Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

SET-Nav
Strategic Energy Roadmap

Insights from large-scale multi-model analyses of the EU Energy transition

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SET-Nav - Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

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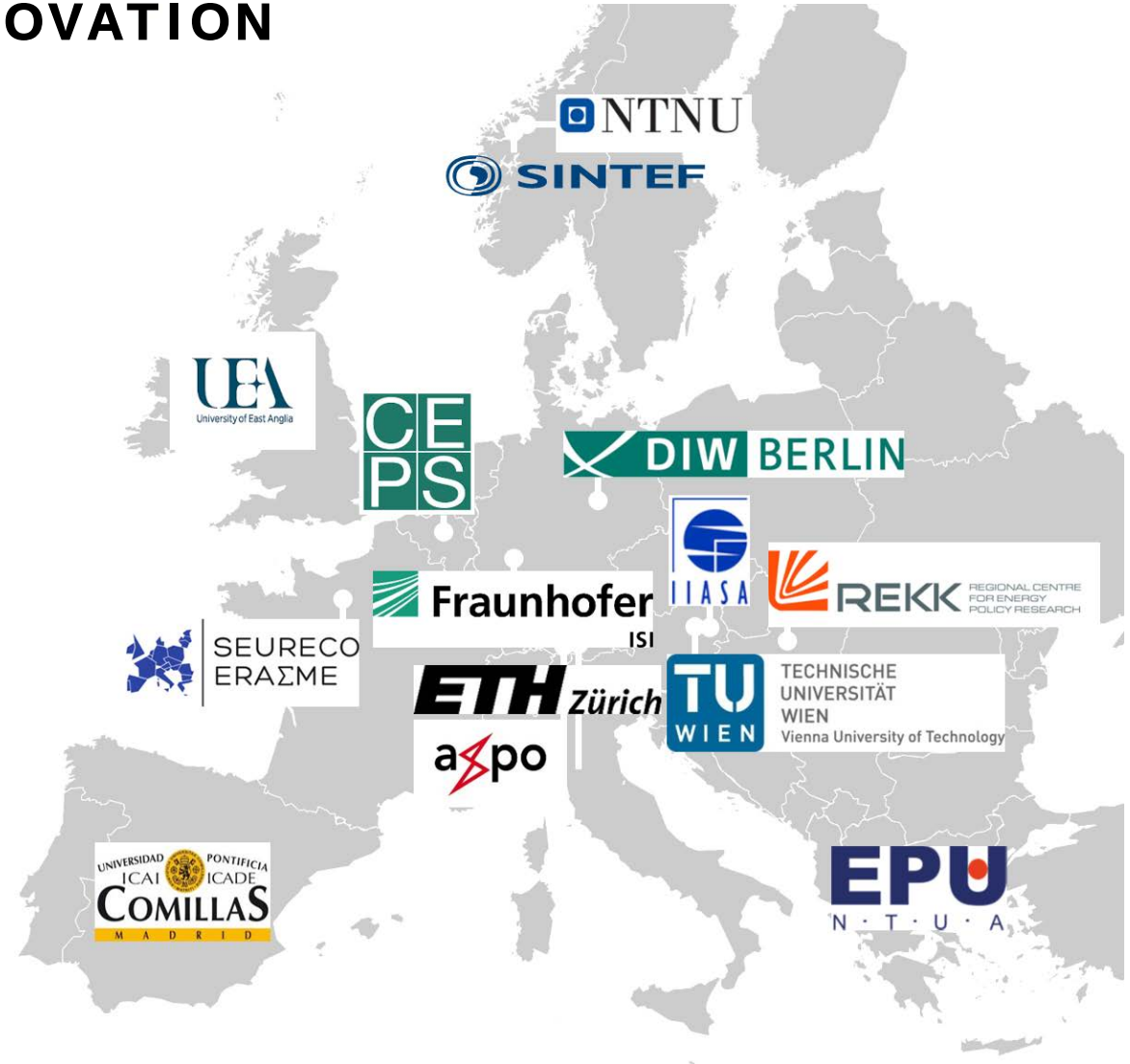
- European Union's Horizon 2020 Research and Innovation Programme (H2020) grant 691843
- April 2016 – March 2019
- Coordinator: Technische Universität Wien, Energy Economics Group (TU Wien)
- NTNU: About 5.5 person-years
  - model development
  - policy analysis
  - WP lead integrated pathway assessment



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Backdrop: The European Strategic Energy Technology Plan (SET Plan)

