

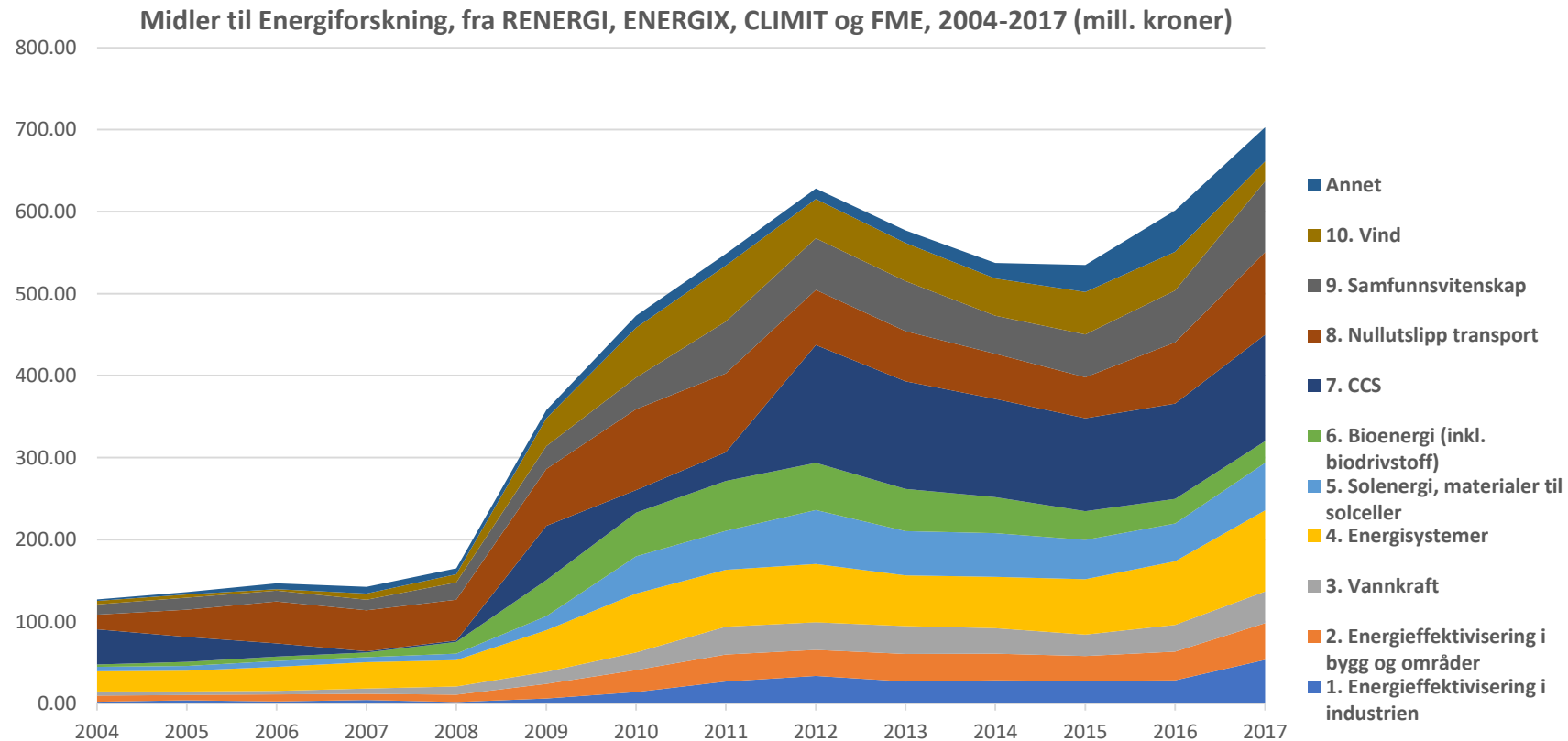


Effects of the bioenergy research in Norway

Success stories 2008-2017

Ordered by the Ministry of Petroleum and Energy OED

Odd Jarle Skjelhaugen, Bio4Fuels Days 11. October 2018



The 8 FMEs

ZEN	Zero emission neighbourhood's in smart cities	Energy in buildings
HighEFF	Energy efficient industry	Energy in industry
NCCS	Norwegian carbon capture and storage	CCS
SUSOLTECH	Sustainable solar cell technology	Materials solar cells
CINELDI	Intelligent electricity distribution	El. grid
HydroCen	Hydropower technology	Hydropower
MoZEES	Mobility Zero Emission Energy System	Batteries & hydrogen transport
Bio4Fuels		Biofuels, biogas

