

## SFI METAL PRODUCTION

### Newsletter No 1/19

The SFI Metal Production has been in operation for 4 years with the Midway Evaluation as the big event in the autumn of 2018 and winter 2019. Students, the research partners NTNU, SINTEF and NORCE, all nine industrial partners, the Executive Committee and the Scientific Committee were involved in the process of the Midway evaluation. All documents were sent to the Research Council of Norway on December 14th. The international expert panel with two generalists and two specialists, visited the Centre on March 6th 2019. A quote from the report from the panel regarding the quality of research and the commitment of the industry partners:

*"Excellent, world-class research contributions are being generated through the research conducted under the auspices of the Centre as evidenced by the admirable portfolio of scientific publications, conference presentations and quality doctorate and postdoctoral candidates."*

*The Norwegian industry's unique openness with regard to sharing of benefits around especially safety and environmental research outputs is worth noting as it elevates the socio-economic impact of the research conducted by the Centre. This unique characteristic adds to the value proposition of the Centre. The value-add to Norway (and the rest of the world) from this institutionalised open-access principle is highly commendable. The midway evaluation process has been instructive, and we have identified both our strengths and improvements".*

Thank you very much to the SFI Metal Production Family who have done an outstanding work these first four years and who made the Midway Evaluation to a positive event.

It's the Spring season and our Spring meeting was carried out the last week in April. We got positive response to the program and we hereby want to thanks all the speakers and the audience for making this to an interesting and successful meeting. Please read the thorough minutes from the Spring meeting on page 2-5.

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# Spring Meeting April 2019

Photos by Berit Fossum, SINTEF

**The Spring meeting** opened with a welcome and brief introduction by the centre manager Aud N. Wærnes. Then, Mette Egli/GE Power presented: "AI Centre of Excellence Oslo – 50 years of innovations, transitions and adaptations to the market." GE Power is a partner in the SFI – a company that among others specialises in gas cleaning of off-gases with respect to HF, PAH and tars from both anode-bake furnaces and the smelting pot. GE Power has delivered equipment to Hydro Pilot at Karmøy, Trimet in Hamburg and Dubal line 1-3 - continuous improvements on site and in the lab. The most important tasks for GE in the SFI are alumina dissolution, scaling in tubes and off-gas measuring campaigns at the aluminium plants.



## **Session I BioCarbon and environment – an important area for the metallurgical industry**

Merete Tangstad, Eli Ringdalen and Øyvind Skreiberg presented past, present and future research on the use of biocarbon in metal production. The research started in the 90ties at SINTEF and NTNU. Three consecutive projects made a valuable fundament for todays challenges to reduce CO<sub>2</sub> emissions in metal production. There is one PhD student - Benedicte B Samsig - working on the use of biocarbon in FeMn-alloys in the SFI. In addition, there are several PhD students (Hamideh Kaffash, Leif Storlien and Sethulakshmy Jayakumari) working with carbon reactions in different zones in the Silicon/FeSi and FeMn/SiMn furnaces. Several new projects on biocarbon, e.g. Reduced CO<sub>2</sub> emissions and BioCarboUp has been started lately, see this Newsletter page 6-7.



In order to get an overview of potential carbon sources for the metallurgical industry like biogas, the session continued with a talk by Terje Hyldmo from Biokraft Skogn: "Biogas – The green shift have started". Biokraft has the capacity to produce 12,5 mill Nm<sup>3</sup> liquid biogas-LBG equivalent to 120 GWh/year or 12,5 mill litres of diesel mainly based on waste from the Skogn papermill. The main market for the biogas is transportation (buses and trailers), an excellent source to reduce the GHG emission, i.e. reduces the use of fossil fuel in addition to the reduction in emissions from the waste that are used as feed-stock.

A broader perspective for the use of biomass was presented by Martin S. Melvær/Bellona, "Biomass in the process industry". BioChar is a climate mitigation measure and is a part of the Roadmap from Norsk Industri. However, Melvær pointed out that even renewable biomass resources are limited. The potential for bioenergy in EU in 2030 is 80 % - and it was 20 % in 2016. Some concluding remark:

- Biochar is positive for the metallurgical industry.
- Waste is not being used to its full potential.
- Ferroalloy industry need high quality CCS in the long run.





# Spring Meeting April 2019

## Session II Modelling

Modelling is an important part of the SFI Metal Production and is emphasised in all the Research Domains. What is modelling and why do we do it? That was the question raised by Kristian Etienne Einarsrud/NTNU. A model is a set of equations used to represent a physical process and different modelling strategies require infrastructure ranging from black envelope to complicated models.

