HighEFF

Energy Efficiency – Research Center

Knowledge - Friendship - Teamwork

FME
FORSKNINGS-
SENTER FOR
MILJØVENNLIG
ENERGI
Norges forskningsråd

The Annual Consortium Meeting

~100 participants

1/3 from user partners

Strategic input

Prosess21 EU

General assembly

International academia

Process systems engineering

Reference group meetings

Industry perspectives

Reducing energy use in practice

Executive board

R&D

Results and progress

PhD/PDs posters

HighEFF

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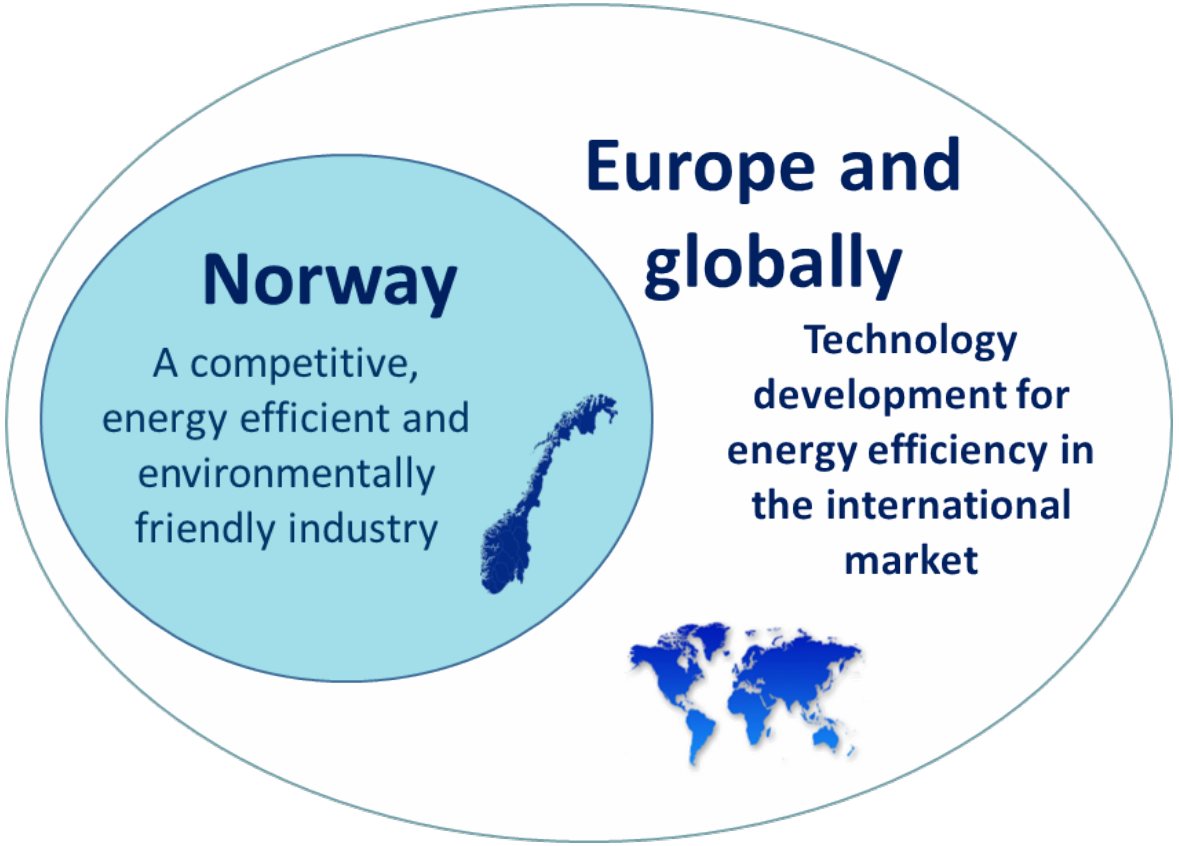
Norges forskningsråd

HighEFF Vision

Joint effort for creating a competitive, energy efficient and environmental friendly industry for the future



