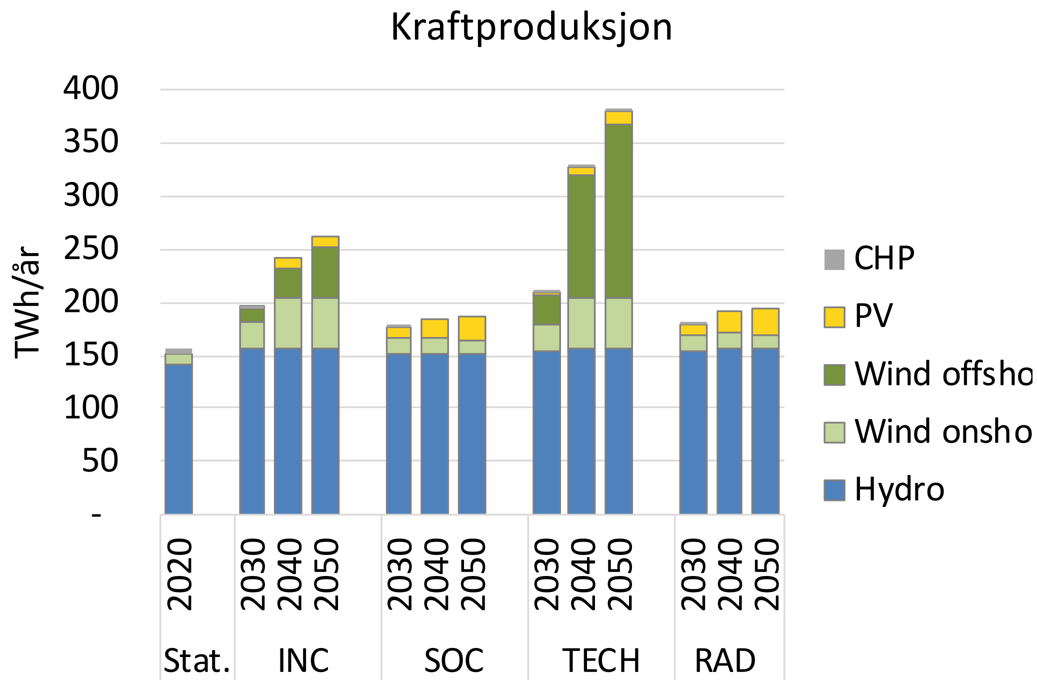
Power production

- Hydro
  - Increase of 12-14 TWh in all scenarios to 2050
- Onshore wind
  - Small increase in scenarios with high societal change
    Higher increase in scenarios with low societal change
    Offshore wind
  - Increase largely in scenarios with high technology change
    Less development in scenarios with low technology change
- Solar PV
  - highest in RAD



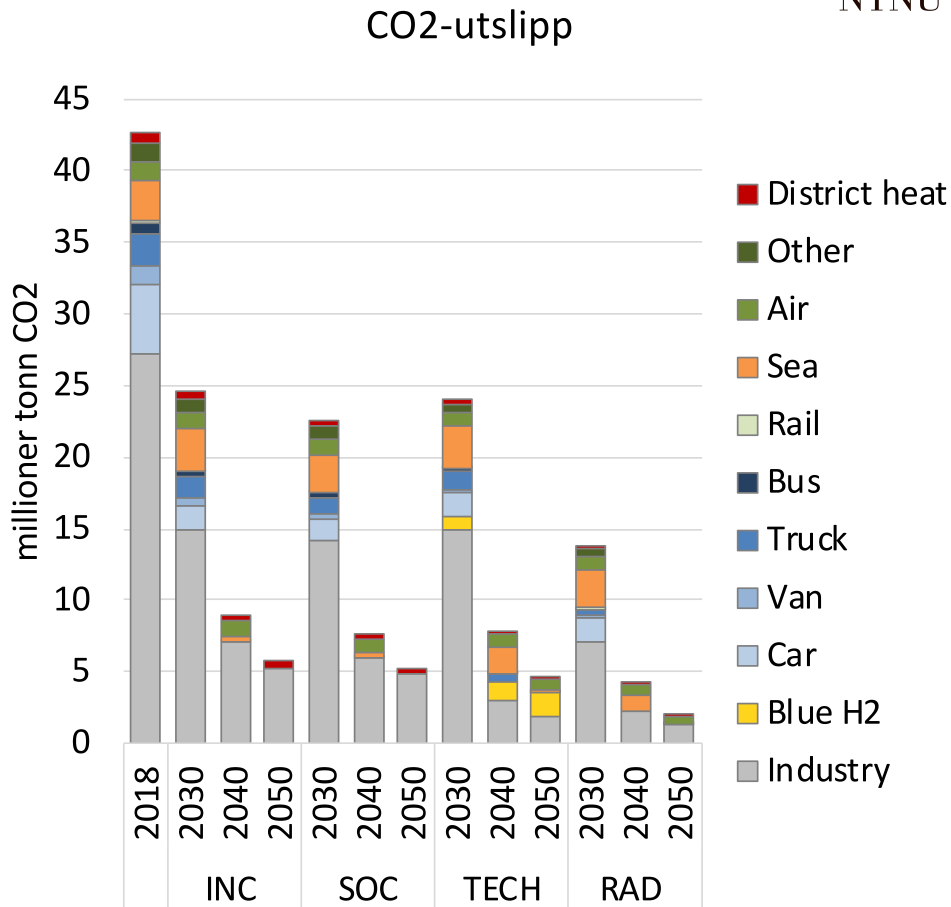
Teknologiendring	Low	Low	High	High
Samfunnsendring	Low	High	Low	High

CO_2 emissions

- All scenarios follow the same trend:
  - Road transport is faster decarbonized compared to sea transport
  - Still remaining emissions in industry, can be reduced with new technology (e.g., CCS or DAC)
- Production of blue hydrogen is not emission-free

Emission reduction:

- INC: 85%
- SOC: 86%
- TECH: 76%
- RAD: 90%



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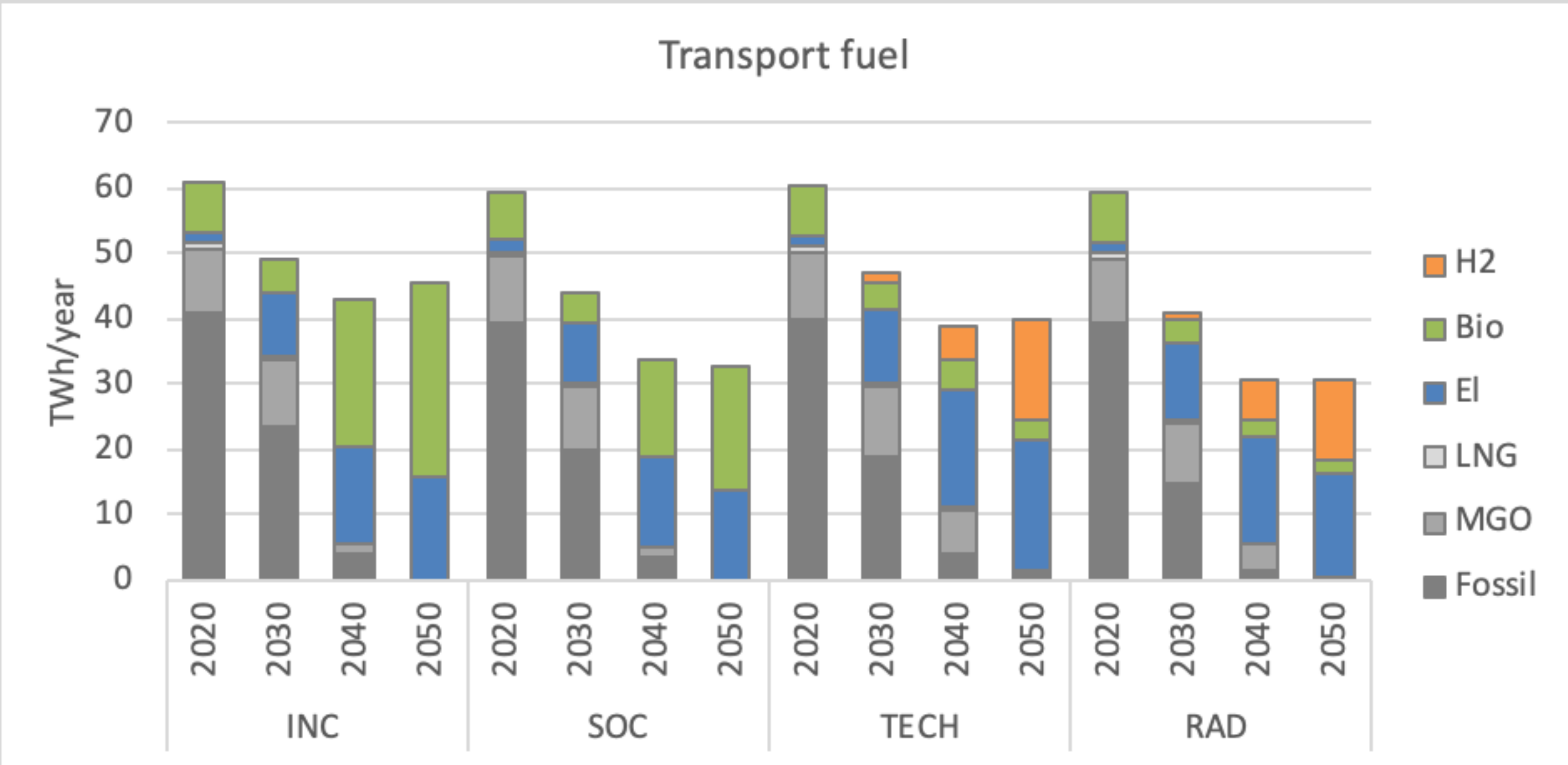
Transport fuels



