Transportation biofuels and climate change mitigation

Francesco Cherubini

Industrial Ecology Programme
Department of Energy and Process Engineering
Norwegian University of Science and Technology (NTNU)
Trondheim, Norway

NTNU

Research partners:

FME Bio4Fuels

Bio-resources

Lignocellulose • Organic residues

Technologies

- Biochemical
- Thermochemical
- Chemical

Stakeholders

- Resource owners
- R&D institutes
- Industry
- Authorities
- NGOs

Bio-resource , Environment, Climate

Primary Biomass Conversion

Secondary Conversion and upgrading

Process design and End Use

SUSTAINABILITY

Markets

Aviation fuel • Heavy Diesel • Biogas • CHP • Valorised Side Streams

Public bodies:

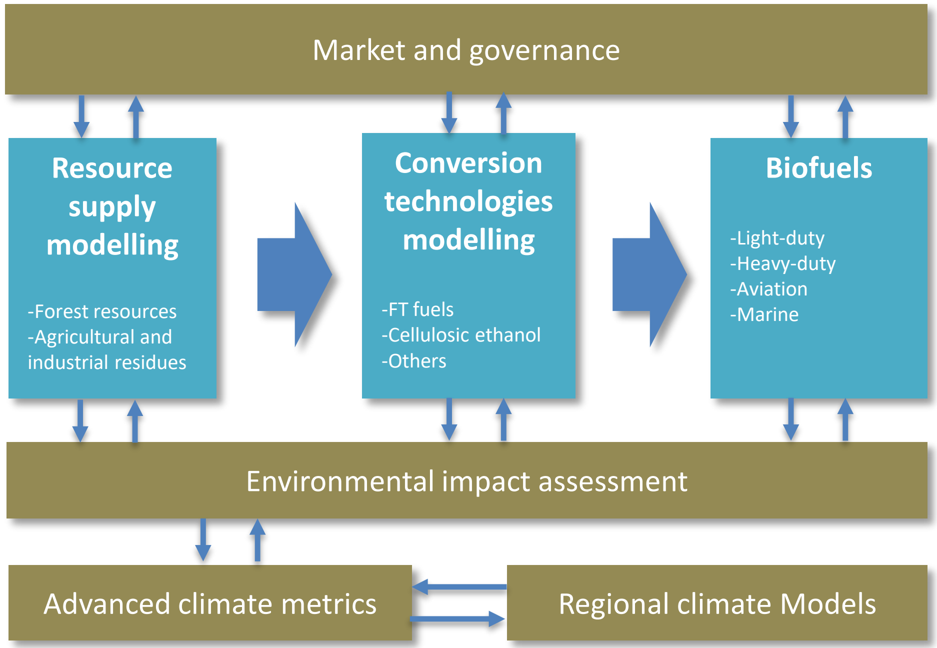
Fylkeskommuner:

- Akershus
- Hedmark
- Nord- og Sør-Trøndelag
- Oppland
- Telemark
- Østfold

Innovasjon Noreg

Industry, NGO's:

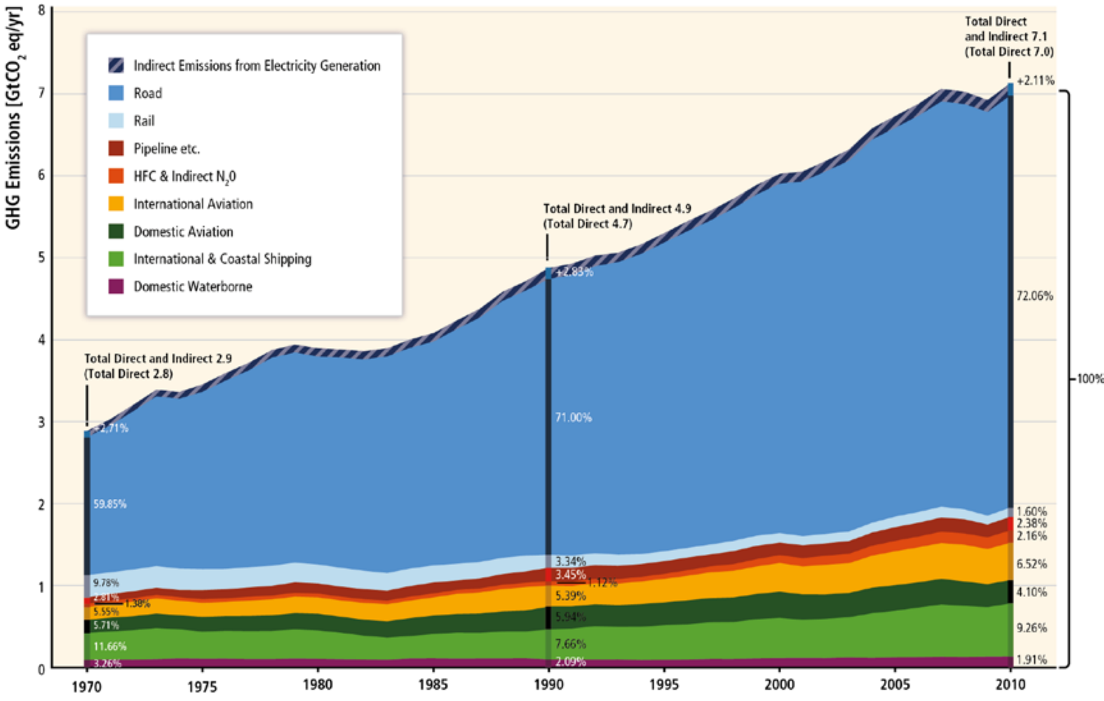
Integrated modelling framework for assessment of biofuel deployment strategies in Norway