Status Bioenergy in Norway 2018

Norway 215 TWh 2017

Bioheat: Steady

District heat 5.5 TWh, Stoves 6 TWh.

Biogas: All time high and still growing

3 new big plants: Oslo EGE, Greve, Biokraft. 1 TWh.

Breakthrough LiquidBioGas LBG technology

Biofuels: Just started

Norwegian production low

Planned & operating: Silva Green Fuel, Biozin , Perstorp, Borregaard

Consumption growing fast, 19 % of total fuel 2017, only 0,4%
produced in Norway IMPORT

Future

Bio-total:

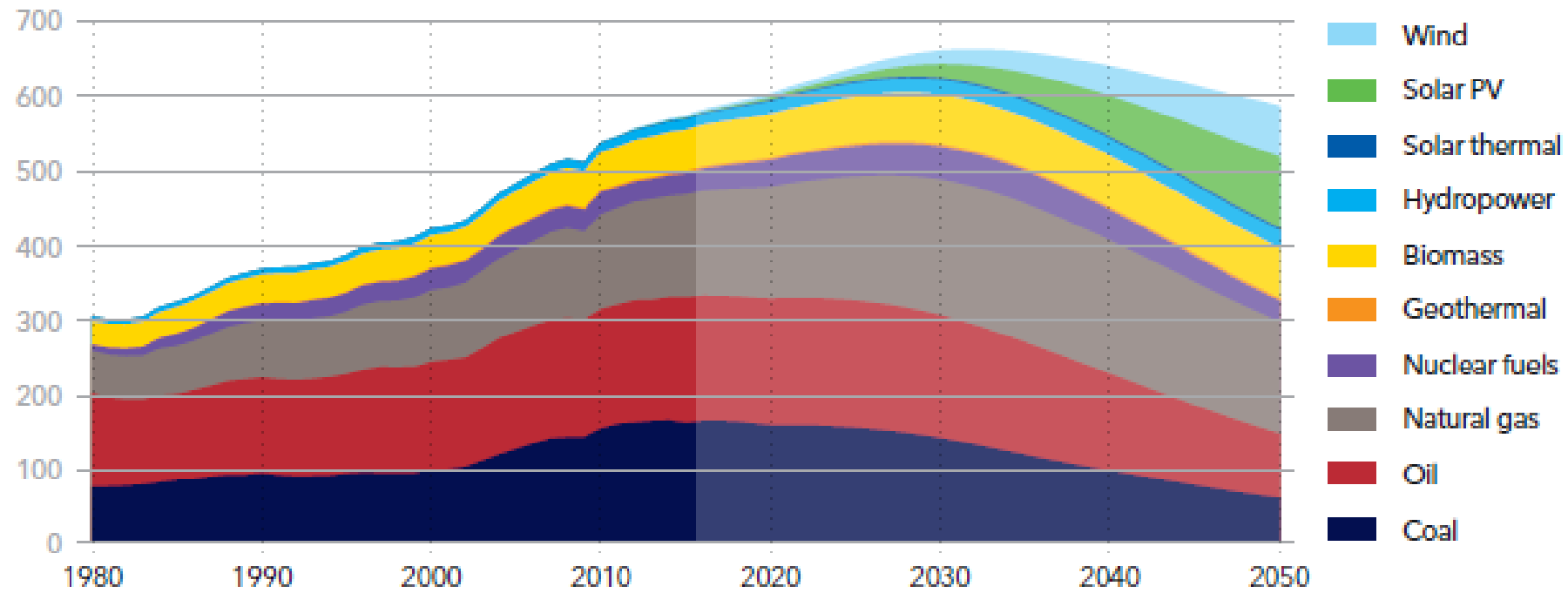
Growing interest

Huge market

Also fossil oil refineries interested in biomass feedstock

World primary energy supply by source

Units: EJ/yr



Ref: DNV-GL 2018



Case 1

Cheaper and faster enzymes for biorefineries

Borregaard, Novozymes, NMBU

Challenges

So far, not possible to convert forest biomass to glukose fast, effective and cheap enough. Enzyme cost a barrier for producing competitive chemicals and biofuels.

Innovations

The enzyme CBP21 and the function of the enzyme group LPMOs found in 2010. Breakthrough for cheaper 2G bioetanol.

LPMO's need hydrogen-peroksid, not oxygen, to work well. Found in 2016. Lower chemical and energy cost as a result.



Case 1

Cheaper and faster enzymes for biorefineries

Borregaard, Novozymes, NMBU

Effects and potential

In 2011 the Danish enzyme producer Novozymes bought the right to utilize the NMBU-patent on CBP21 and the LPMO's.

Today, Novozymes produce these enzymes for sale to biorefineries world wide

Borregaard, the worlds most advanced biorefinery, use LPMO- enzymes and H_2O_2 in their BALI-demo plant. Result: simpler operation and cheaper glukose production.



Case 2

Demo-plant for advanced forest-based biofuel

Silva Green Fuel*, SINTEF

(*owned by Statkraft and Södra),

Challenges

Forest residues is an important feedstock for advanced biofuel, but the relevant value chains are not economically viable

Innovations

The Norwegian Statkraft and the Swedish Södra established in 2015 Silva Green Fuel to develop production of biofuel from woody biomass

During 3 years the company and SINTEF evaluated 30 process technologies, completed basic design studies and produced fuel samples



Case 2

Demo-plant for advanced forest-based biofuel

Silva Green Fuel, SINTEF