We study the European power system with EMPIRE

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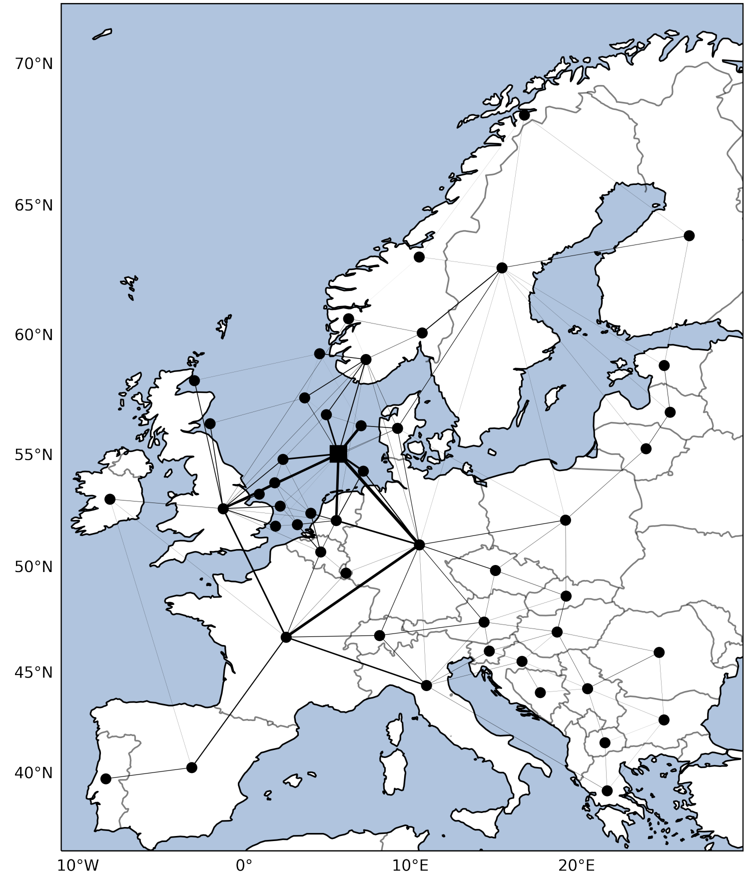
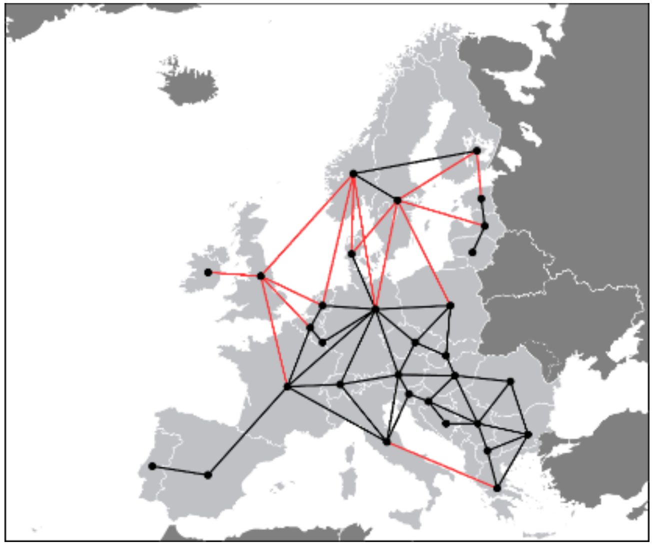
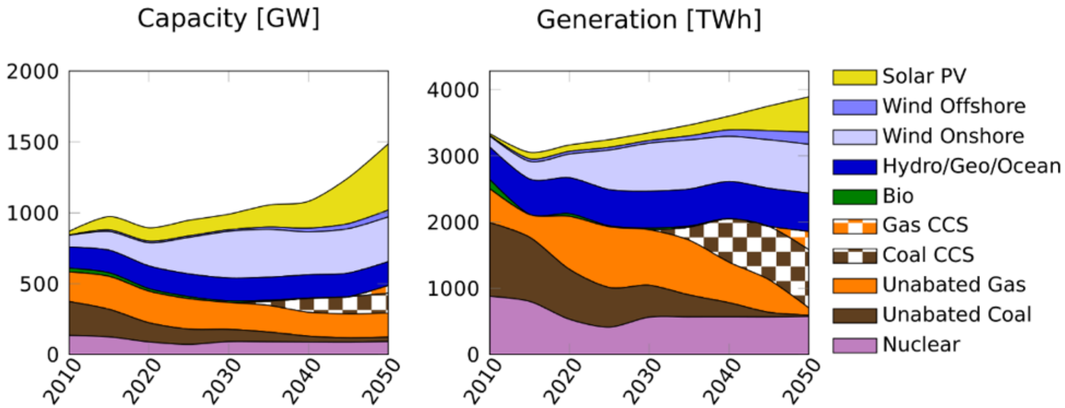
- Optimizes development of power system in line with European Commission's net neutrality goals
- Simultaneous optimization of European power investments & hourly dispatch of assets
- Features uncertainty for hourly power demand & power generation from renewable assets
- Allows us to investigate different futures for the European power system



