ETSAP WS series
Current practices

15.-16. 09.22

IFE, Norway
Teams

Current modelling practices: Human behaviour in IFE-TIMES-Norway 15.09.2022

Pernille Seljom, Kristina Haaskjold, Eva Rosenberg, Kari Espegren

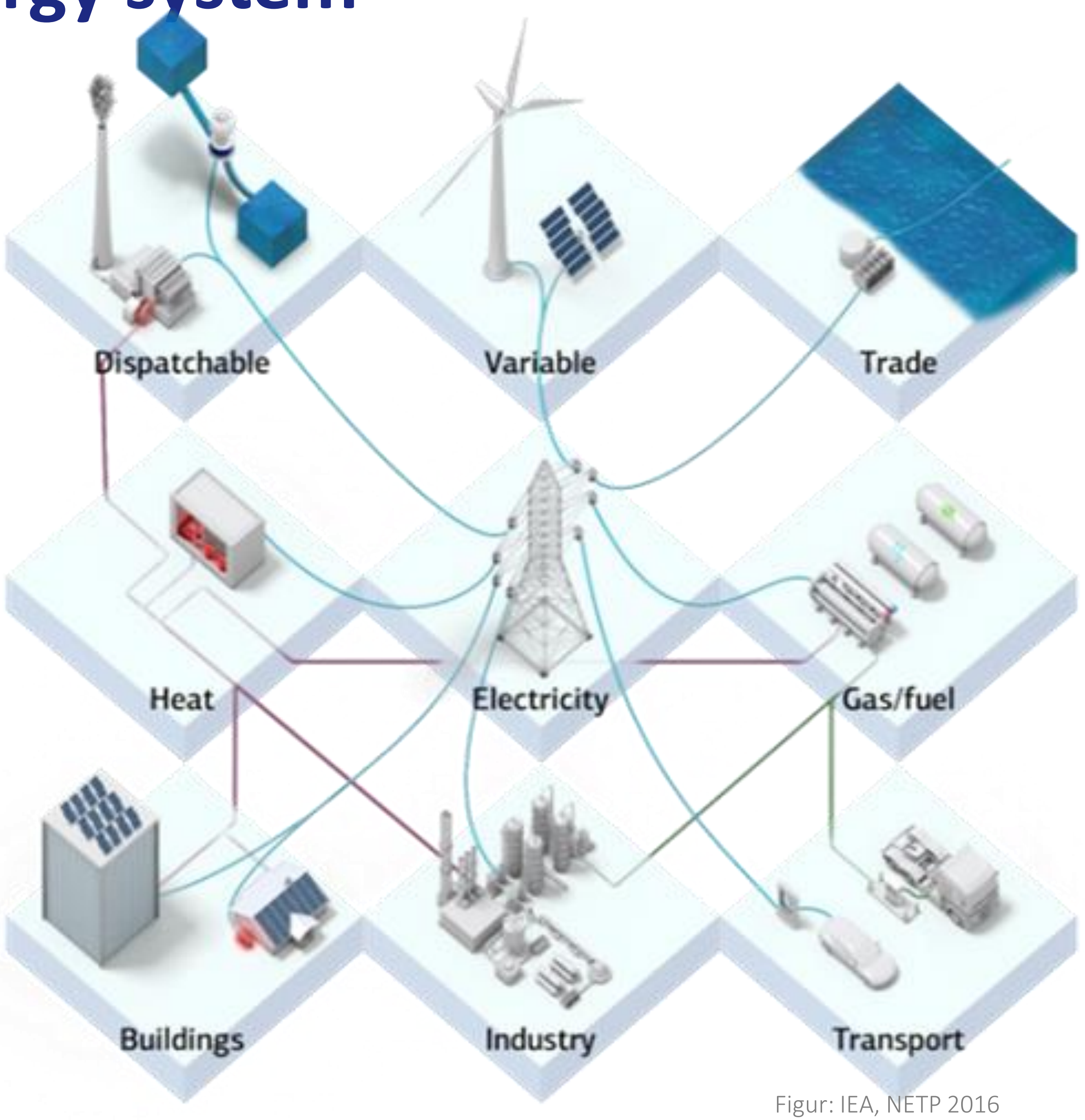
Renewable Energy Systems

Institute for Energy Technology (IFE)