- ✓ Identification of most promising value chains
- ✓ Advanced climate assessment considering the complexity of biofuels-land-energy nexus
- ✓ Results are upscaled at National level
- ✓ Consideration of the most important market induced effects
- ✓ Inputs to improve Policy instruments on biofuel deployment

The transport sector accounts for 7 $GtCO_2$ direct emissions in 2010, of which more than 70% come from road transport

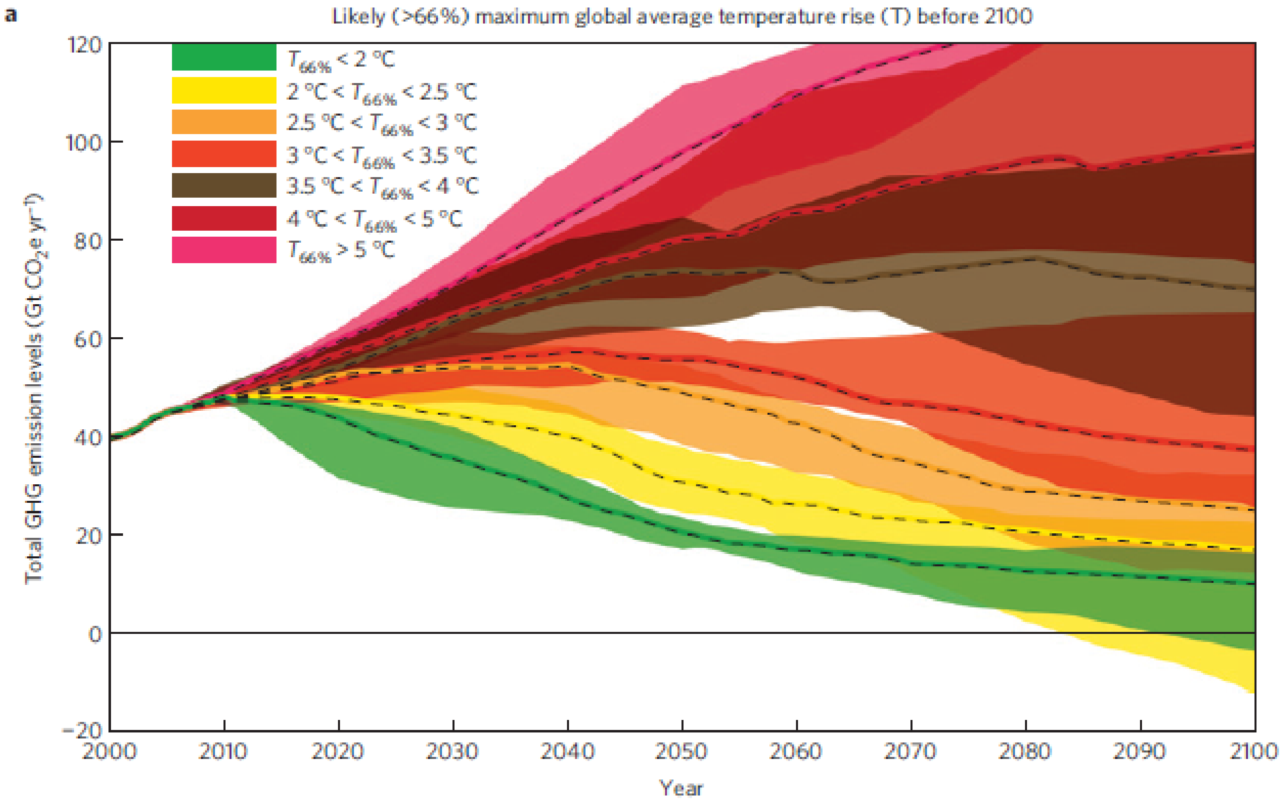
Without implementation of substantial mitigation policies, **transport emissions will increase at a faster rate than emissions from any other sector** and reach around 12 Gt CO_2-eq./yr by 2050



IPCC AR5 WG III

NTNU

Future emission trends and peak warming



Rogelj, J., et al. (2011). Nature Clim. Change 1(8): 413-418.