In all models, the quality of the data input is of major importance. John Morud/SINTEF continues the session with "Uncertainty quantification in Process Models". The focus was on the quality of input data that sometimes are not known or very uncertain (Sometimes a model requires input you do not have). Controlling experimental uncertainties is also very important and how can the uncertainty be quantified and/or assessed, is a key question.



The industry partners are using modelling as a tool to better understand the governing conditions on industrial processes. Three interesting presentations from the industry partners followed; Mehdi Kadkhodabeigi/Eramet, Eirik Manger/Hydro og Halvard Tveit/Elkem followed. They all contributed with examples on cases where modelling has been an important tool in process optimisation.



Modelling session continued with some examples on Modelling in SFI Metal Production – a PhD perspective, by A. Kovacs, S. Gylver, D. Clos, E. Bjørnstad, V. Canaguier (NTNU). The modelling session finished with Jesper Friis and Bjørn Tore Løvfall who described the challenges with different models that interacts together. Modelling is getting more mature – Interoperability – the ability of computer systems or software to exchange and make use of information.



The day ended with a “production line talks” where some of the PhD students and the Postdocs presented their work in 5 minutes. All presentations were very impressive, with an excellent focus on and disposition of time :) The presenters were: Hamideh Kaffash/Internal NTNU PhD & SFI, Hossein Salehi/Internal NTNU & SFI, Cathrine Kyong Won Solem/SFI PhD, Artur Kudyba/SFI PostDoc, Kamilla Arnesen/SFI PhD, Andrea Broggi/SiNoCO2-project, PhD, Trine Asklund Larssen/FME HighEFF, PhD, Leif Sigurd Storlien/Industrial PhD, Karin Fjeldstad Jusnes, HighTemp Quartz, PhD, Mertol Gökelma/BEST project, PostDoc.

# Spring Meeting April 2019

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## Session III Material Flow analysis (MFA)

MFA can be used on a global level as well as on a single plant. Daniel Müller/NTNU started this day talking about MFA as an Environmental Management Method for the Industry on a global level. The EU funded project MinFuture was used as an example. Today isolated flows are monitored, not systems and this often results in large data gaps and very often high uncertainties in data. Therefore ONTOLOGY – the quality of data is important for future use of MFA.



There is one PhD students working on MFA in SFI Metal Production, Romain Billy. He presented "Global Aluminium Cycle - Links to Technology and Infrastructure Stocks" with a focus on the flow of aluminium globally. The motivation is to forecast how the Global Aluminium Cycle will look in 2050; What are the possible scenarios for future AI demand, share of primary vs secondary AI, challenges for different new technologies etc.

MSc student Louis Monnier followed with "Physical accounting in a Primary Aluminium Production Plant". His work was concentrated on MFA at Hydro Sunndal, the largest AI plant in Europe. The study included the Anode production, smelting (electrolysis), casthouse etc. The limitations for MFA is it fails to reflect the operational reality of the site's activity and to inform decisionmakers. However, MFA provides a detailed understanding of GHG emission sources linked with product activity in a consistent framework.

"MFA as an environment management method in industry" was the title of a last presentation in this session by Jean-Pierre Birat/F Steelman. He elaborated on Who is active in MFA? Mostly the academics, the industry was not much active with the exception of Critical materials. In order to be able to utilise the strength of MFA, access to data is crucial. He concluded that it is rather difficult to sell MFA inside business and that MFA is pursuing its own targets, not necessarily listening to the need of the industry.

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# Spring Meeting April 2019

## Session IV Waste and Circular economy

Linus Perander/Outotec started this session with "Bauxite Residue – Status and Future Developments". Hard facts; 1 tonne of alumina produces 1-2 tonnes of bauxite residue. 120 mill tonnes of bauxite residue/red mud are produced per year, and only 3% is utilised. Most of the red mud ends up in wet disposal, dry stacking or dry disposal. There have been some very serious accidents with disposed red mud, so a solution i.e. a way to utilise the residue, is highly appreciated. The most promising ways for utilisation include metallurgical processes is to use in Iron and Steel plants as additives, direct Iron Reduction etc. Other areas of applications is as additive in building and construction materials, cement industry - only 5% RM, fundament for roads, light weights concrete etc.



The next speaker was Linda T. Wiik/Hydro. She presented interesting results from two ongoing projects, Alpakka and Dare2C. The Dare2C project's main goal is to develop a new type of reinforced concrete that is more durable and more environmentally friendly than existing qualities. The aim is to replace about 50% of the clinker with less CO<sub>2</sub>-intensive cement constituents like Bauxite Residue. Another project objective is to use lightweight aluminium as concrete reinforcement. The main objective of the Alpakka - Circular Aluminium Packaging in Norway, is to establish a Norwegian flagship demonstrator for Circular Economy in practice, which will increase the aluminium packaging circularity in Norway by value-chain cooperation between collectors, food producers/packaging designers and aluminium recyclers as well as through engaging the consumers.