FME HighEFF

Largest effort in supporting research, development and innovation

To structure the research

- **41 partners**
- **2016-2024**
- **23 PhD / Post docs**
- **400 MNOK**

20-30 % reduction in specific energy use

10 % reduction in greenhouse gas emissions

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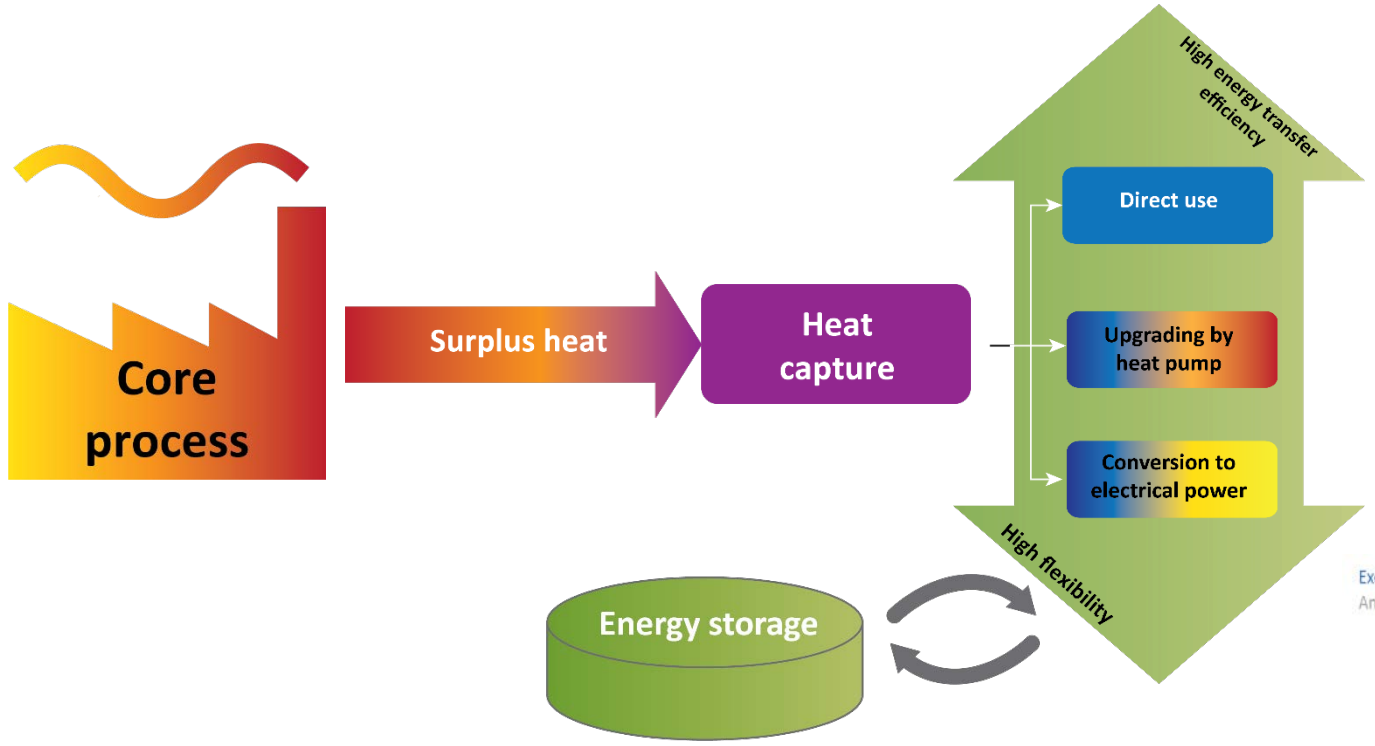
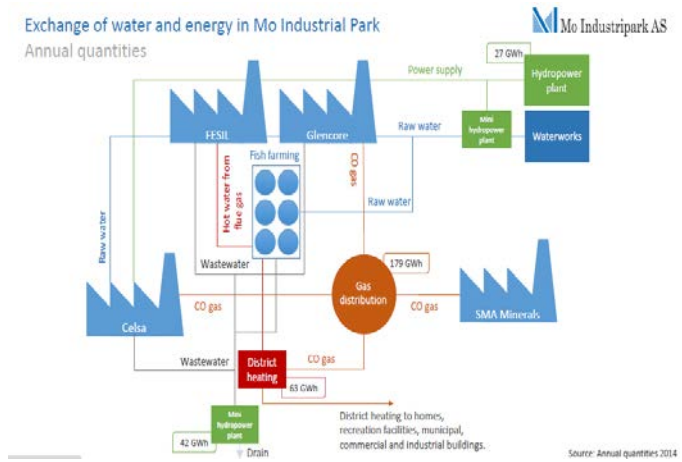
Norges forskningsråd