Effects and potential

Silva Green Fuel decided in 2017 to build a demo plant. The preferred technology vendor is the Danish company Steeper Energy

Demo Plant will be designed as a scaled down commercial plant

Full-scale plant to be decided in 2020, in operation 2022/23

Annual production: 100-150 million litre, about 20% of Norwegian consumption 2017

Annual climate impact: 250-375.000 tonnes lower CO₂ -emission

Next plant in Sweden, and more plants to come

An aerial photograph of an industrial site in Tofte, Oslofjorden, Norway. The foreground features several large, red industrial buildings with dark roofs, situated on a cleared, light-colored ground. To the left, there's a large, open area that appears to be a construction or storage site. In the center, a small body of water is enclosed by a concrete wall. The background shows a vast expanse of water, likely the Oslofjorden, with distant hills and a city skyline visible on the horizon under a hazy sky.

Tofte, Oslofjorden, the site
for pilot and full-scale
biodiesel production



Case 3

Advanced biogas value-chain for source separated food waste in Oslo

Oslo EGE, Cambi, NIBIO, NMBU

Challenges

Technologies and systems for biogas value chains still are immature

Construction and operation of biogas plants often depends on economic support

Innovations

The Oslo EGE *'food waste to energy and fertilizer value chain'*, with very high claims on energy efficiency and bioreact quality, is first of its kind world wide

New technology for converting biogas to liquid biogas LBG has been developed



Case 3

Advanced biogas value-chain for source separated food waste in Oslo

Oslo EGE, Cambi, NIBIO, NMBU

Effects and potential

After 4 years testing and optimising, the EGE-plant was in full operation i 2017, creating value from food-waste from 600.000 inhabitants in Oslo

150 buses, 60 minibuses and 60 municipal trucks are powered by LBG from the plant

The value chain is closely linked to agriculture, and farmers buy high value bio-fertilizer from the plant, replacing mineral fertilizer and reducing climate gas emissions

The value chain and the technology has an international market. Technology provider Cambi is now involved in planning a similar plant in Beijing.