Impact of behaviour on the energy system

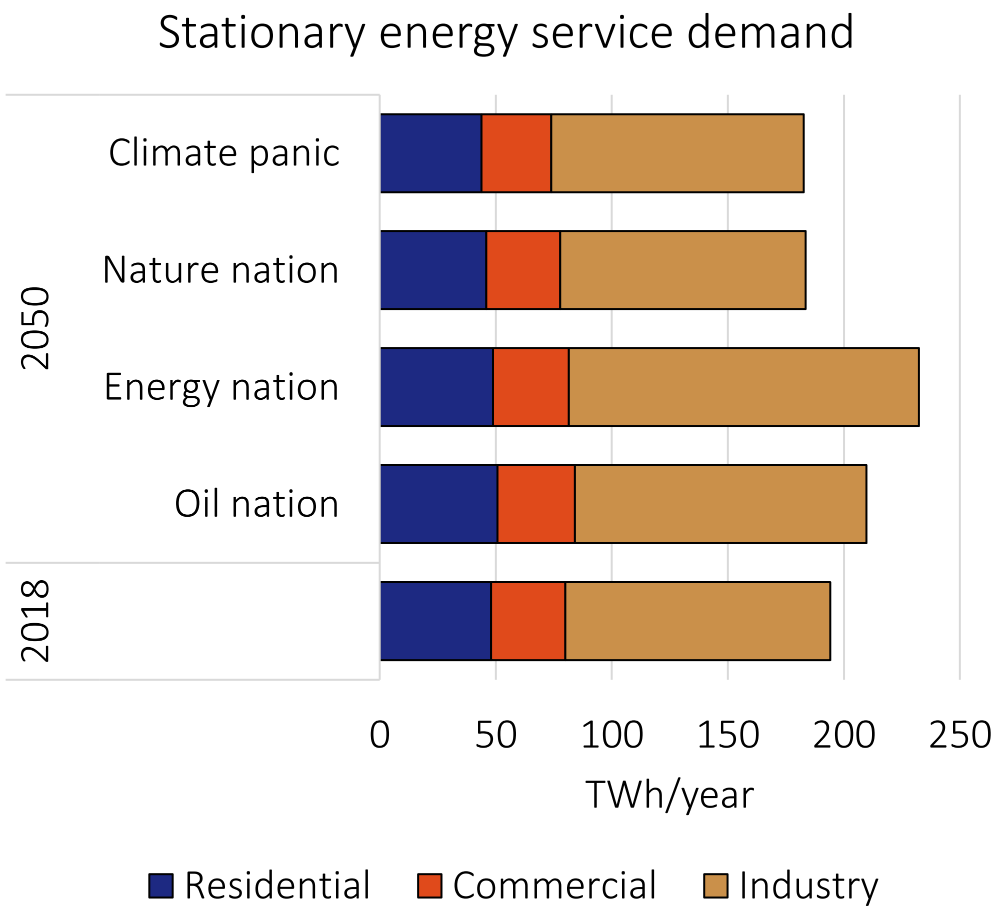
- Energy system development depend on **behaviour** of private households, e.g.
  - New technology
  - Technology preferences
  - Flexibility availability
  - Energy efficiency implementation
  - Modal shift in transport
  - Settlement patterns

- Energy system development depends on **public acceptance** of capacity expansion and new infrastructure