Focus areas of HighEFF





Centre Management Team

Centre Director
SINTEF ER

Petter E. Røkke
Research Director

Scientific Leader
NTNU

Truls Gundersen
Professor

Scientific Coordinator
SINTEF ER / NTNU

Petter Nekså
Chief Research Scientist/Professor

Centre Coordinator
SINTEF ER

Line Rydså
Research Manager

RA Leaders



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WBS

Centre Building

Education

Management

Methodologies
RA 1
Egil Skybakmoen

- KPI's, Energy and Exergy Analyses — *Olaf T. Berglihn*
- Process Systems Engineering — *Sigurd Skogestad*
- Future processes — *Asbjørn Solheim*

Components
RA 2
Armin Hafner

- Heat Exchangers — *Geir Skaugen*
- Work Recovery & Compressors — *Christian Schlemminger*
- Natural Working Fluids — *Trygve M. Eikevik*

Cycles
RA 3
Trond Andresen

- Energy-to-Power Conversion — *Trond Andresen*
- HTHP, Cooling and Drying — *Michael Bantle*
- Energy Storage — *Hanne Kauko*

Applications
RA 4
Aud Nina Wærnes

- Process Improvements — *Bernd Wittgens*
- Surplus Heat Recovery — Vidar T. Skjervold
- Industry Clusters and Technology Integration — *Kristian Einarsrud*

Society
RA 5
Ingrid Camilla Claussen

- Innovation, Barriers and Enablers — *Jens Røyrvik*
- Novel Emerging Concepts — *Arne Petter Ratvik*
- Dissemination and Communication — *Ingrid Camilla Claussen*

Case Studies
RA 6
Monika Nikolaisen

- Metal, Material — Ida Teresia Kero
- Oil, Gas, Energy — Monika Nikolaisen
- Food, Chemical — Michael Bantle
- Industry Clusters — Kristian Einarsrud

Training of Experts

HighEFF

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Norges forskningsråd

Annual report 2018

Petter E. Røkke
@proekke
Følg

«Our cities are hidden power stations» - Development of smart thermal grids for #energyefficiency in urban areas. Worth reading! :-) #fme #higheff @SINTEF @Statkraft @RCN_Norway

SINTEF Energy @SINTEFenergy
Waste heat and locally-produced renewable energy can be generated by compact, "urban power plants" that are efficient enough to supply heat to entire housing estates
geminiresearchnews.com/2018/01/cities...

13:09 - 18. jan. 2018 fra Trondheim, Norge

3 retweets 3 likes

JANUARY

Petter E. Røkke
@proekke
Følg

Attending @EASACnews meeting on Energy & environment today, giving advice on SET plan priorities within #energyefficiency and discussing policy advice for EU strategies within this topic.
#fme #higheff @EERA_SET @EU_ScienceHub @EU_H2020 @RCN_Norway @stracma

09:25 - 24. apr. 2018

4 retweets 8 likes

APRIL

Petter E. Røkke
@proekke
Følg

Best paper award at @ESCAPE_28 to #fme #higheff paper from Yu, Vikse and Gundersen; "Comparison of reformulations of the Duran-Grossmann model on Work and Heat Exchange Network Synthesis (WHENS)". tugraz.at/events/escape2... @eptntnu @NTNU @EnergyNTNU @SINTEFenergy @RCN_Norway

01:52 - 18. juni 2018

4 retweets 11 likes

JUNE

Horisont 2020
@Horisont2020
Follow

Kunnskapen fremskaffet i Prosjektet SuperSmart etterspørres nå fra resten av Europa. @SINTEFenergy i førersetet for å spare energi i supermarkeder.
#arendalsuka2018 #horisont2020

7:54 am - 15 Aug 2018

5 Retweets 9 Likes

SINTEF Energy
@SINTEFenergy
Følg

Vår forsker Camilla Claussen bidrar til at du (og europeere) kan spise is med god klimasamvittighet
gemini.no/2018/08/norske... #arendalsuka @forskningsradet @EU_Commission @proekke @Nils_Rokke @eptntnu

01:20 - 15. aug. 2018 fra Arendal, Norge

5 retweets 9 likes

AUGUST

Ingrid C. Claussen from HighEFF at Arendalsuka

NTNU Energy
@EnergyNTNU
Følg

Rundt dette bordet er ledere fra mange FMEer, @NTNU OG @SINTEFenergy samlet for å finne ut hvordan vi kan få enda mer #innovasjon ut av forskningssentrene for #miljøvennlig #energi (#FME). Vi kaller det Innovation Task Force