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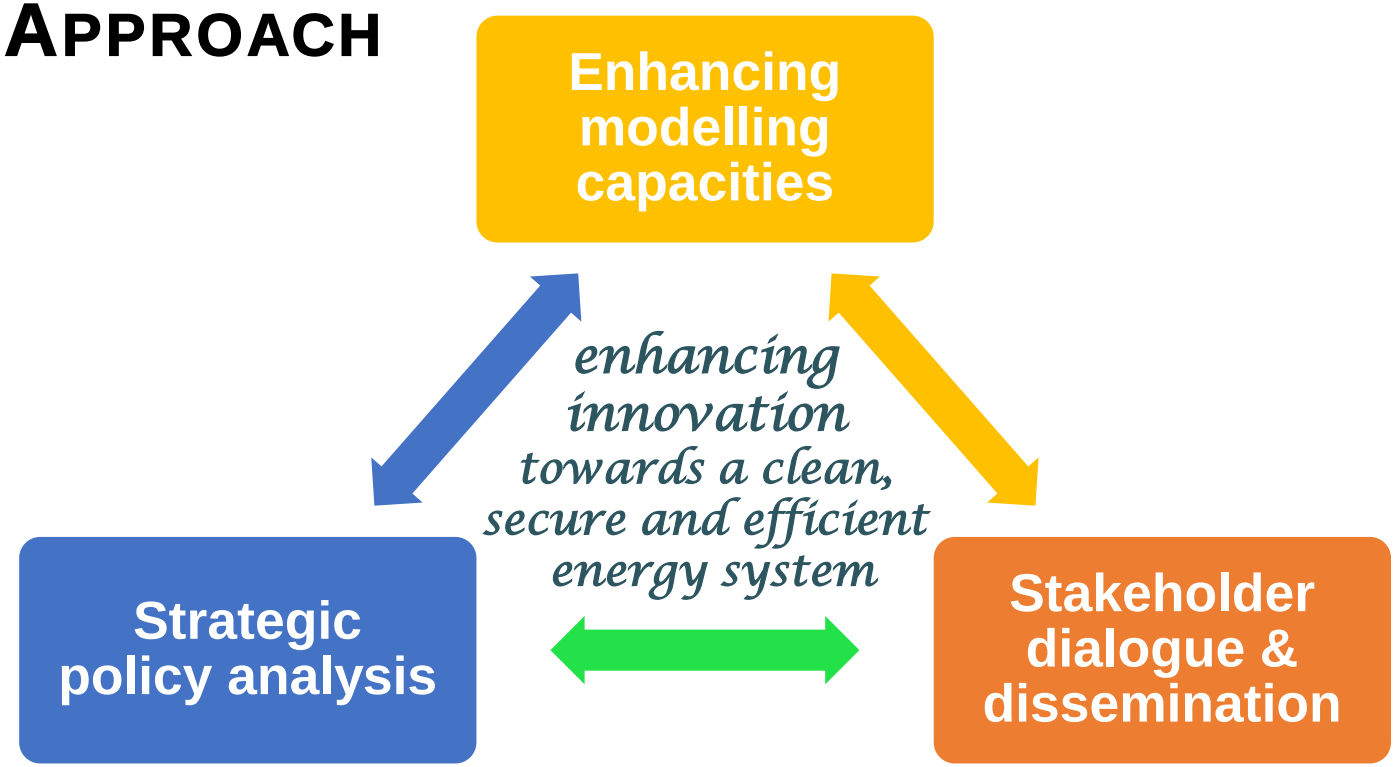
- accelerate development and deployment of low-carbon technologies.
- improve new technologies and bring down costs.
- promotes research, innovation and cooperation amongst EU countries, companies, research institutions, and the EU itself.

- **Strengthen research and cooperation to bring new, efficient and cost-competitive low-carbon technologies to the market faster and in a cost-competitive way**

SET-Nav Main Objectives

Provide quantitatively underpinned insight in low-carbon trajectories and uncertainties and derive robust policy recommendations for technology enhancement, markets and portfolios

SET-Nav Approach



- **Theory of technology innovation, diffusion & spill-overs**
- **Linked Model portfolio to capture interdependencies across levels, energy carriers, and sectors.**