Romerike Biogass Pant outside Oslo





Case 4

Bioenergy and climate

IPCC, NTNU

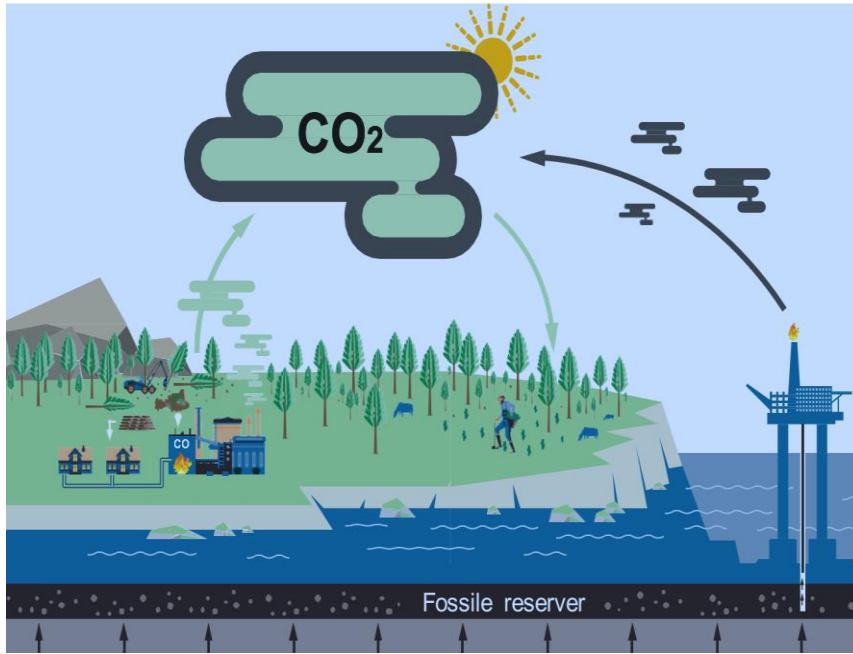


Challenges

Crucial for Norway to follow the scientific part of the international climate observations and calculations, especially within the energy sector.

Innovations and effects

Albedo (reflection of solar energy) is a key mechanism for climate control. Earlier not included in the international climate analyses. NTNU-researchers are pioneers and international leading. Relevant for calculating climate impact caused by land use change and use of bioenergy.



Case 4

Bioenergy and climate

IPCC, NTNU

The short- and the long-lived carbon

Improved modelling and better understanding of the carbon cycle for bioenergy contra fossil energy. And understand how reversible or irreversible the man-made climate changes are.

Potential

Two Norwegian researchers are main authors in IPCC reporting. Frequently consulted by Norwegian Environment Agency and Ministry of Climate and Environment



Case 5

Low-effect fireplace for low-energy houses

Dovre, SINTEF

Challenges

New low-energy houses need fireplaces with high energy efficiency and low particle emissions, but low effect and long burning time, a challenging combination.

Innovations

The new fireplace insert ZEN100 deliver down to 1,9 kW with 80 % efficiency and low particle emissions. Two versions, with glass on one or two sides (look through).

The unique design ensures strict air flow control and high temperature in the combustion chamber, a key to success.



Case 5

Low-effect fireplace for low-energy houses

Dovre, SINTEF

Effects and potential

1008 fireplace inserts sold after introduction to the market in 2015.

Dovre /ZEN100 was honoured number 3 RCN Innovation prize 2015.

Dovre plans to produce a wood stove with the same combustion chamber insert, thus strengthening Dovre market position.

Dovre, in collaboration with Jøtul, Kleber and SINTEF, have started a project on developing *automatic wood stove control*. Based on wanted room temperature the stove will produce the heat needed without reducing the good combustion properties.

Further work

Economic impact (value for money)

Produce easy-to-read 2-pagers

Two consultant companies strongly involved: IMPELLO and MENON

Reflection: This a recipe for how present future Bio4Fiels results?