03:23 - 9. jan. 2018

14 retweets 29 likes

MARCH

#SINTEFblog

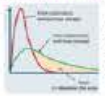
HighEFF Annual Meeting – Picture Blogg

BY INGRID CAMILLA CLAUSSEN

MAY

Alexis Sevault
@AlexisSevault
Følg

Wanna know more about Phase Change Materials and how they contribute to increase #energyefficiency? Read my blog here: blog.sintef.com/sintefenergy/p... @SINTEFenergy @SINTEF @NTNU @eptntnu



What are Phase Change Materials? (Will they be the next bi...
What are Phase Change Materials (PCMs) and what are they used for? Experts say Phase Change Materials are close to maturity as solutions for thermal energy storage (Keeping thing...
blog.sintef.com

09:23 - 9. aug. 2018

3 retweets 9 likes

JULY

SEPTEMBER

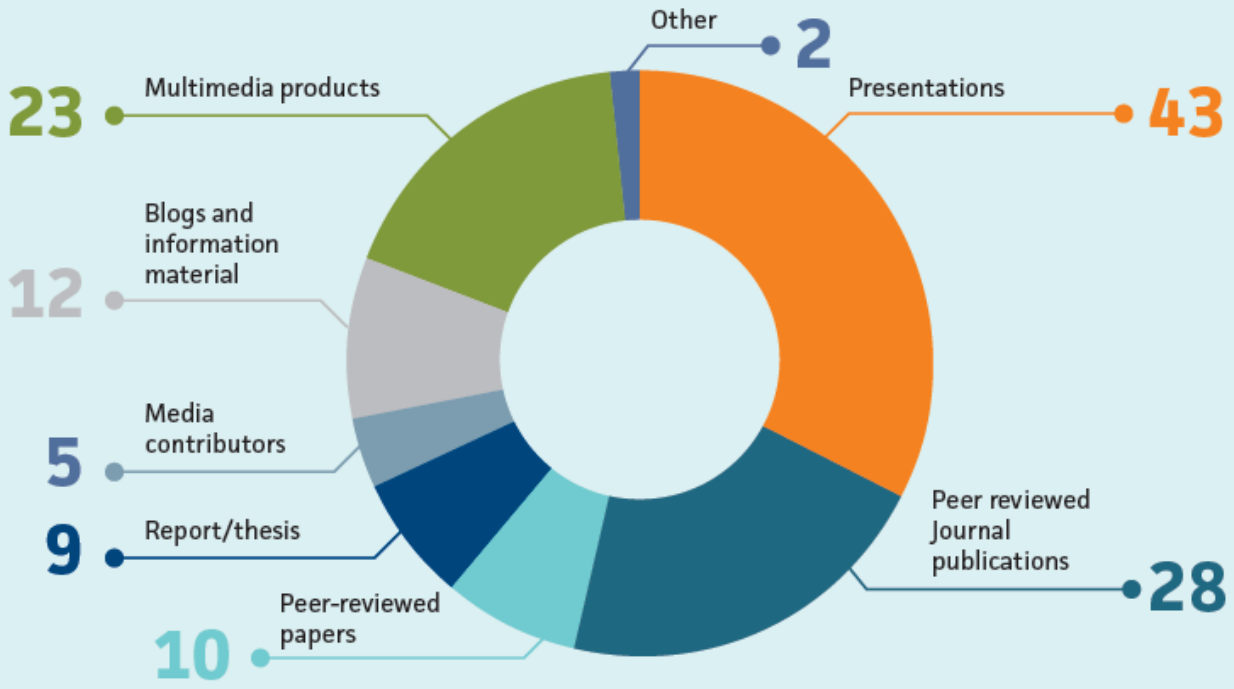
HighEFF presentation at the Research Council of Norway contact meeting