NTNU

Stringent mitigation results in less than 40% fossil fuel in 2100. Many models yield 20-40% biofuels in the global transport sector

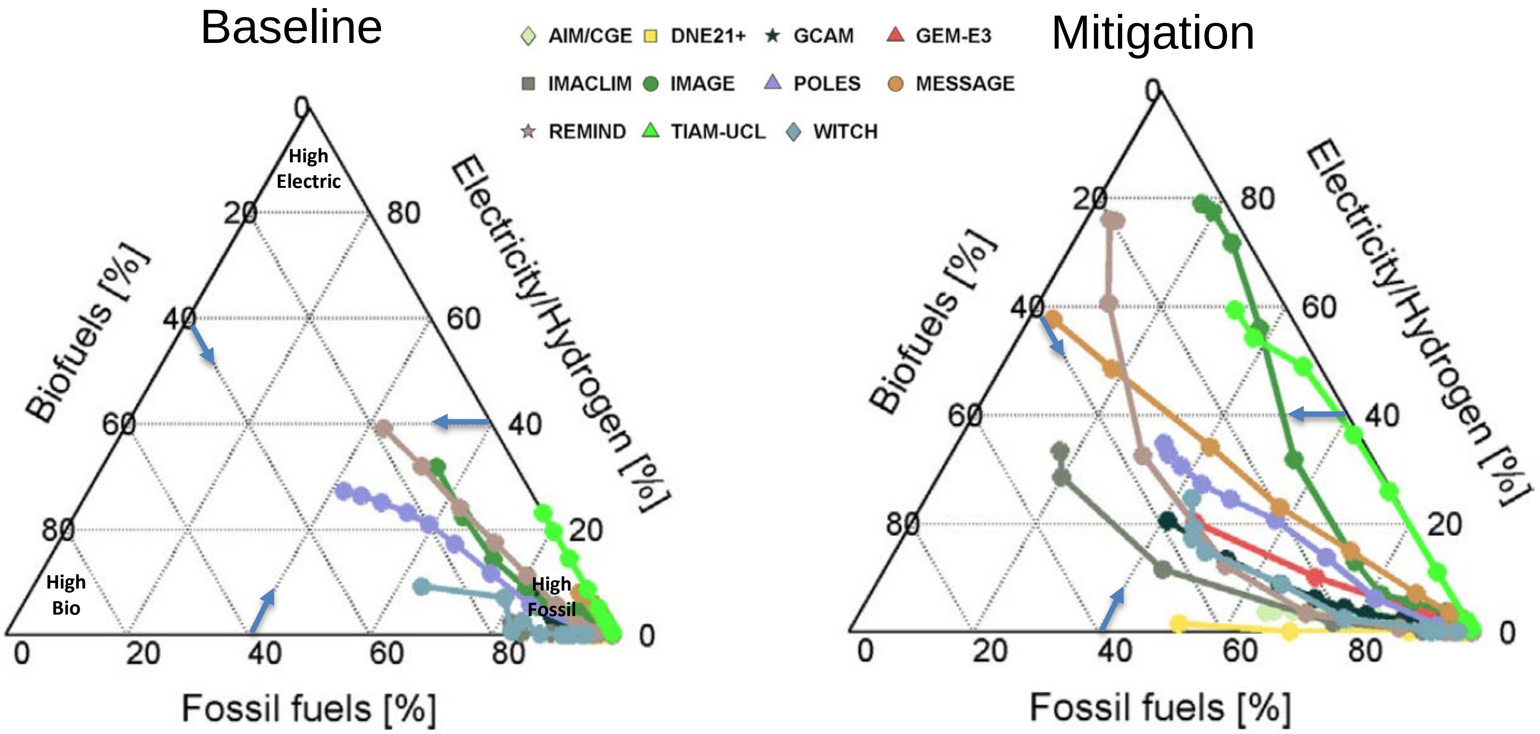
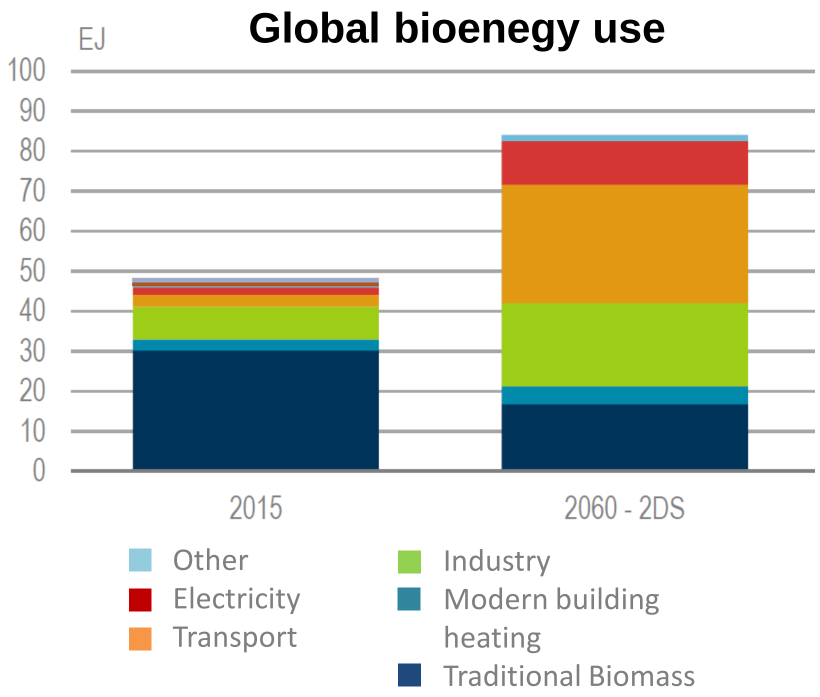
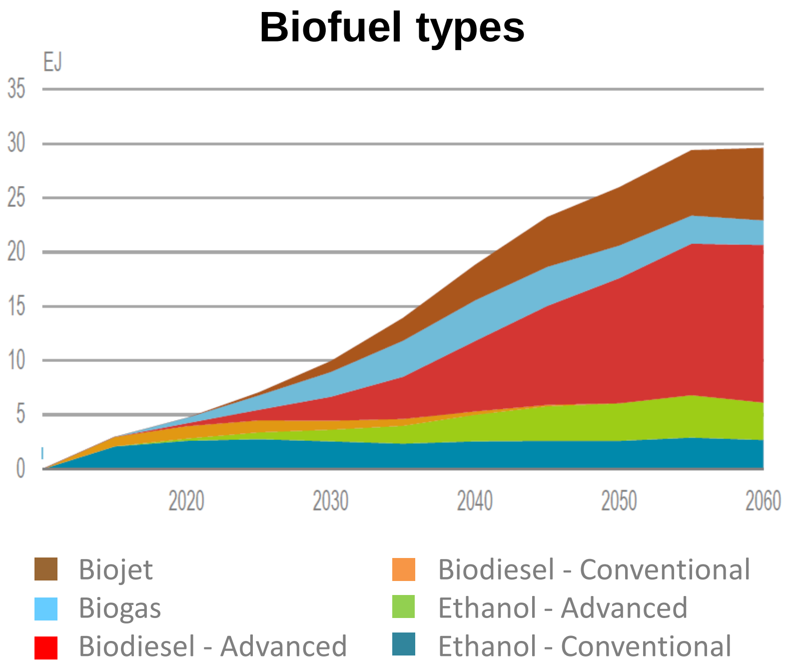