Figur: IEA, NETP 2016

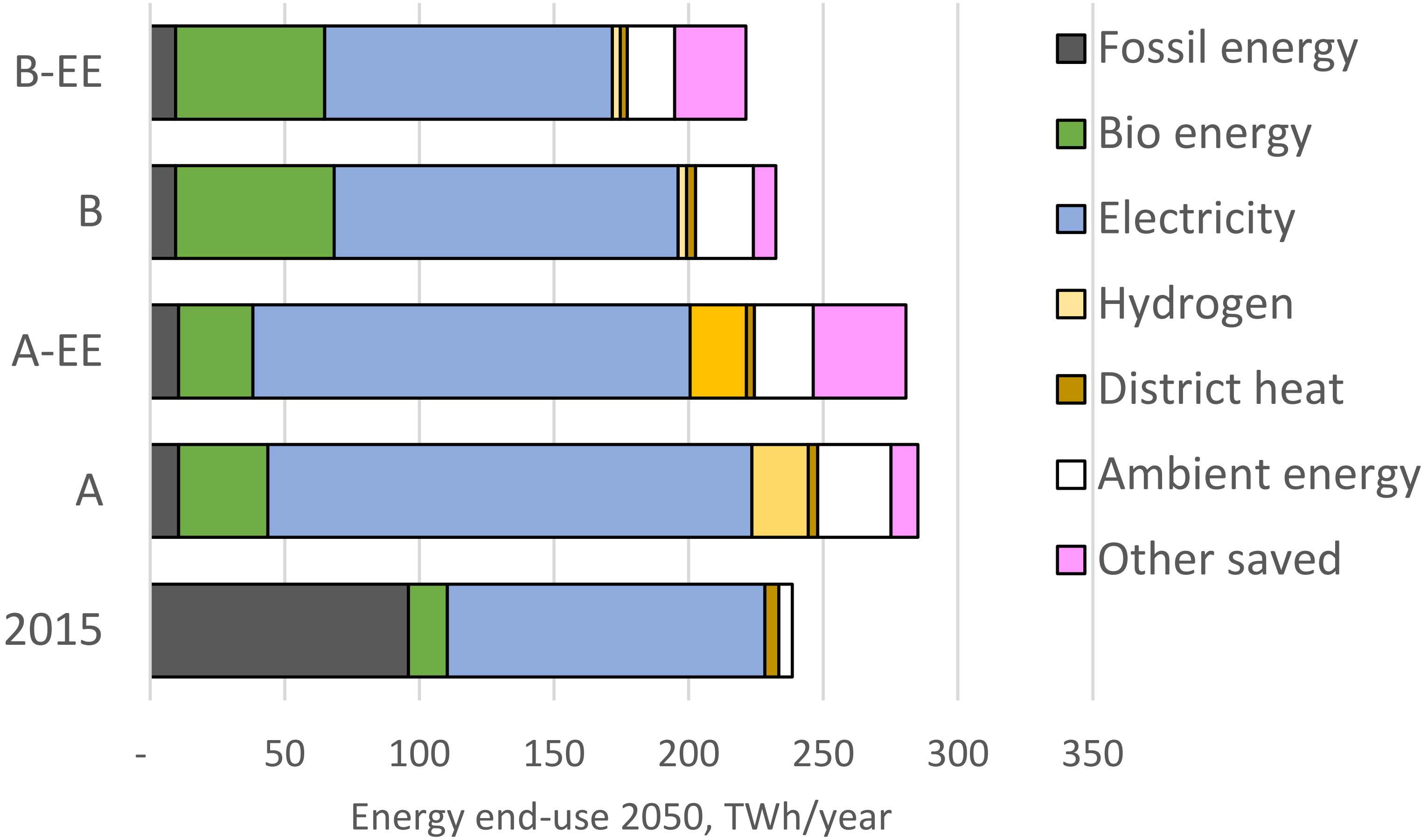
Example of energy behaviour assumptions related to demand projections



Source: KPN FlexBuild 2020

- **Behavior dependent drivers for demand projections in buildings**
  - Number of people living per building type
  - Area of new buildings
  - Type of buildings, apartments or single houses
  - Location of new buildings, decentralization versus centralization
  - Demolition rate
  - Implementation of energy efficiency

Example of energy behaviour assumptions related to energy efficiency measures



A og B represents different scenarios in 2050

Investments in energy efficiency (EE) reduces demands for energy services

- A: 24 TWh
- B: 18 TWh

EE reduced final energy demand

- A: 6 TWh bio + 17TWh el.
- B: 4 TWh bio og 21 TWh el.

Arbeid fra FME NTRANS

NTRANS transition pathways

Behavioral assumptions – Narrative, assumptions and results

Four types of pathways

	Minor ← System architecture change → Major	
Major (Subsystem change)	**Modular substitution pathway** Incumbents are challenged Existing rules ('fit-and-conform') Subsystem knowledge obsolete Architectural knowledge intact	**Radical transformative pathway** Incumbents are severely challenged New rules ('stretch-and-transform') Subsystem knowledge obsolete Architectural knowledge obsolete
Minor (Subsystem change)	**Incremental innovation pathway** Incumbents not challenged Existing rules Subsystem knowledge intact Architectural knowledge intact	**Architectural change pathway** Incumbents very challenged New rules Subsystem knowledge intact Architectural knowledge obsolete

Technology change

Minor <------------------------------------Subsystem change ------------------> Major