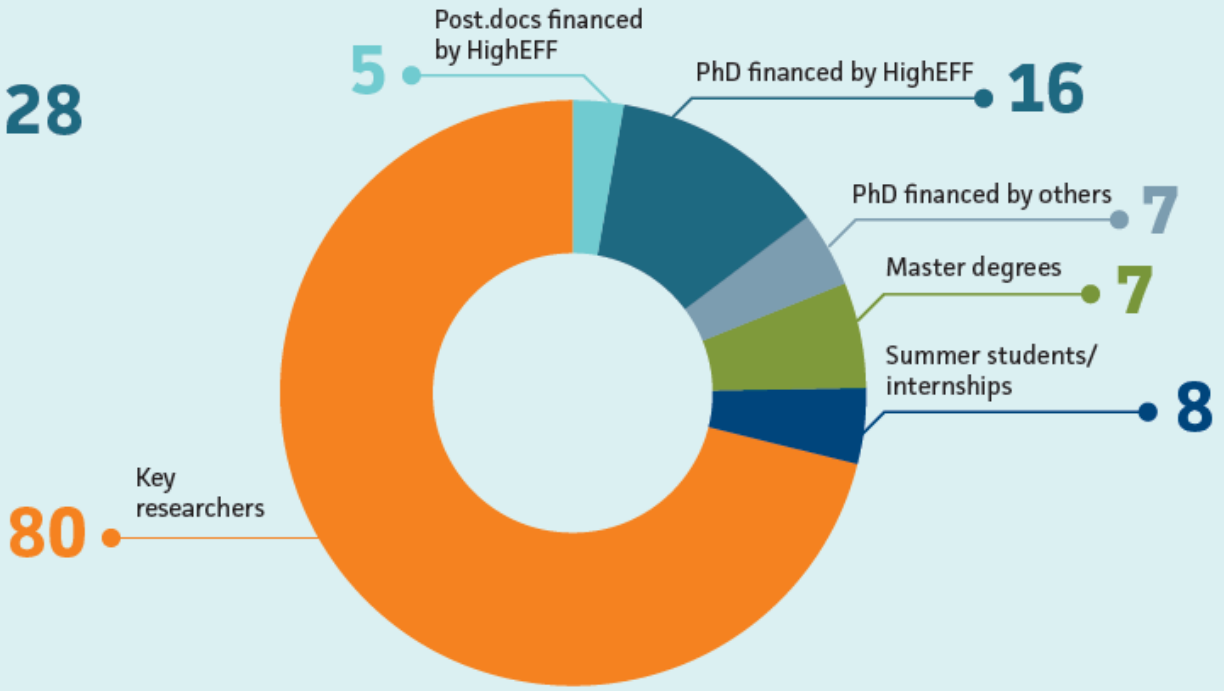
OCTOBER

HighEFF Cross-sector workshop

DECEMBER

2018 by the numbers





R&D investments pays off!

What is the estimated impact of 48 R&D projects?

16 GNOK in realized economic benefit in Norway (2008-2017)

- Increased value/income, reduced costs. Reduced or postponed investments
- Realized investments in industry
- Documented for 9 out of the 48 cases

100 GNOK identified future economic potential

- Identified and estimated for 12 out of the 48 cases (Norway, Europe)

Yes, Energy research pays off:

- 4 GNOK funded by RCN to approx 670 projects (2008-2017)
- Realized economic impact 4 times the funding

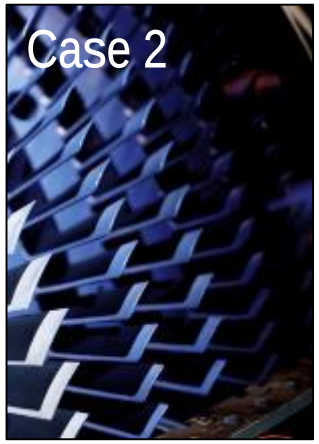
Energy efficiency in industry – impact and potential

- >30 % reduced energy use realized in projects with industry. Significant emission reduction.
- Competitive Norwegian process industry based on knowledge from Norwegian R&D&E

CO_2 as refrigerant in cooling and heating processes

18.000 supermarkets:
- Energy use: 1,6 TWh/yr
- Cost: 650 mill. kr
- Emissions: 19 Mt CO_2

Potential Europe:
- Energy use: 9 TWh
- Emissions: 53 Mt CO_2



Heat recovery in offshore gas turbines

Potential offshore:
- Average 140 mill. kr/platform in reduced consumption (CO_2 tax)
- 2,2 Gt CO_2 at full implementation

Increased utilization of low temperature waste heat

New TINE dairy built:
- 40 % lower energy use
- 5 GWh/yr, 2 mill kr/yr

Potential in Norway:
- 1 TWh/yr in similar industry
- 500 mill. kr reduced cost

Reduced energy use and emissions in the aluminium industry

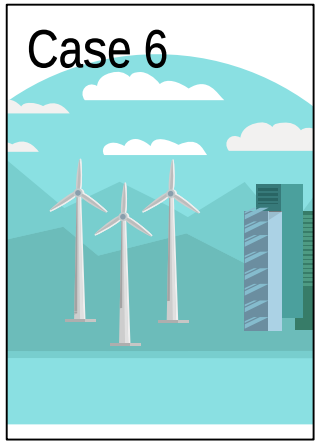
Hydro Karmøy Technology Pilot:
- In operation in 2018