Figure 6, Bottom Panel - in Edelenbosch et.al 2016 Transportation Research Part D

IEA scenarios for bioenergy and biofuels under the 2 °C target

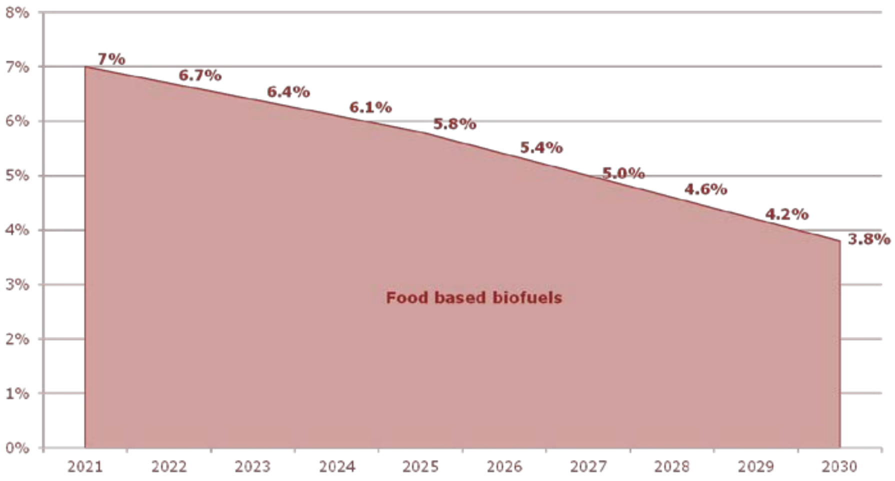


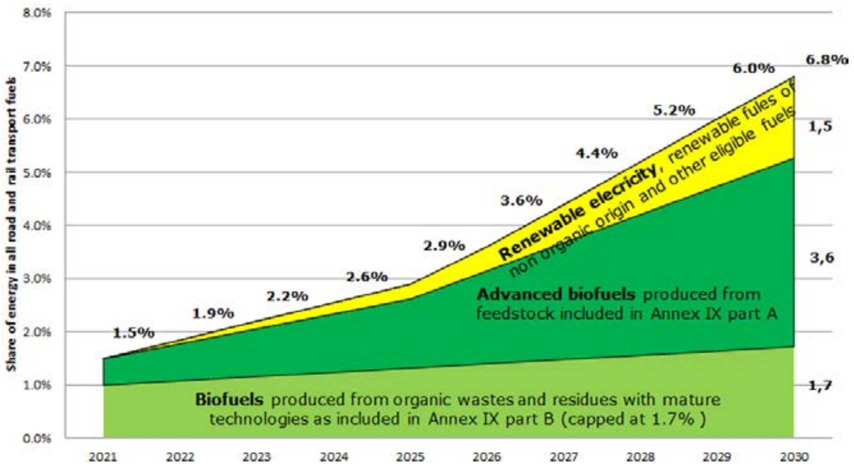


Policy context
Biofuel mandates in EU

Revised Renewable Energy Directive (**RED II**, under discussion)

- Increase the share of advanced biofuels of fuels supplied in 2030
- Phase-out food crop-based biofuels from 2021
- To ban the use of biodiesel from all vegetable oils by 2030 and of palm oil biodiesel as early as 2021





Policy context
Biofuel mandates in Norway

Biofuels targets from the National Transport Plan 2018-2029

	2017	2018	2019	2020	2030
Biofuels in transport sector	7%			20%	
Advanced biofuel share	2.5%	3.5%	4.5%	8%	
Aviation biofuels			1%		30%

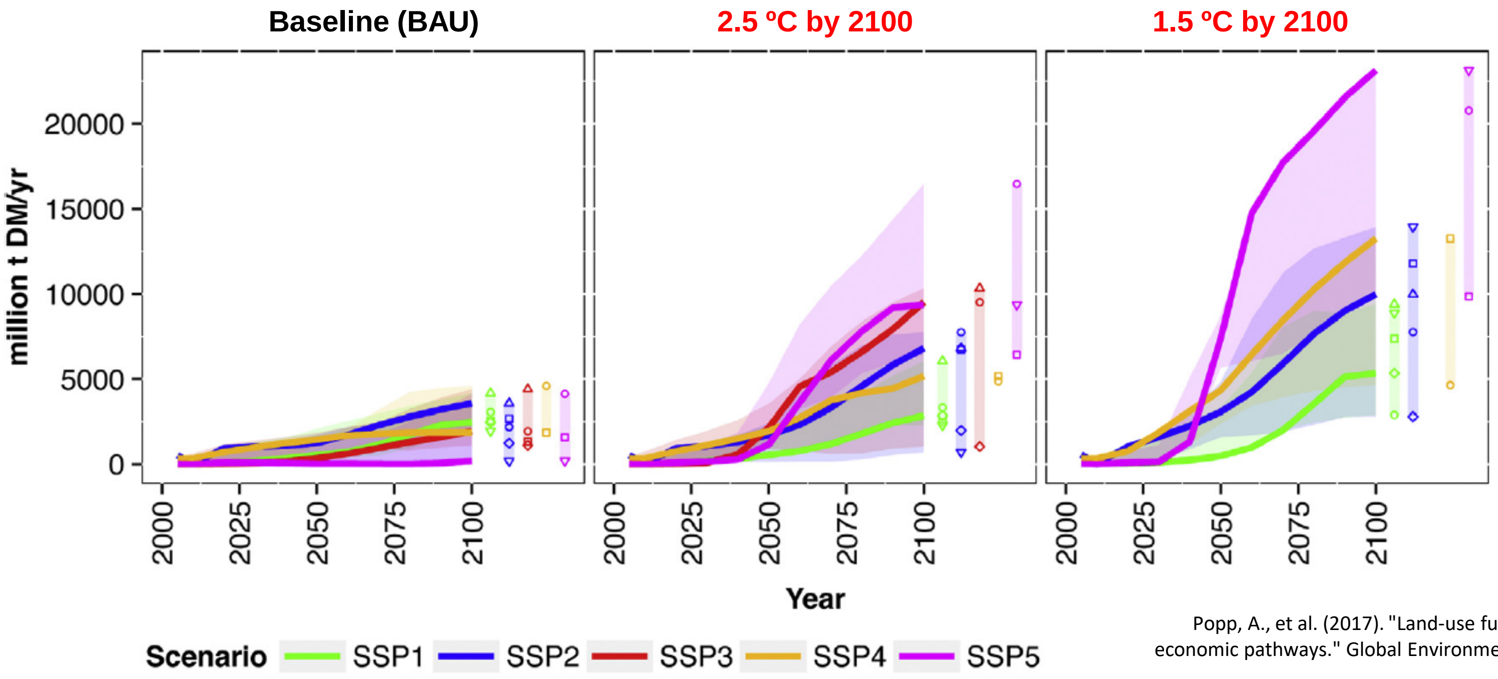
World futures in the 21st century: the Shared Socio-economic Pathways (SSPs)

Different characteristics

- Population
- Economic growth
- Dietary regimes
- Technological developments
- Land use regulations
- …

O'Neill, B. C., et al. (2017). "The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century." Global Environmental Change: 169-180.