Minor <------------------------------------System architecture change------------------------------------> Major

socio-institutional, behavioral & cultural change

Modular substitution pathway		Radical transformative pathway	
Lead firms	Some incumbents reorient to EV but some fail, limited new entrants	*Lead firms*	Dominated by new entrants while some incumbents may preserve
Users practice	End-user practices are largely unchanged; charging at home in addition	*Users practice*	Shift from personal cars to shared zero-emission vehicles and mobility. New high-tech assisted ways to replace mobility needs.
Institutions	Regulation: support new vehicles and charging Informal: unchanged	*Institutions*	Regulations: major change; shared mobility; digitalization Informal: New sustainable values, novel ways to meet human needs.
Technology	Electric/H2 vehicles	*Technology*	Autonomous and shared zero-emission vehicles. New technologies to circumvent the need to travel, e.g. virtual reality
Consumption	Level unchanged	*Consumption*	Reduced demand level and new structure

Incremental change pathway		Architectural change pathway	
Lead firms	Incumbent firms stay in place with minor adaptations to technologies and business models	*Lead firms*	Dominated by new entrants while some incumbents may preserve. Focus on ICT.
Users practice	End-user practices are unchanged	*Users practice*	Shifts to shared mobility (radical change) and new modalities (public transport, biking, walking)
Institutions	Formal and informal institutions are largely unchanged	*Institutions*	Institutional and cultural change towards less unnecessary travelling, change of values towards sustainable mobility.
Technology	Biofuels strategy (100%) with existing engines and fuelling infrastructure	*Technology*	Smart apps for multi-model mobility, mobility-as-a-service
Consumption	Level unchanged	*Consumption*	Reduced demand level and new structure

Assumptions

	Modular	Radical
	High activity/demand	Low activity/demand
	High wind onshore	Low wind onshore
	Unlimited transmission	No new transmission
	10 % rate	4 % rate
	Municipal waste as today	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

	Incremental	Architectural
	High activity/demand	Low activity/demand
	High wind onshore	Low wind onshore
	Unlimited transmission	No new transmission
	10 % rate	4 % rate
	Municipal waste as today	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

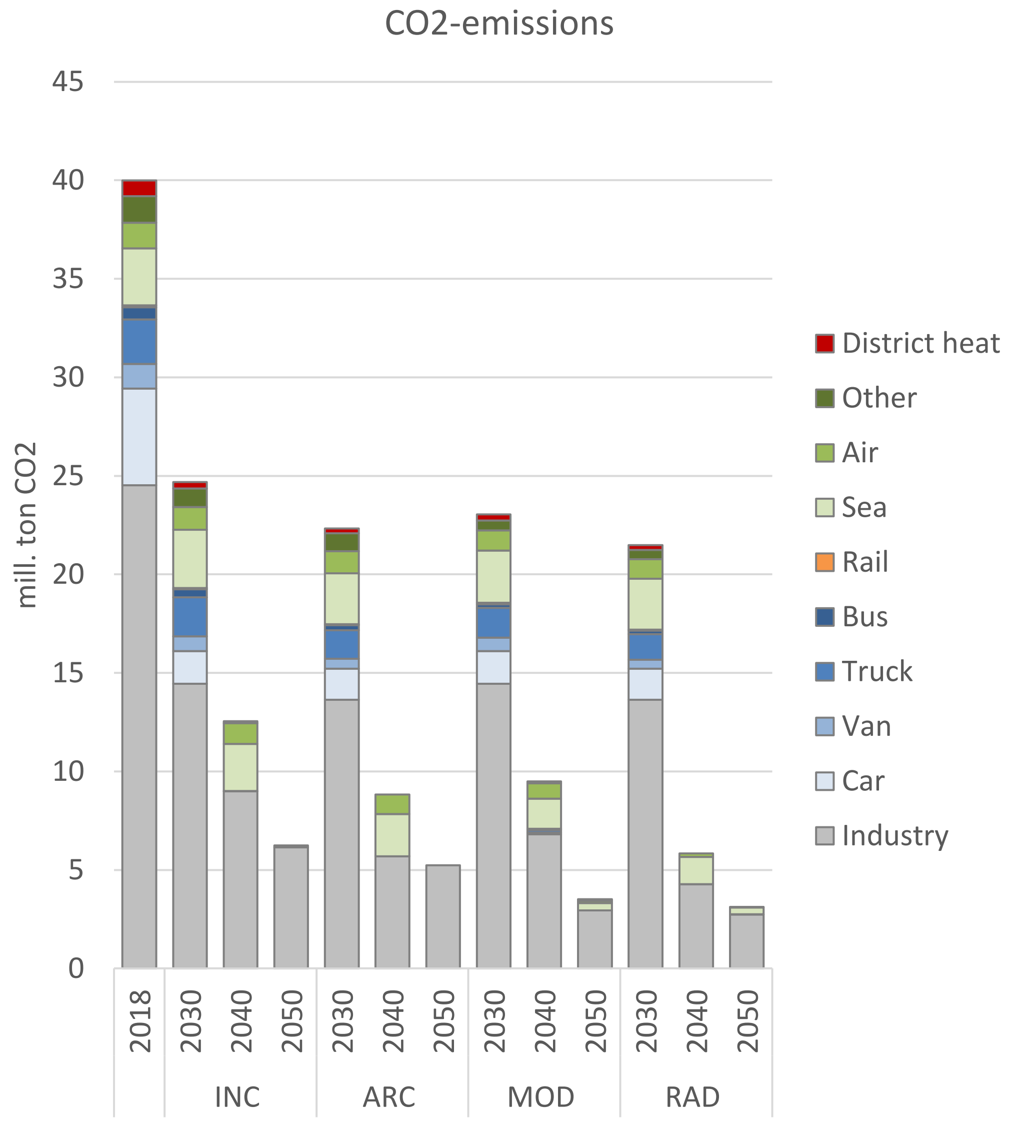
Minor <------------Subsystem change ------------> Major