Potential Al in Norway:
- 2,3 TWh/yr
- 900+ mill. kr/yr

Energy effective and environmental friendly copper production

Glencore Nikkelverk:
- Pilot in operation (2012)

Potential at Glencore:
- Demo (2022) decided
- 35 % reduced energy use
- 26 GWh, 10 mill kr/yr



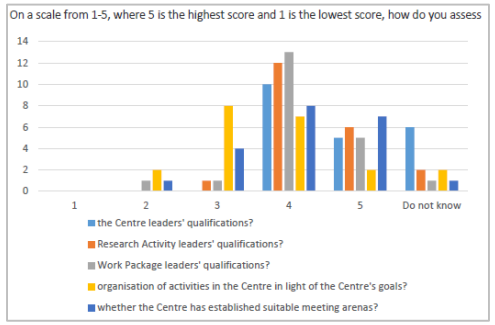
Integrated energy system for industry (clusters)

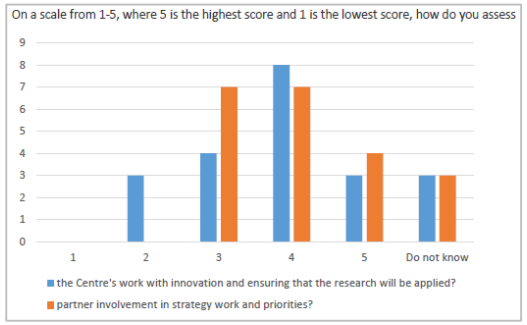
REALIZED EFFECTS

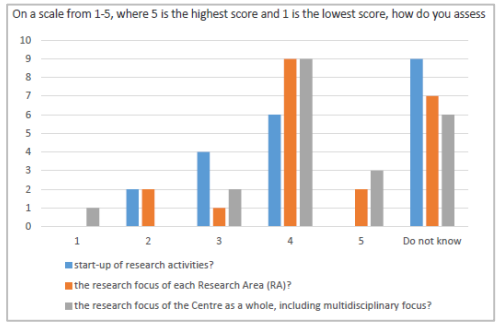
POTENTIAL EFFECTS

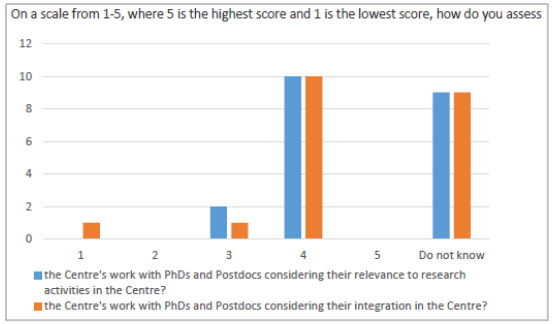
Self assessment 2019

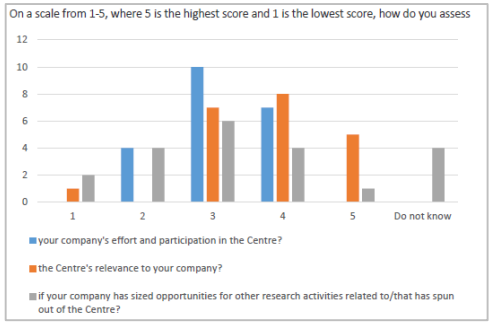
#	Main topic	Average score *[span, low-high]*
1	Organisation	4.0 *[2-5]*
2	Innovation and involvement of partners	3.7 *[2-5]*
3	Research	3.7 *[2-5]*
4	Education	3.8 *[1-4]*
5	Relevance	3.3 *[1-5]*
	ALL	**3.7 *[1-5]***











Education

25 PhD/PostDocs

- 23 in progress
- 2 without candidates yet, planned startup 2019

8 associated PhDs in progress

134 registered conference/journal publications already

PhD/PD students in the room? Raise your hands!

Meet them, read their posters!