The Research Council of Norway has announced start up of about 10 new SFI Centre (SFI-IV) and formal deadline for applications is at the end of September 2019. Johan Berg Pettersen/NTNU presented the idea for a new SFI on Circular Economy.

The Waste and Circular Economy session finished with an interesting panel discussion. The panel participants were Jean-Pierre Birat, Daniel Müller, Johan Berg Pettersen and Linus Perander. They were focus their attention on what Norway can do to be more resource efficient, what are the barriers and what actions can be taken.



# New Associated Projects

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## **BiCarbUp, Optimising the biocarbon value chain for sustainable metallurgical industry**

is a new competence building project (KPN) with SINTEF Energy Research as project owner. This project is a continuance of the ended project BioCarb+ (Biocarbon as reductant in metallurgical industries) and is one of several interesting projects within the biocarbon research area.

The overall objective of BioCarbUp is to optimise the biocarbon value chain for the metallurgical industry through:

- Production of biocarbon with sufficient quality satisfying the end user quality while ensuring optimum utilisation of the by-product.
- Optimises sourcing of Norwegian forest resources for biocarbon production towards the specific metallurgical processes
- Maximising the energy and cost efficiency of the biocarbon value chain for metallurgical industry.

The project holds 11 partners (4 research and 7 industry and 3 collaborative partners); SINTEF, NTNU, Norwegian Institute of Bioeconomy Research, University of Hawaii at Manoa, Elkem AS, Norsk Biobrensel AS, AT Skog SA, Eyde-nettverket, Saint Gobain Ceramic Materials AS, Eramet Norway AS, Alcoa Norway ANS.

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## **PAHssion, Industrial efforts towards zero emissions of PAH**

is a new innovation project (IPN) with Elkem as project owner. The main project objective is to develop more reliable PAH measurement methods and thereby improve emission control and reporting. The core of the project is the need for higher performance measurements. The development of such methods constitute the key innovation which will, in turn, enable further innovations in terms of abatement methods and process design and operation. The whole metallurgical industry and research in Norway are working together in this project to improve methods with the aim of reduce emissions which are already approaching the lower detection limits of prevailing standard methods.



The project partners are: Elkem, Eramet Norway, Wacker Chemicals Norway, Ferroglobe Mangan Norge, Saint-GObain Ceramic Materials, Finnfold, Washington Mills, TiZir Titanium & Iron, SINTEF Molab, SINTEF Industry, SINTEF Helgeland, NORCE, EYDE and NTNU.

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## **Alpakka, Circular Aluminium Packaging in Norway**

is a new innovation project (IPN) with Norsk Hydro as project owner. The main objective for Alpakka is to establish a Norwegian flagship project and demonstrator for Circular Economy in practice. The project aims at increasing the recycling rate of aluminium packaging waste, transforming the material into value-added products by combining innovations in return/collection systems, packaging design, and furnace operations for packaging melting/recycling operations, and thereby preventing 40.000 tonnes of metal from going to waste incineration each year in Norway.

Project partners are Hydro Aluminium Rolled Products AS, Metallco Aluminium AS, Norsk Metallgjenvinning AS, Infinitum AS, O. Kavli AS, NTNU and SINTEF.

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# New Associated Projects

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## Reduced CO<sub>2</sub> emissions in metal production

is a new KPN Project with Eli Ringdalen (SINTEF Industry) as project leader. The overall aim of “Reduced CO<sub>2</sub> emissions in metal production” is to develop the basis for reduced climate effects from the production of Si, FeSi, Mn-alloy and TiO<sub>2</sub> slag to obtain 30% lower CO<sub>2</sub> emission in 2030 and zero CO<sub>2</sub> emission in 2050.

The industrial partners in the project Reduced CO<sub>2</sub> are all the Norwegian Si, FeSi and Mn-alloy producers; Eramet, Elkem, Wacker and Finnfjord and TiZir that produces TiO<sub>2</sub> slag. NTNU is research partner and SINTEF is project leader and research partner.



*Left: Senior Researcher Eli Ringdalen, SINTEF Industry, exchange students Annah Thembeke Chaldien and Julian Venter and NTNU Professor Merete Tangstad. Foto: Thor Nielsen/SINTEF*

Reduced CO<sub>2</sub> emissions will focus on primary metal production, focussing on the removal of oxygen from raw input materials with minimal CO<sub>2</sub> emissions. The project will generate the competence basis for the development and implementation of new raw materials, methods and technologies enabling reductions in CO<sub>2</sub> emissions when oxidic raw materials are converted to alloy. More specifically, the overall aim is translated into the primary objectives

- Develop methods for substituting fossil carbon in Si, FeSi, Mn-alloy and TiO<sub>2</sub> slag production with bio-carbon, hydrogen, or process off gases.
- Identify new technologies for Si, FeSi and Mn-alloy production with a high potential to produce Si, FeSi and Mn-alloys with zero CO<sub>2</sub> emissions in 2050.