Co-optimization of strategic and operational decisions

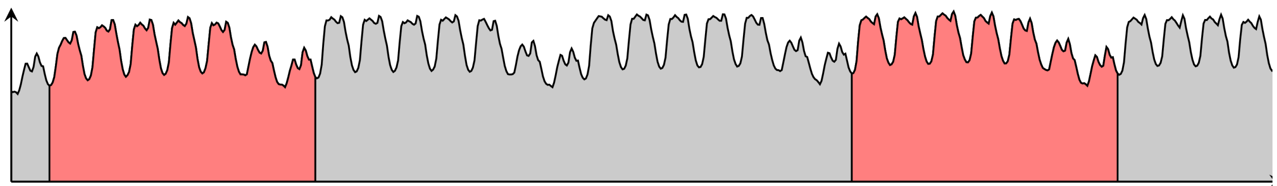


Optimal investment strategy 2010-2015

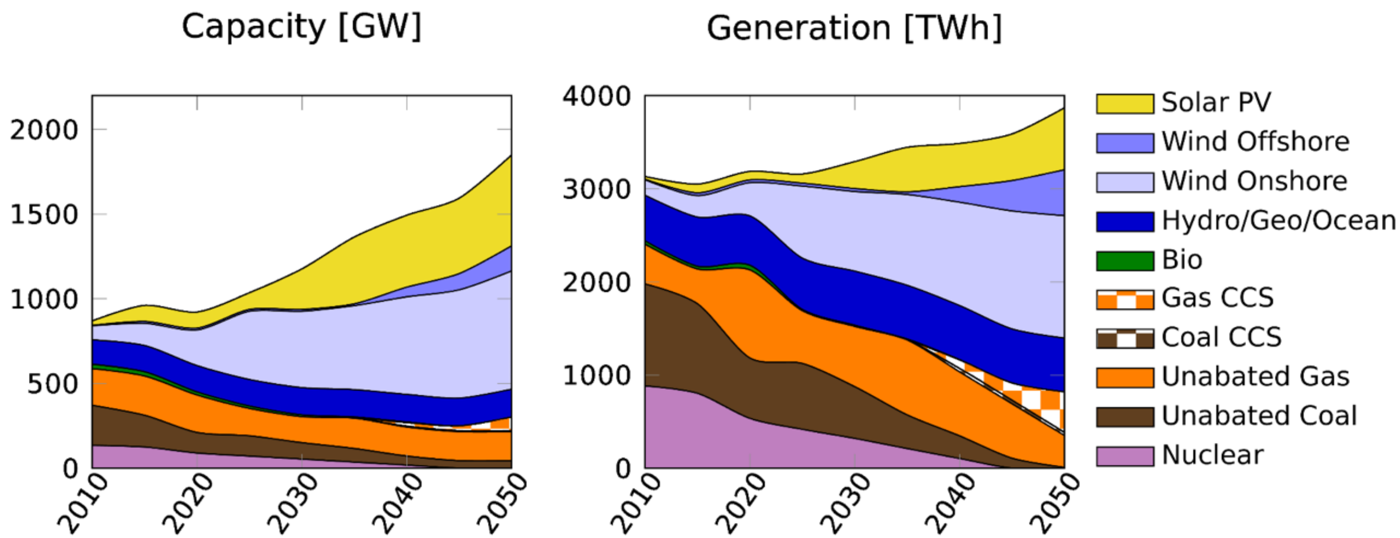


Coupled optimization problem to minimize total system costs

Optimal dispatch for representative 168-hour blocks



Baseline scenario: 90 % emission reduction



Technology/fuel (2050)	Capacity [GW] (% share)		Generation [TWh] (% share)	
Solar	536	(29%)	665	(17%)
Wind onshore	698	(38%)	1314	(34%)
Wind offshore	149	(8%)	492	(13%)
Gas CCS	81	(4%)	436	(11%)
Coal CCS	6	(0%)	33	(1%)
Fossil unabated	215	(12%)	350	(9%)
Others (Hydro, Geo, etc.)	164	(9%)	577	(15%)

NoCCS scenario: 90 % emission reduction

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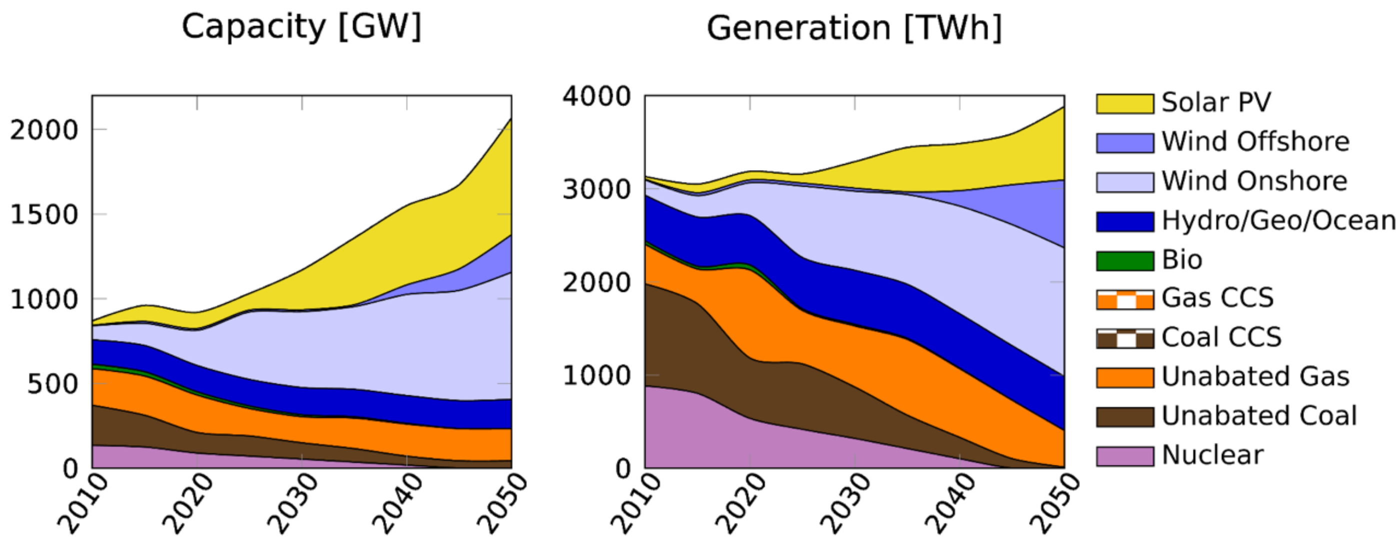

Technology/fuel (2050)	Capacity [GW] (% share)		Generation [TWh] (% share)	
Solar	690	(33%)	788	(20%)
Wind onshore	751	(36%)	1381	(36%)
Wind offshore	222	(11%)	730	(19%)
Coal (unabated)	43	(2%)	11	(0%)
Natural gas (unabated)	190	(9%)	393	(10%)
Others	173	(8%)	580	(15%)