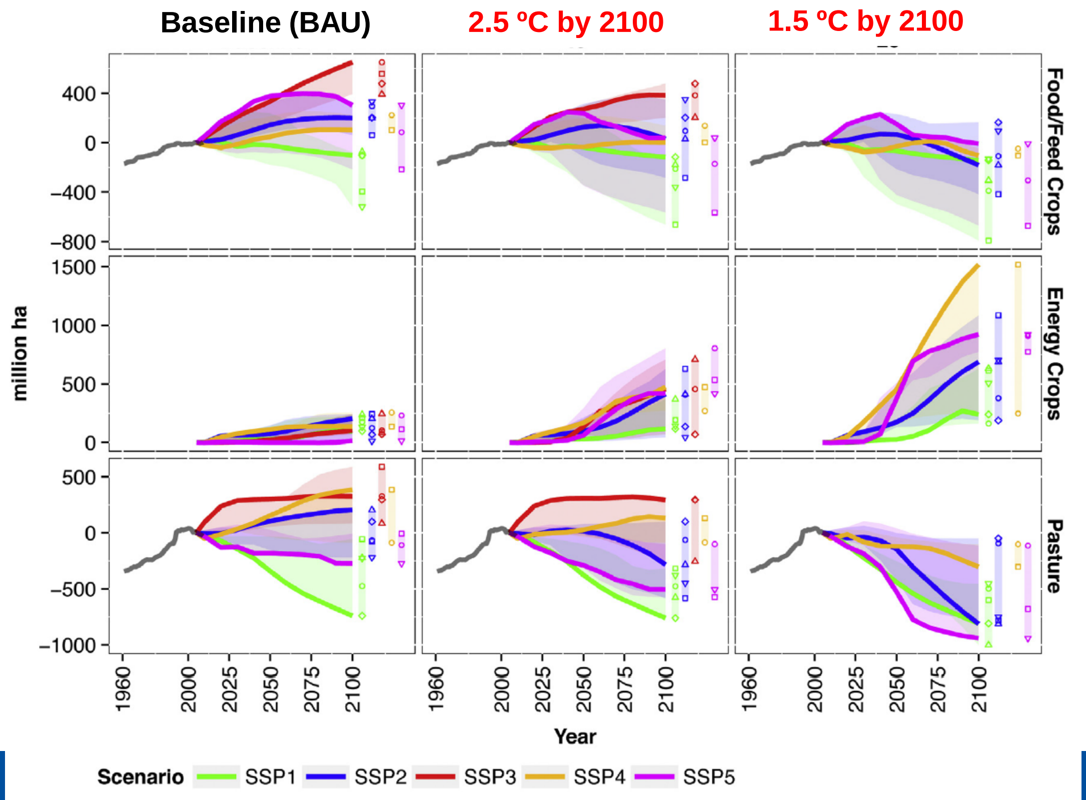
The demand for 2nd generation bioenergy crops can range from less than 5,000 up to about 20,000 million ton per year by 2100 under stringent climate mitigation objectives



Popp, A., et al. (2017). "Land-use futures in the shared socio-economic pathways." Global Environmental Change 42: 331-345.

NTNU

Bio-energy plays a critical role in all mitigation scenarios. The SSPs allocate between 120 million ha (SSP1) and 1517 million ha (SSP4) to ligno-cellulosic bioenergy crop in 2100

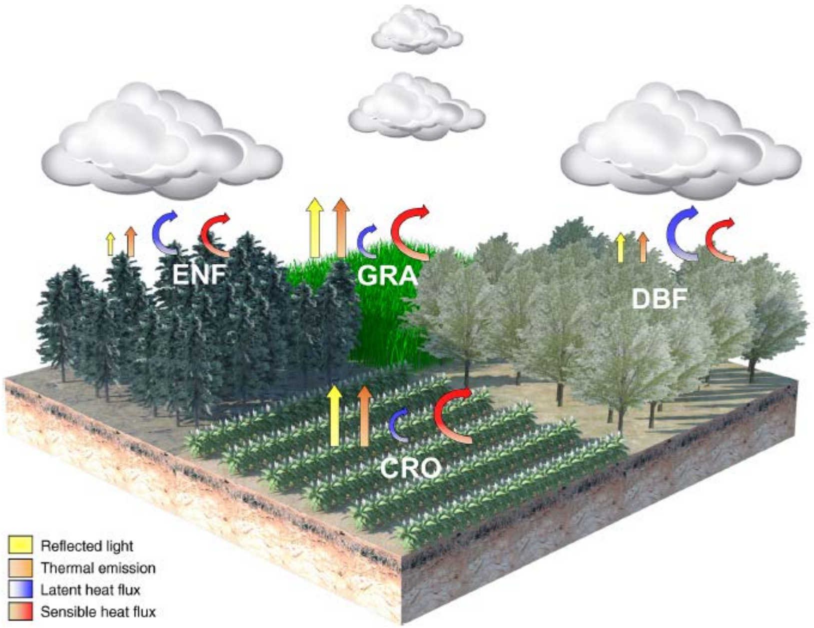


Competition for land

Land for bioenergy crops comes at the expense of other natural land (SSP4), unprotected forests (SSP3), land for food and feed crops (SSP2, SSP4 and SSP5) and pasture land (SSP2, SSP4 and SSP5)