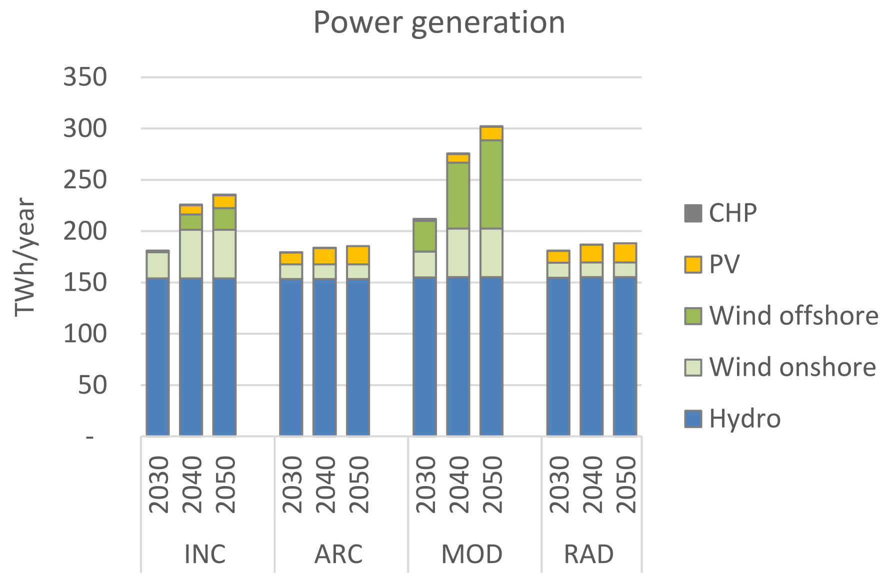
Technological change

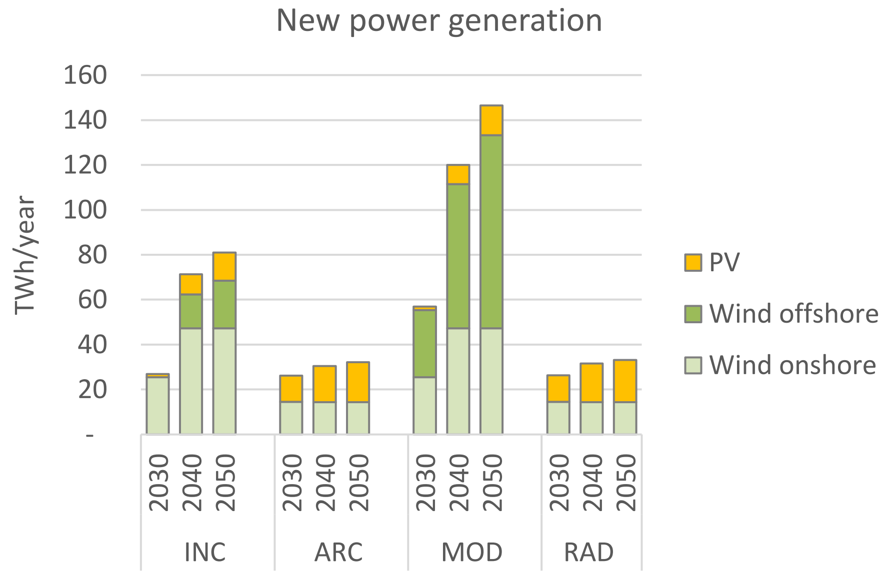
Minor <--------------------------------System architecture change--------------------------------> Major