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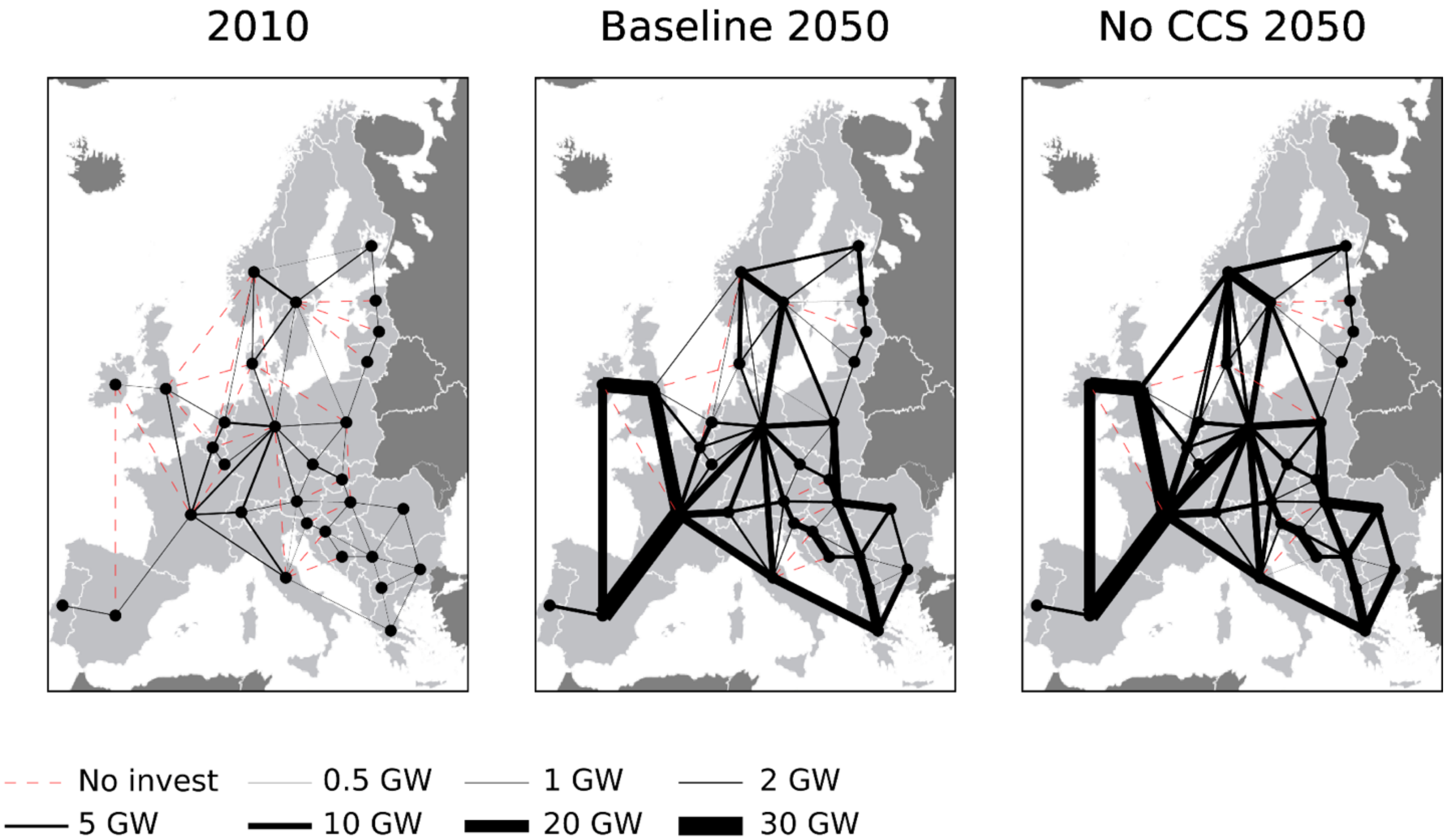
Transmission



Baseline
cross-boarder expansion: increases by 701% from 2010 to 2050

NoCCS
Capacity increases by 811% from 2010 to 2050

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Alternatives to transmission

FIRST CONCLUSION:

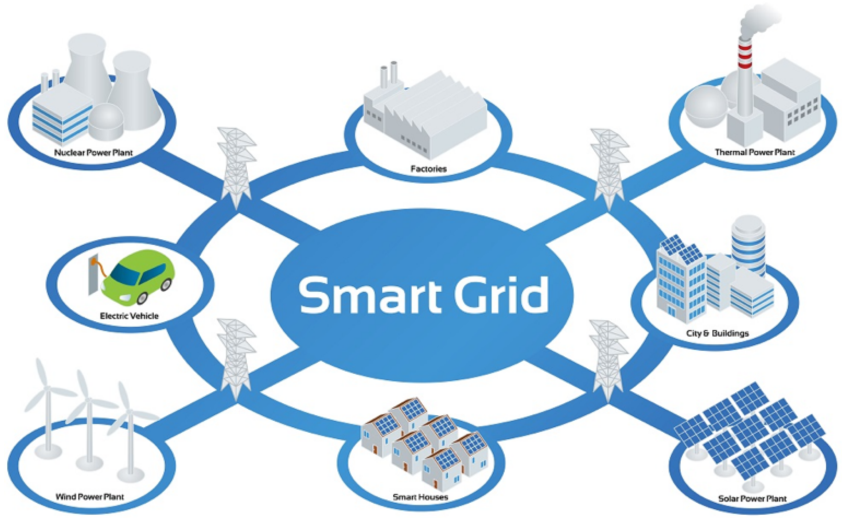
There is a high need for flexibility in the future system

In the studies I have shown, transmission investment seems to be the solution.

NEW DRIVERS:

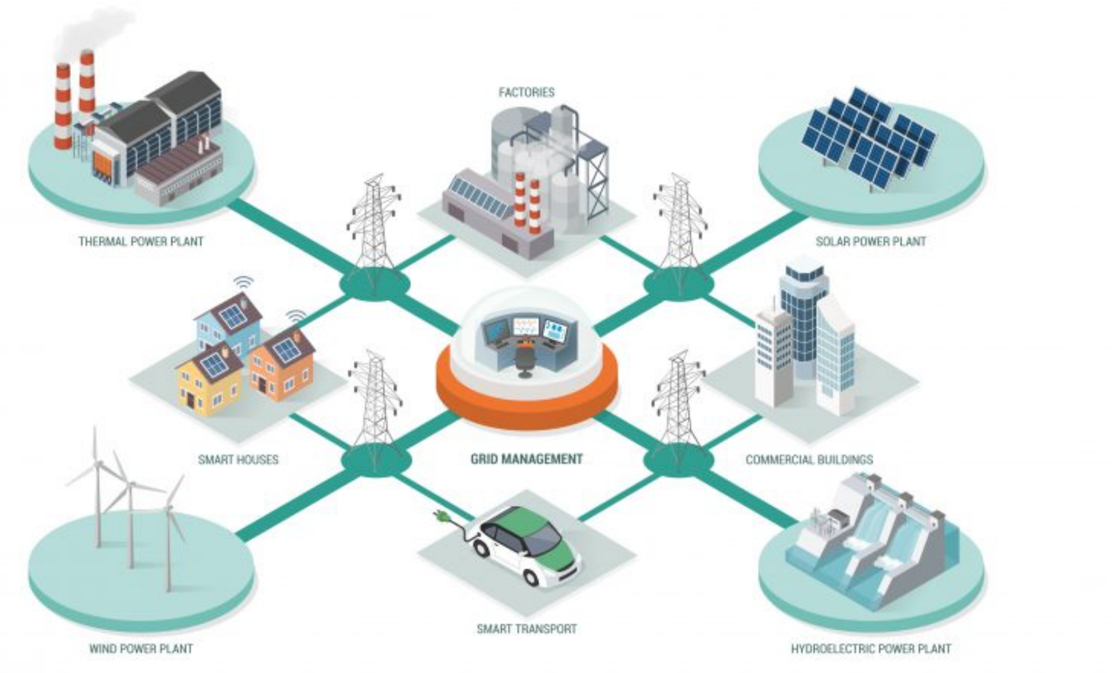
- System integration – sector coupling
- The merger of the power system and ICT
- The active consumers and demand response

How will this affect the transition to a near zero emission power system?