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Phase I: CASE STUDIES

designed to address specific SET-Plan challenges; each analyzed by a few models

Fossil fuel markets	**Scenarios for the global fossil fuel markets** *Capture the interdependence between European low-carbon policy and global fossil fuel prices and renewable energy markets as well as technological progress*
Energy in Buildings	**Energy in buildings and the role for RES market integration** *How does energy efficiency improvement in buildings, heating system choice, flexibility options (demand response) and on-site RES affect market integration of RES and CHP?*
Industrial Sector	**Innovative technologies to decarbonize industrial process heat** *What is the contribution of RES, energy efficiency and CCS technologies in decarbonizing the industrial process heat sector?*
Transport Sector	**Ways to a cleaner and smarter transport sector** *Which measures can accelerate the transition of the transport sector from a fossil fuel based towards an energy efficient and low-carbon system ?*
Electricity grid	**Decentralized vs. centralized development of the transmission grid** *What are the main grid architectures that should be considered? Impacts of solar and wind?*
Gas sector	**Projects of Common Interest (PCI) and gas producers pricing strategy** *What are the gas infrastructure projects that should be prioritized? How vulnerable will Europe be to the suppliers' pricing strategy?*
Carbon Capture	**Role for Carbon Capture and Storage in the Future Energy Mix** *What will be Europe's CCS infrastructure needs? What is the impact of CCS on total system costs?*
RES policy	**Diffusion rate of renewable electricity generation** *Capability of the system to accommodate RES volatile generation by coupling energy carriers and other innovation measures in the system*
Flexibility gas-elec.	**Unlocking flexibility and synergy in electric power and gas systems** *Integrate electricity and natural gas supply flexibility options to deal with high levels of predictable short-term load variability and uncertain variability in supply and demand*
Nuclear power	**Perspectives for nuclear power – a closer look at cost developments** *Conduct a comprehensive technology assessment of nuclear power with a focus on cost estimates and future developments*
Macro economy	**Macroeconomic impacts of sustainable energy sector innovation** *Interaction and feedback loops between the broader economy and the energy sector will provide boundary conditions for what can be achieved and how to achieve it*

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NTNU INVOLVED IN 5 OF 14 MODELS

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Feedback between the **the wider economy** and the energy system

ASTRA
Integrated macro-economic, Transport performance and technology modelling

NEMESIS
interaction between economy, prices, energy demand

REMES
interaction between economy, prices, demand, trade between regions

Scenarios of **global resource markets** & their impact on the fuel mix

MultiMod
global energy system, supply-demand balance by country

EMPIRE/RAMONA
electricity and natural gas investment + dispatch

Enertile
power sector dispatch and investment model

In-depth analysis of **specific sectors** (electricity, gas, buildings, etc)

GGM
natural gas model for investment + dispatch, import into Europe

CCTSMOD
carbon capture, transport and storage, focus on infrastructure

INVERT
building sector energy demand model

FORECAST
energy demand (multiple sectors)

TEPES
detailed electricity power flow model

Nexus-Security
Risk factors of the gas-electricity system operations

Green-X
RES policy and investment model

Selected demand side results:

Case study	Main results
 Energy in Buildings	• Strong decrease in final energy demand expected • Uptake of solar thermal, heat pumps, and biomass. • Need further reduction of natural gas • Thermal renovation and efficient new construction help limit electricity demand heat pumps • High potential for district heating; needs high connection rates • Heating and cooling have high flexibility potential
 Industrial Sector	• Emission reduction most challenging in iron and steel, cement and chemicals. • Biomass most important RES in industry, particularly medium term. • Competition with other sectors for biomass resources • RES-based power-to-heat promising but need heavy policy support • Improved material efficiency and circular economy have huge mitigation potential.

Selected supply models results

Case study	Main results
Flexibility gas-elec.	• Strengthening grid central to exploit flexibility options across the continent. • By 2050, a mix of electricity storage, biomass- & gas-fired power plants to manage large RES share • Gas interesting flexibility option medium term. However capacity utilization drops significantly over time. Incentives needed to keep capacity up • 2025-2030 seems to be critical period to strengthen system flexibility in preparation for later RES deployment.
Carbon Capture	• CCTS not compatible with fully decarbonized energy sector (captures max 90%) • Increasingly high CO2 price causes switch from Coal CCTS to Gas CCTS and general decline in CCTS generation. In the long run, Gas CCTS most relevant. • Currently business case for CCTS is challenging. Both in electricity and industry, alternative low-carbon technologies available with the same abatement costs (at smaller scale and / or risk).