Prof. Truls Gundersen and PhD students Silje Marie Smitt and Julia Jimenez interviewed at PhD/PD seminar 25th Feb 2019

Case studies

HighEFF

Case Study, Food Sector

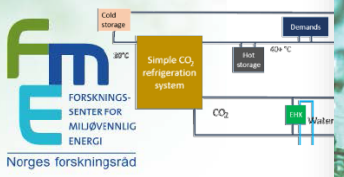
Novel Dairy Energy System with HTHP

Eight different energy solutions for a new dairy are compared. The dairy will have heat and cold demands at three and two temperature levels respectively for building, storage and processes. The findings are based on hourly demand for an entire year.

35%	48%	47%
less need for district heating	lower electricity demand	

The solutions included direct and indir… with CO_2 and the use of a high temper… either a propane/butane cascade or a …

Today's standard solution, cooling with… surplus heat, and heating with electrici… formed the foundation for comparison… improvement.



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Case Study, Meta…

H_2 production from CO-rich …

Off gas utilisation example: Industrial cluste…

The gas currently flared at Mo Industrial Pa… conditions produce enough hydrogen to pov… year; eliminating approximately **3600 tons o…**

36	0%
Hydrogen-powered city buses	Lower furnace energy consumption

Currently, about 10-15% of the gas is flared… gas is sold to neighbour industries for furna…

Hydrogen production would have no effect on furnace energy consumption but would reduce the climate gas emissions.

Picture from Toyota

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Case Study, Metals and Materials Sector

Electricity generation from CO-rich off-gas

Off gas utilisation example: Stand-alone plant at Sauda

Currently, the CO-rich furnace off-gas is flared but the combustible gas can be burned for thermal power generation instead, reducing the electricity bought from the grid by 18%.

133 GWh	18%	0%
Electricity generated form off-gas	less electricity required from grid	Less CO_2 emissic…

Power generation would not result in lower greenhouse gas… emissions but in significantly improved gas utilisation and energy efficiency of the plant.

Thermal power plants for flue gas are commercially available…

Off gas with around 60% CO have reportedly given efficienci… of around 37% for power generation.

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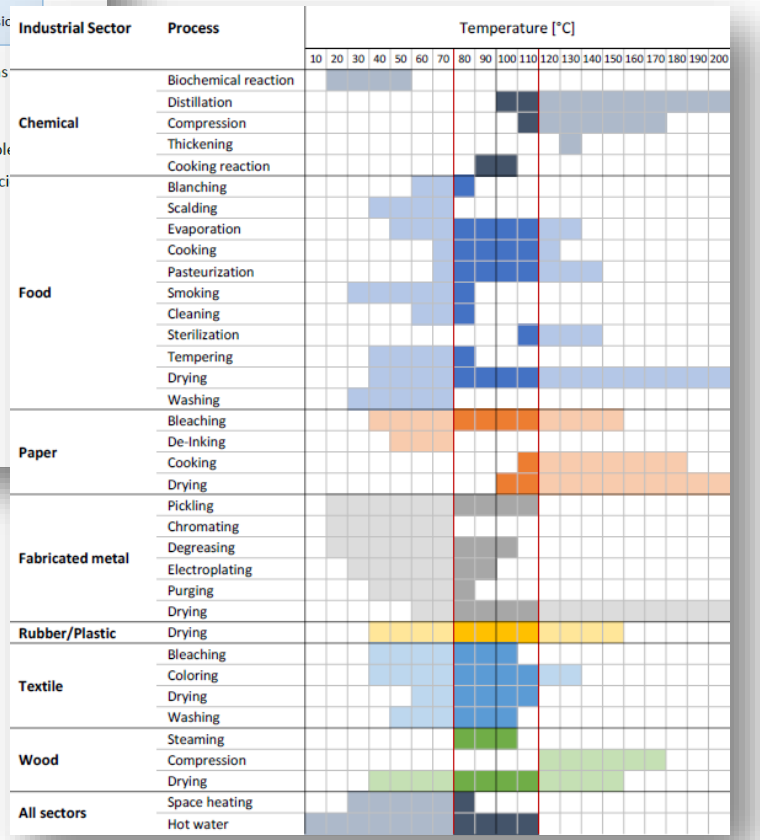
Temperature ranges of the different process with in the industrial sectors

Industrial Sector	Process
Chemical	Biochemical reaction
	Distillation
	Compression
	Thickening
	Cooking reaction
Food	Blanching
	Scalding
	Evaporation
	Cooking
	Pasteurization
	Smoking
	Cleaning
	Sterilization
	Tempering
	Drying
	Washing
Paper	Bleaching
	De-Inking
	Cooking
	Drying
Fabricated metal	Pickling
	Chromating
	Degreasing
	Electroplating
	Purging
	Drying
Rubber/Plastic	Drying
Textile	Bleaching
	Coloring
	Drying
	Washing
Wood	Steaming
	Compression
	Drying
All sectors	Space heating
	Hot water



CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway

Spinoff projects

Registering and supporting spin off projects – confirming relevance and complementarity for applications to RCN, RFF, EU etc…

2017 → 10 R&D projects receiving funding

2018 → 4 R&D projects receiving funding (so far)

In addition; industrial development and implementation

2017

Short title	Full title	RA, WP	Contact person (name, partner)	Collaborating partners	Research program (NFR/EU..., ENERGIX/BIA...)	Project type	Topic(s)	Support letter from HighEFF?	Application sent (date, YYYY-MM-DD)	Granted? (yes, no)
Free2HEat	Emission free industry: Development of efficient two phase compressor as replacement for fossil energy	WP2.2, WP3.2	Michael Bantle, SINT	toCircle er søker	Energix	IPN	High temp heat pumps	Signed	11.10.2017	Yes
Rockstore	Rockstore - develop, demonstrate and monitor the next generation BTES system	WP3.3, WP4.3	Karoline Kvalsvik, SI	CMR vertskap	Energix	KPN	Geotermisk	Signed	07.09.2017	Yes
COMPACTS2		RA2, 3 og 6	Medt Mazzetti, SINT	ConocoPhillips, AkerBP	Petromaks2	KPN	Compact bottoming cycles	Yes	07.09.2017	Yes
->	Reduced CO_2 emissions in Metal Produc	RA1, RA4, RA6	Eli Ringdalen, SINTE	...	Energix	KPN	...production processes in S	Signed	07.09.2017	Yes
LTTG+	Low-temperature thermal grids with surplus heat utilization	RA4, WP4.3	Hanne Kauko, SINTE	NTNU, Statkraft Varme, Dora AS, Fortum Oslo Varme AS	EnergiX	KPN	Local thermal grids, district heating, waste heat utilization	Signed	07.09.2017	Yes
CleanTex			Ole Stavset, SINTEF E	Norteksti	Energix	IPN		Signed	11.10.2017	Yes
EnTrain			Karoline Kvalsvik, SI	Norske Tog AS, NSB	Energix	IPN		Signed	11.10.2017	Yes
	Klimavennlig asfaltproduksjon fra fjernvarme		Sverre Fosdie	Veidekke AS, FJØRDEFJORD	RFF			Signed	08.11.2017	Yes
	Combination of new and future oriented energy solutions	RA2, 3 og 6	Christian Schlemmin	Rørosmaleriet	ENOVA			Signed	30.10.2017	Yes
PREMA		RA4	Eli Ringdalen, SINTEF	European consortium	EU H2020	EU	Materials	-		Yes

2018

Short title	Full title	RA, WP	Contact person (name, partner)	Collaborating partners	Research program (NFR/EU..., ENERGIX/BIA...)	Project type	Topic(s)	Support letter from HighEFF?	Application sent (date, YYYY-MM-DD)	Granted? (yes, no)
BioCarbUp	Optimising the biocarbon value chain for sustainable metallurgical industry	RA4, RA6	Øyvind Skreiberg, SI	NIBIO, NTNU, SINTEF Indus	EnergiX	KPN	Biokarbon	Signed		Yes
COOLFISH	Energy efficient and climate friendly cooling, freezing and heating onboard fishing vessel	RA2, RA3	?, SINTEF Ocean	SINTEF Energi++?	MAROFF	KPN	EE næringsmiddel	Signed		Yes
Skala UP	Sustainable and efficient heat pump development for combined process heat and cool	RA3.2	Michael Bantle, SINT	Skala fabrikk	EnergiX	IPN	Heat pumps	Signed		Yes
BioCirc	BioCirc – en sirkulærøkonomisk tilnærming til biokarbonproduksjon	General	Per Anders Eidem, SI	SINTEF Industri, SINTEF Energi	RFF Nord	RFF	Biokarbon, energikaskader	Signed		Yes

www.sintef.no/projectweb/highefflab/

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

The Research Council of Norway

HighEFF

Annual report 2018

HighEFF

Centre for an Energy Efficient and Competitive Industry for the Future

HighEFF

Energy Efficiency – Research Center

Knowledge - Friendship - Teamwork

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