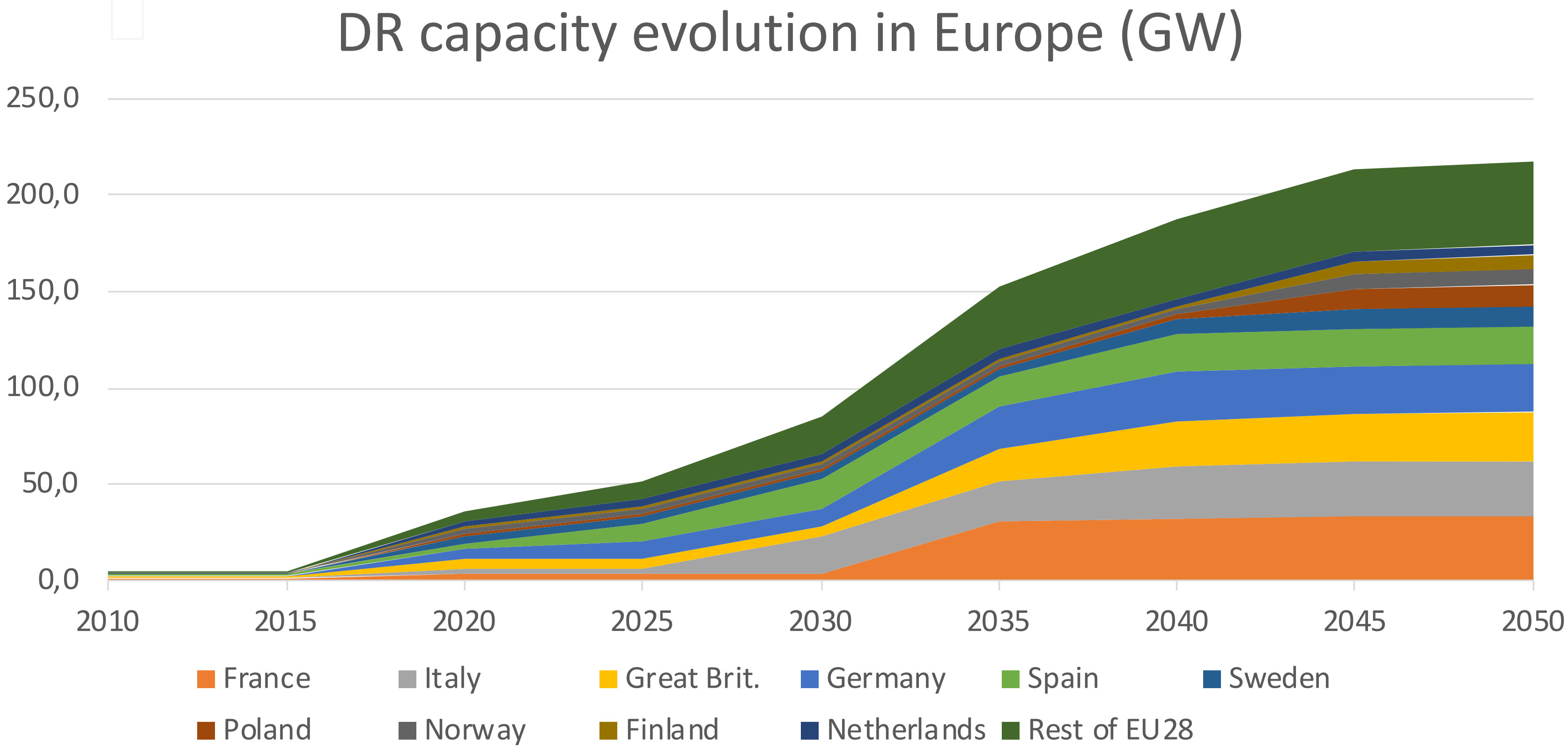


Sector coupling

- Integration of energy, industry, transport and the built environment
- Energy carriers: Electricity, heat, hydrogen, natural gas
- Flexibility and storage
- Active and flexible demand side
- Flexible supply side



Shutterstock


DR capacity evolution in Europe (GW)
250,0
200,0
150,0
100,0
50,0
0,0
2010
2015
2020
2025
2030
2035
2040
2045
2050
France
Italy
Great Brit.
Germany
Spain
Sweden
Poland
Norway
Finland
Netherlands
Rest of EU28

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Decarbonizing industry

The transition of industries will require emission reductions

- in mechanical work,
- in process heat,
- in steam production,
- from exhaust (CCS)
- and from other process emissions.
- Energy effciency and circular value chains