Socio-institutional, cultural change

Example of results





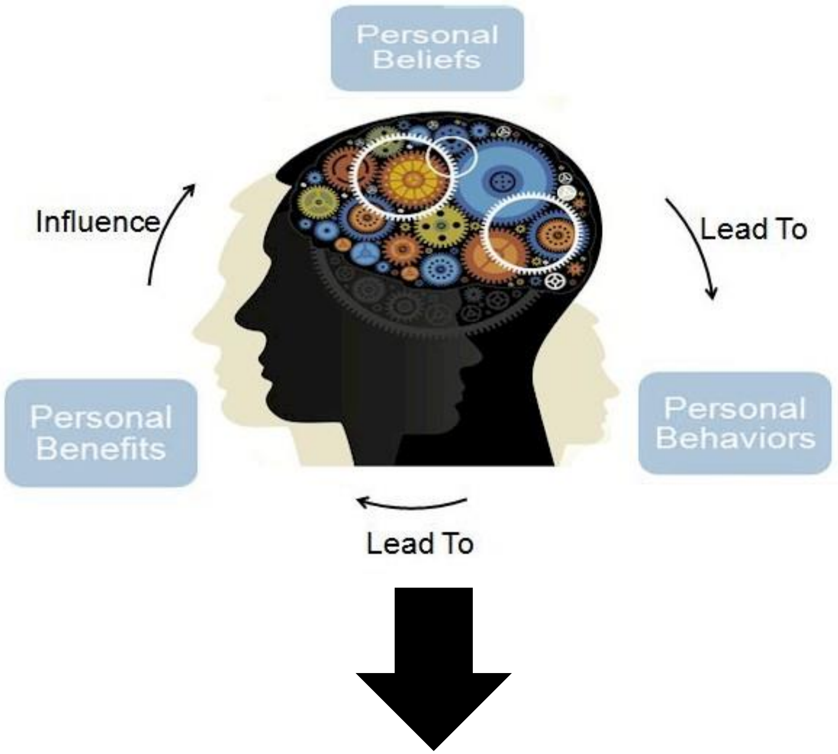


Linkage with ABM to represent behaviour in energy systems

- We will evaluate and test different methods for a bi-directional connecting agent-based model with the energy system model in ongoing project.

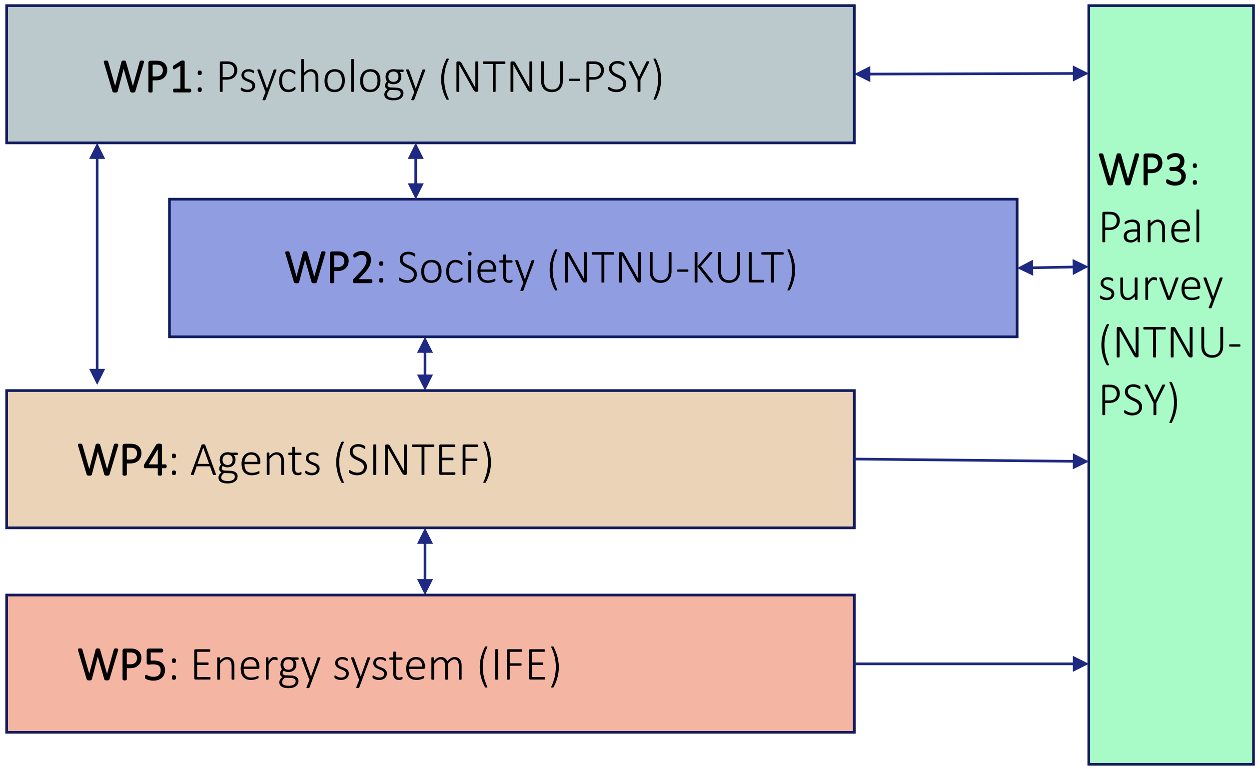
Three case studies:

- Building mass upgrade
- Building applied PV
- Flexible demand in buildings



$$
\begin{array}{ll}
\text{maximize} & \mathbf{c}^{\mathrm{T}}\mathbf{x} \\
\text{subject to} & A\mathbf{x} + \mathbf{s} = \mathbf{b}, \\
 & \mathbf{s} \geq \mathbf{0}, \\
 & \mathbf{x} \geq \mathbf{0}, \\
\text{and} & \mathbf{x} \in \mathbb{Z}^n,
\end{array}
$$

Interdisiplinary approach



WP6: Project Management, user involvement, dissemination (Pernille Seljom, IFE)

WP1: Psychology, Consumer decision strategies (Christian A. Klöckner, NTNU-PSY)
Developing and use a decision-making model which is sensitive to the societal, technical, and political context

WP2: Society, Socio-technical constraints and enablers (Tomas Moe Skjølsvold, NTNU-KULT)
Organizational, institutional, technological and practical conditions and processes that enable or disable the successful implementation of energy efficiency
Responsible for facilitating work across the scholarly disciplines and methods involved in the project

WP3: Panel Survey (Christian A. Klöckner, NTNU-PSY)
Bundling empirical work related to data collection

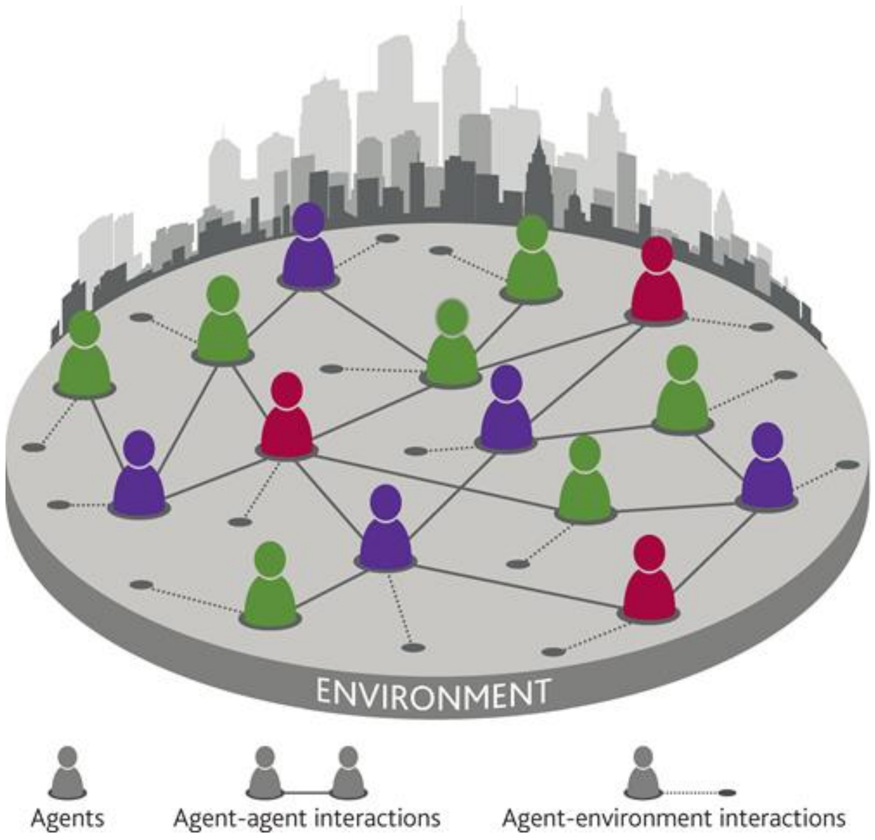
WP4: Agent-based modelling (Lars Hellemo, SINTEF)
Provide insights on the behavior of collective consumers in and with details of individuals consumer-decision processes in a societal context
Bridge the qualitative research in WP1-WP3 to quantitative input on consumer-decisions in WP5