Popp, A., et al. (2017). "Land-use futures in the shared socio-economic pathways." Global Environmental Change 42: 331-345.

Not only Carbon: Land management and land use changes can affect the climate system through many complex mechanisms

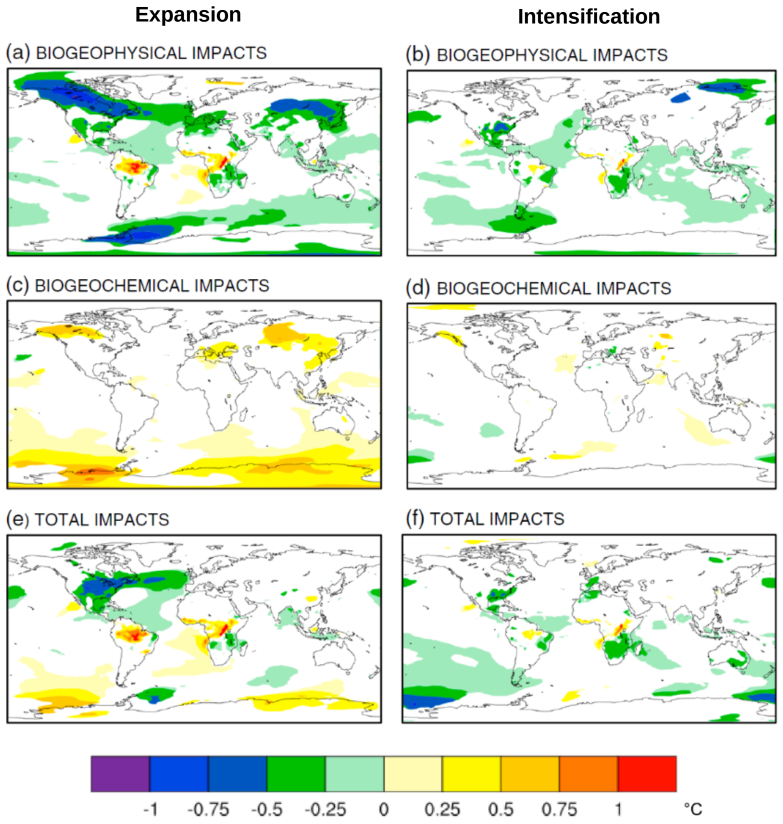


Biogeochemical effects:
- CO_2 and other GHGs
- Biogenic VOCs

Biogeophysical effects:
- Surface albedo
- Evapotranspiration
- Surface roughness

Figure from: Zhao, K. and R. B. Jackson (2014). Ecological Monographs 84(2): 329-353.

Climate impacts of LUCs from large-scale biofuel deployment



Difference in surface temperature (°C) between biofuels and no-biofuel scenarios

		Intensification	Expansion
Biogeophysics (e.g., albedo)			
	Extratropics	-0.18	-0.12
	Tropics	-0.05	-0.08
	Globe	-0.12	-0.1
Biogeochemistry (CO_2)			
	Extratropics	0.16	0.05
	Tropics	0.06	0.03
	Globe	0.11	0.04
Combined			
	Extratropics	**-0.02**	**-0.07**
	Tropics	**0.002**	**-0.06**
	Globe	**-0.01**	**-0.06**