Energy effciency

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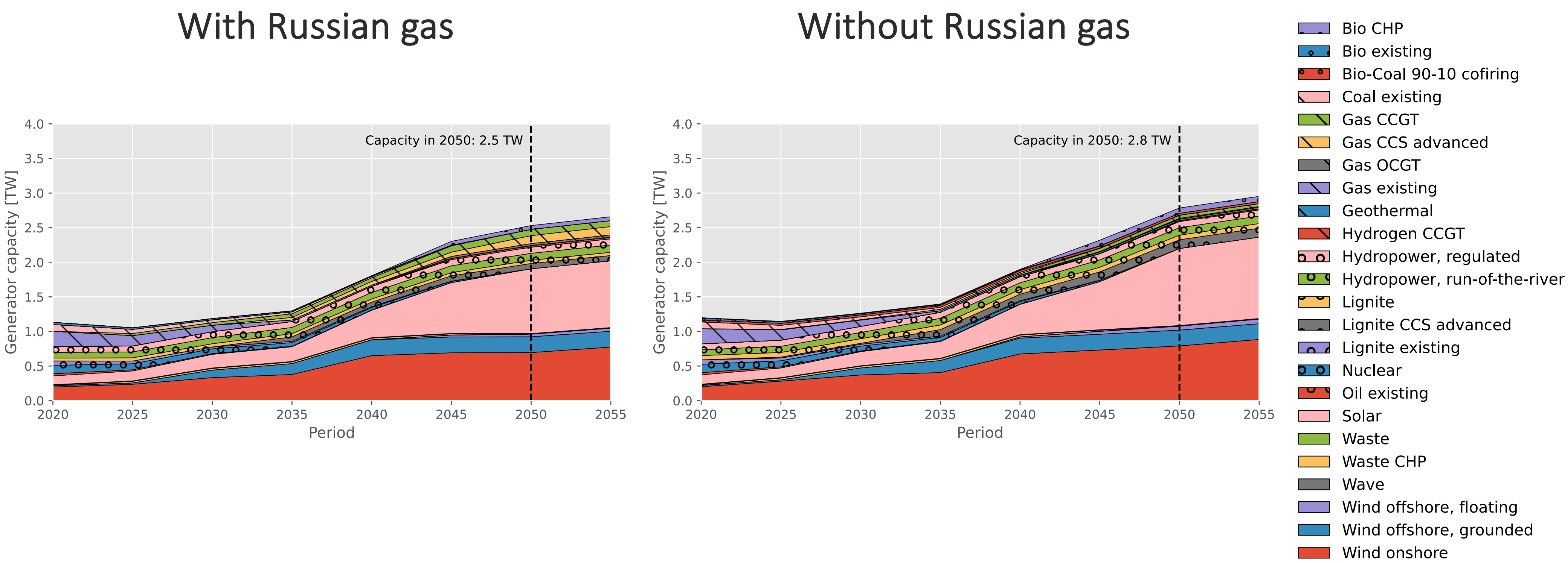
Integration of renewable energy, hydrogen and natural gas

Over the next years Europe faces an energy trilemma. In short

- Security of supply with an increasing renewable volume
- Affordable energy
- Clean energy

- Hydrogen may play a role, but does not change the fact that there is energy shortage in the European system (clean, secure and affordable)

Lower availability of natural gas increases power generation from coal and renewables



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Offshore wind is instrumental for decarbonization

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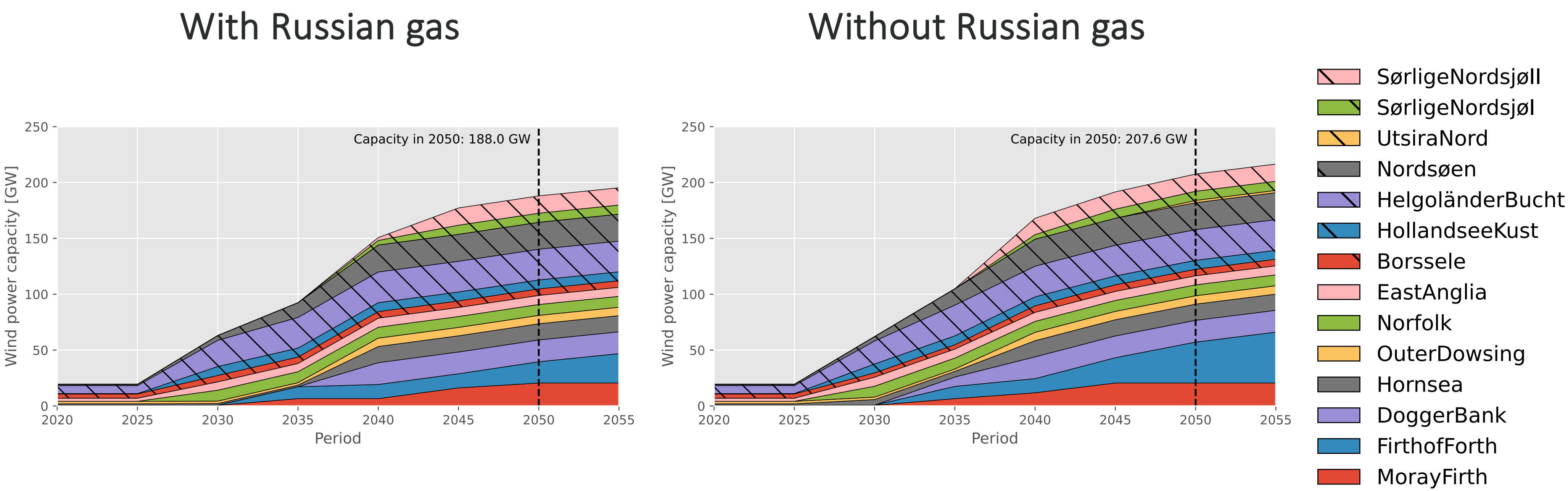
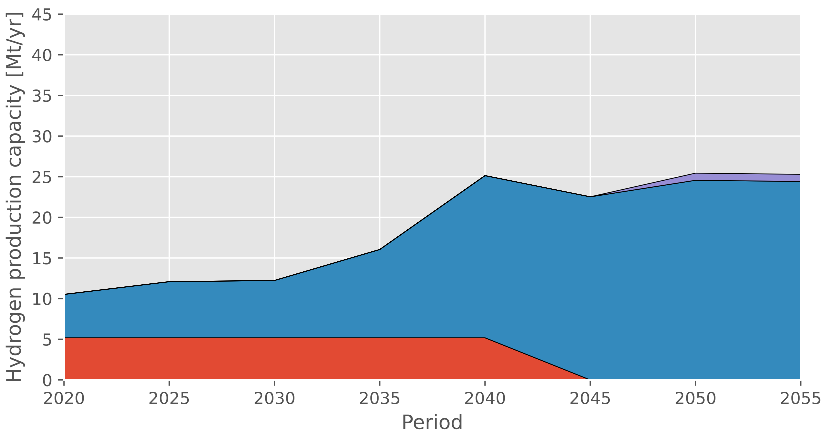
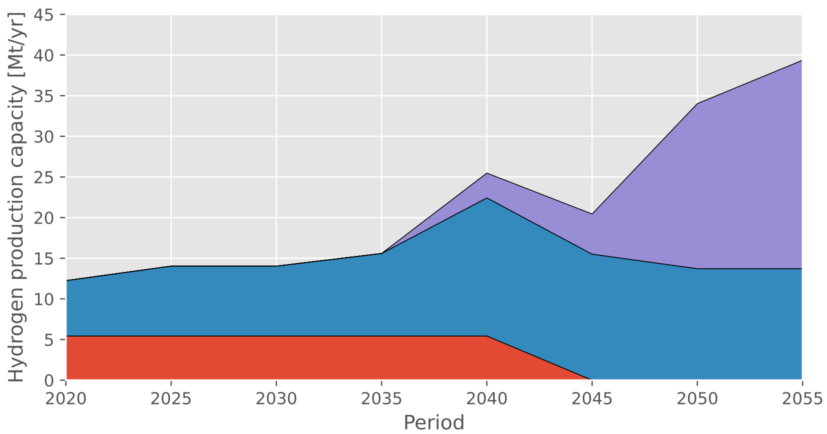