WP5: Energy system modeling (Pernille Seljom, IFE)
Energy system analysis considering consumer-dependent decisions in private household towards 2050
Investigate different methodologies to couple agent-based model with energy system model

Agent-Based Models (ABM) for Energy Behavior

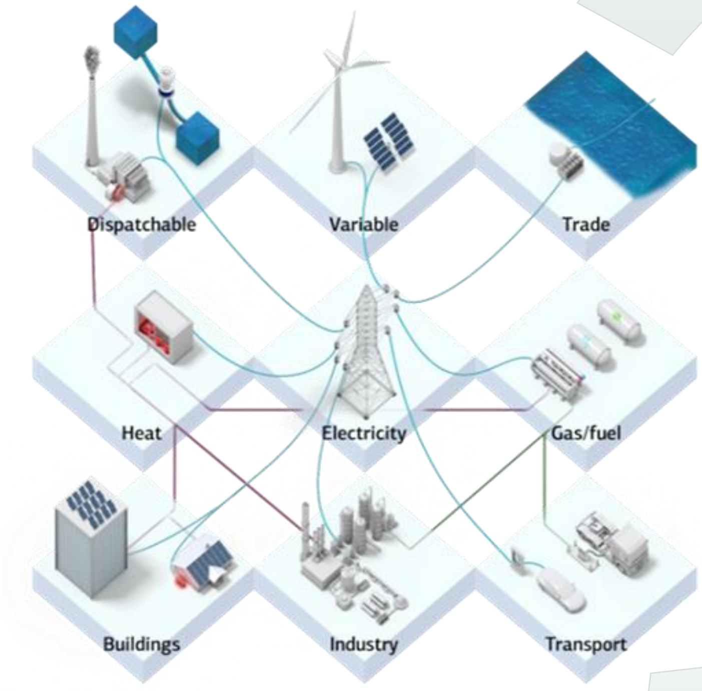
- **Agent-based models (ABMs)** may yield more realistic predictions than equation-based models

- **Top-down modeling** approach focused on individuals and their interaction within an environment



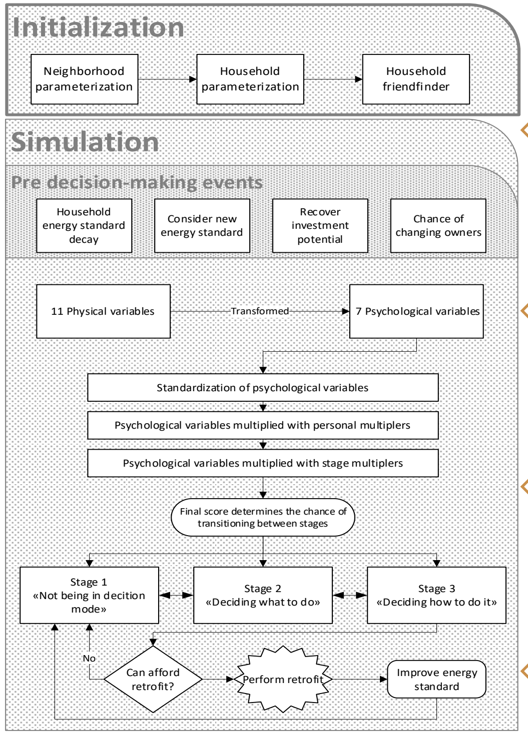
Framework design
- Interaction ABM & ESM

Energy efficiency measures
Electricity prices
Capacities
Demand profiles



Energy System model (ESM)

Energy standards
Energy consumption
Retrofits performed over time
Potential realized vs predicted



Agent-Based Model (ABM)

Distributed Computing

Hyperparameter Optimization

Optimizing agent decisions

Uncertainty Modeling

Questions?