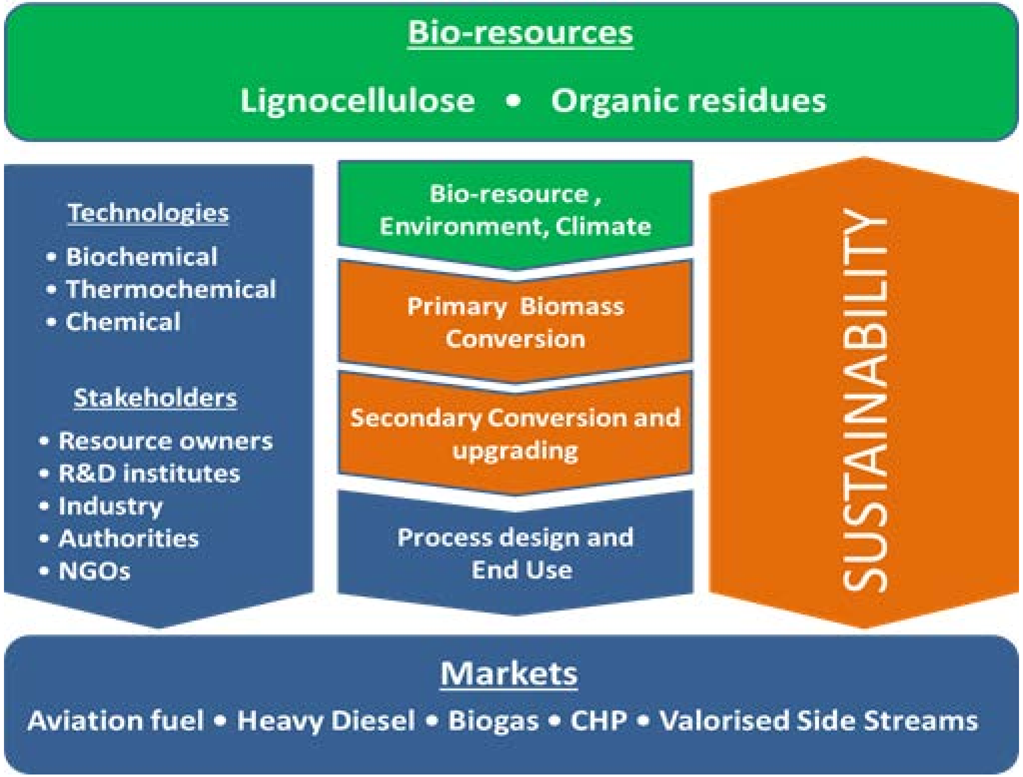
Hallgren, W., et al. (2013). "Climate impacts of a large-scale biofuels expansion." Geophysical Research Letters 40(8): 1624-1630.

Key Scientific Challenges

Picture from: Tilman, D., et al. (2009) Science 325(5938): 270-271.

- Land/Climate interactions associated with large-scale biofuel production remain largely unexplored, especially when it comes to regional climate
- Technological improvements still needed
- Reconcile sectorial studies with large projections in IAMs
- Links to ecosystem services, food security, land degradation, desertification

FME Bio4Fuels



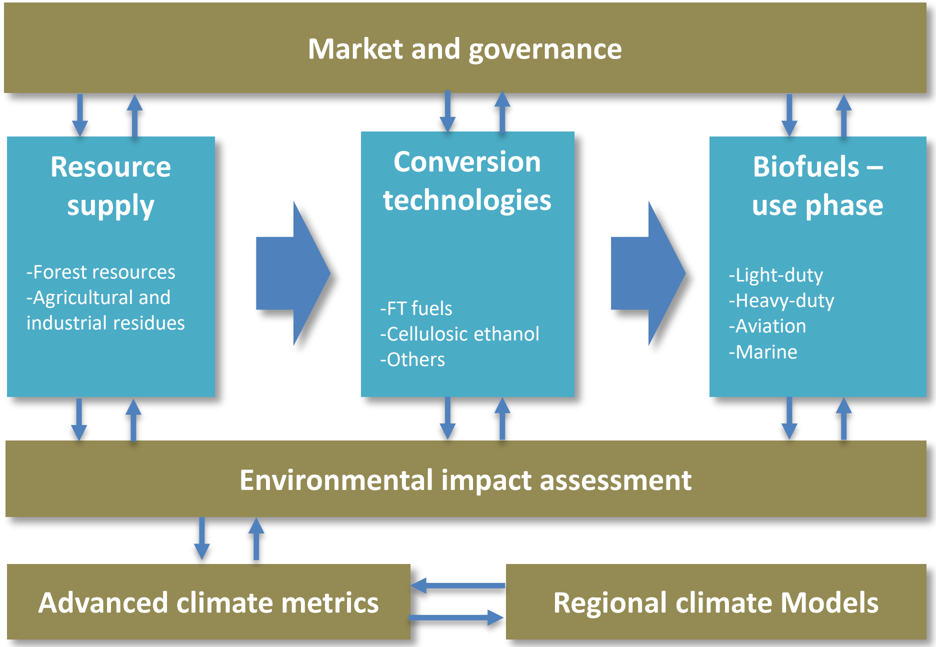
Research partners:

Public bodies:

Fylkeskommuner:
- Akershus
- Hedmark
- Nord- og Sør-Trøndelag
- Oppland
- Telemark
- Østfold

Industry, NGO's:

Integrated modelling framework for assessment of large-scale biofuel deployment in Norway



- ✓ Identification and analysis of the most promising value chains
- ✓ Address the complexity of the biofuels-land-energy nexus
- ✓ Analysis at a Norwegian system level
- ✓ Inclusion of market induced effects
- ✓ Identification of the best policy instruments to boost biofuel deployment in Norway

Thank you for your attention