Natural gas remains an important source of hydrogen, but green hydrogen has tremendous future potential

With Russian gas



Without Russian gas



PEM Electrolyzer   Autothermal reforming, gas heated reformer, CCS   Steam methane reforming

Hydrogen uptake in steel sector is sensitive to availability of affordable hydrogen

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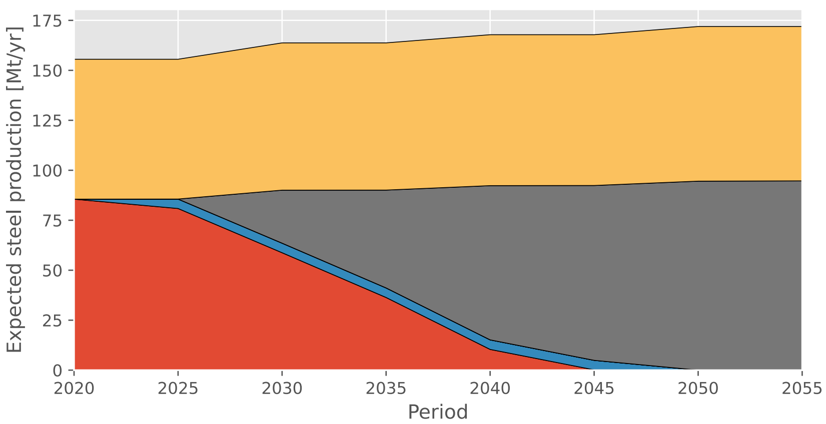
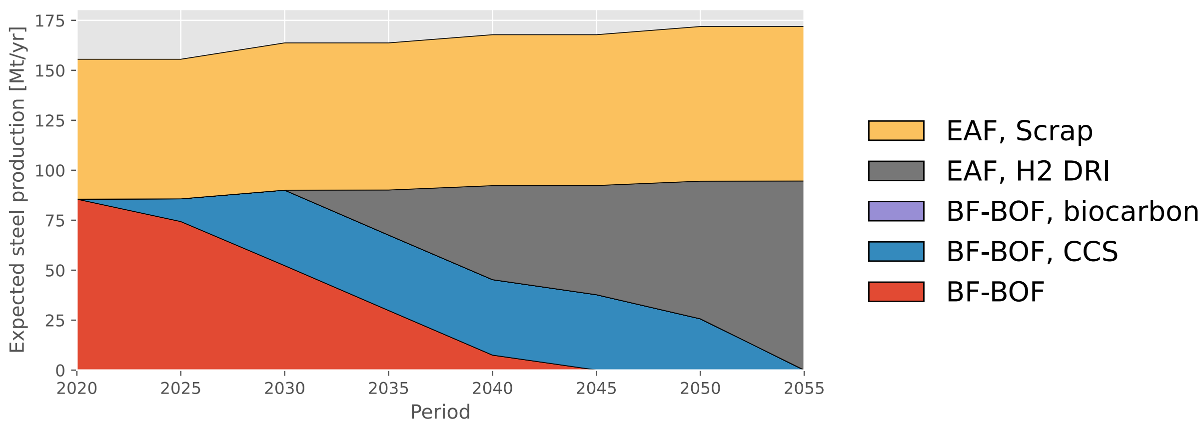
With Russian gas



Without Russian gas



Note the high share of scrap

Summary

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H_2

- Restrictions on gas lead to a significant increase in total power generation capacity in Europe
- This increase is primarily in coal & renewables
- North Sea plays key role in all cases

- Natural gas reforming is a highly competitive source of hydrogen
- Green hydrogen much more attractive as natural gas supply is restricted

- Steel is primarily decarbonized through hydrogen
- The uptake of hydrogen depends heavily on the availability of cheap hydrogen

We need more renewable energy and CCS, and North Sea is central in both

Where does this leave European industry

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- Energy efficiency is critical. Energy savings as well.
  - Closing industry have been a solution in the short-run

- Circular economy is key
  - Does deglobalization change this
  - Materials, heat, waste

- Flexibility will have a higher value

Some references

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