SET-Nav Energy Transition Pathways

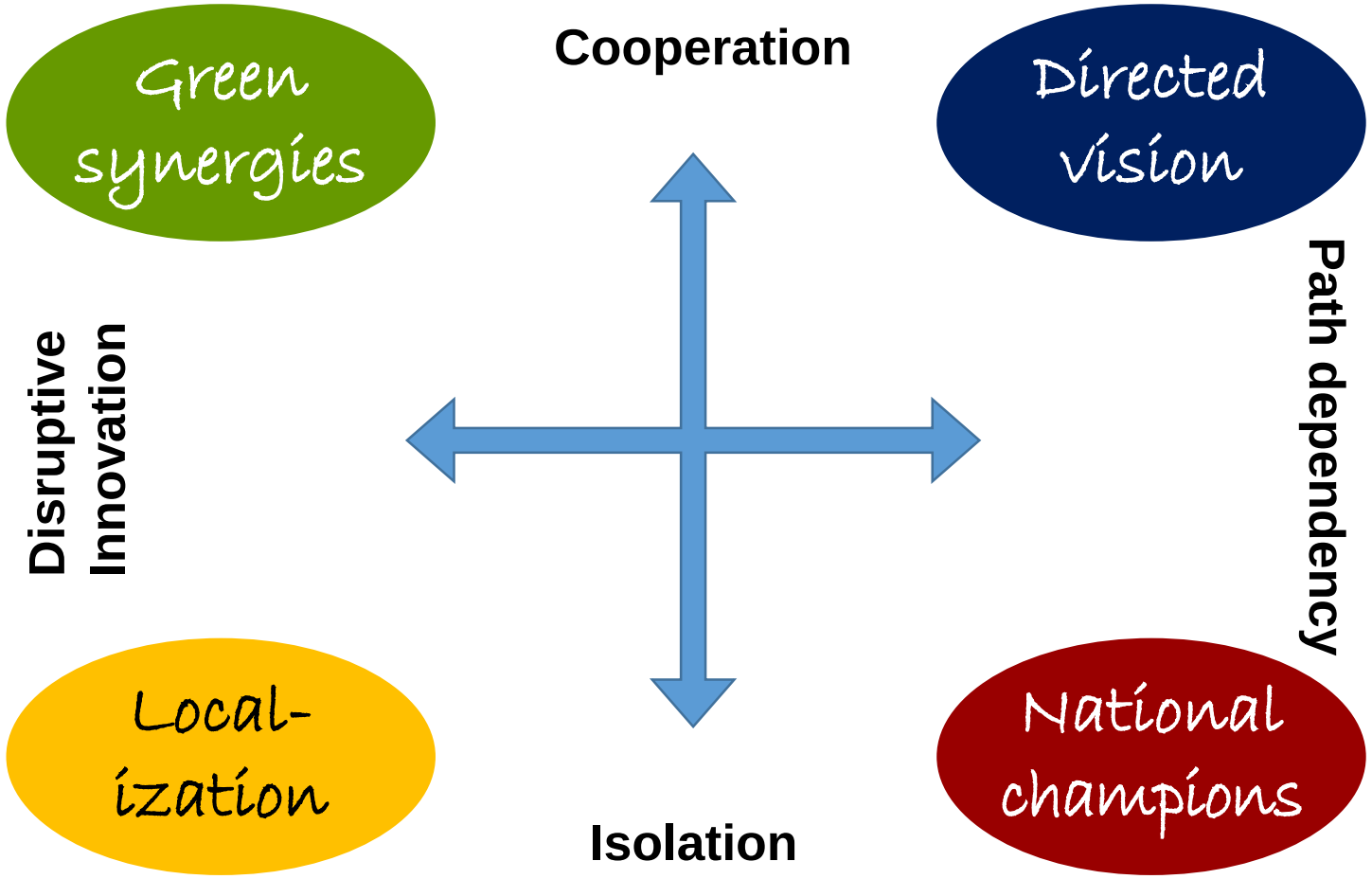
Pathways drivers: (inputs, assumptions, boundary conditions)

- Storylines and assumptions on critical uncertainties behind the scenarios

Pathways consequences (outcomes, implications)

- Robust cost-effective “no regret” options to meet 2030 and 2050 targets?
- Long-term impacts of different mitigation options on the economy, energy sectors and technology development?
- Optimal electricity supply mix considering different load types, flexibility and balancing needs in conjunction with central-decentral grid enforcements?
- What technologies need or deserve support?
- What policies provide the right incentives?

SET-Nav Phase II: Energy Transition Pathways



- heterogeneous actors
- coordination (beyond markets)
- digitalization (open IP)
- regulatory change
- disrupt incumbents

- EU/state-directed
- shared vision
- strong EU policy framework

- local resources
- resistance to big infrastructure
- experimentation & diversity (many niches)
- digital winners-take-all

- utilities & incumbents
- regulatory capture
- low transition costs

Some terms adjusted for clarity

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Some Perspectives for Norway

- Norway must adjust to play a role in the future EU energy system. Low-carbon, flexibility, rather both
- Flexibility:
  - mid-term clearly a role for natural gas
  - long-term: needs CCTS & (unexpected?) competing options such as Heating and Cooling in buildings
- Biomass-RES:
  - opportunity for forestry resources?
- CCTS:
  - Case study results: separate sectors may think they can do without, but decarbonizing entire system challenging and expensive without
- Market designs and policies should provide incentives to actors

Thank you

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