Follow the project at Facebook: <https://www.facebook.com/CO2ReductionProject/>

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# People

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## Nicholas Smith is our second PhD candidate candidate to be awarded a doctor's degree at SFI Metal Production!

In January we congratulated Dr. Nicholas Smith who successfully defended his thesis. First, Nicholas did an excellent presentation of the trial lecture "Effects of water vapor on oxidation of various liquid and solid metals" followed by the presentation of his PhD thesis "Methods of Oxidation Inhibition for Al-Mg Alloys" and the defence. Professor Gabriella Tranell (NTNU) was the supervisor for Nicholas and Senior Research Scientist at SINTEF Industry Anne Kvithyld was co-supervisor.

The Assessment Committee for the defence was Professor Bernd Friedrich (RWTH Aachen University), Dr. Jan Anders Sæter (Alcoa Mosjøen) and



Professor Hans Jørgen Roven (NTNU). The committee was very satisfied with the quality of the thesis and the handling of the raised question and comments during the defence.

Thanks to Nicholas who have worked hard for three years and did excellent research with innovative results on behalf of SFI Metal Production. Nicholas is now working as Research Scientist at SINTEF Industry.



*A satisfied PhD candidate and a proud supervisor.*

*According to the tradition amongst the PhD candidates, Nicholas got "the pipe of peace" as a present.*

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## New postdoc researcher at the Center!

Dr. Artur Kudyba is our latest employed postdoc researcher at the Centre. Arturs's preliminary project title is "Treatment and utilization of Al dross for other materials production." Associated Professor Jafar Safarian is his supervisor.

Artur got his PhD degree in materials science and engineering from Institute of Metallurgy and Materials Science of Polish Academy of Sciences, Cracow. For the last 15 years he has been working at the Centre for High Temperature Studies at the Foundry Research Institute in Cracow with experimental research on the behavior of liquid metals and alloys (based on Al, Mg, Zn, Sn, Si) in contact with various refractories (oxides, carbides, nitrides or borides). His research mainly focused on the analysis of physicochemical and structural properties. In addition, he was involved in designing and building of new high temperature experimental devices (furnaces) dedicated to investigation of wettability and reactivity in various metal/ceramic systems.





# Seminars & Conferences

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The Seminar “**Diffuse utslipp til luft fra Industri**» was held on March 19-20th. This was a cooperation between SFI Metal Production, EYDE cluster and Norsk Industri. The intention of this seminar was competence building and best-practise sharing.

The program included presentations from the ferroalloy, aluminium and oil industries on their efforts to measure and control fugitive emissions. Representatives from NTNU/SINTEF (Gabriella Tranell, Ida Kero and Bernd Wittgens) presented work on fugitive emissions carried out through project collaboration with industry over the past 30 years, with specific emphasis on the importance of long term R&D commitment and efforts.

The long term aim of the seminar is to gather contributors to a “White paper” on measurement of fugitive emissions. link to the programme: <https://www.eydecluster.com/no/kalender/2019/seminar-om-diffuse-utslipp-til-luft/>

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Up-coming seminar on “**Scaling/fouling in the metal industry**”, June 5, 2019.

Scaling/fouling is a general problem in a number of industries. So far in SFI Metal Production, emphasis has been on scaling in the aluminium industry. We would like to welcome you to this seminar Scaling/fouling in the metal industry, which will take place in Trondheim. The seminar will have speakers from both the industry and academia. It will give an overview of the challenges and current understanding of scaling/fouling in the SFI Metal Production industries, and relevant work already performed within the SFI will be presented. The seminar will be concluded with a plenary discussion on the way forward within scaling/fouling within the SFI.

For more information, please contact Vidar Torarin Skjervold, SINTEF Energy, [VidarTorarin.Skjervold@sintef.no](mailto:VidarTorarin.Skjervold@sintef.no).

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Up-coming conference: As you may already know, **International Molten Slags, Fluxes and Salts conference** is one of the most prestigious and extensive conferences specialized on the research related to slag, flux and salts. This conference has been held every 4 years since 1981. The 11<sup>th</sup> conference, MOLTEN 2020 will be held in Seoul, South Korea in May 2020 is next year, but Abstract Submission is June 30th 2019!



We are expecting more than 1000 participants for the conference. This conference will be certainly a good chance for many pyrometallurgists to meet and exchange the most recent research work. The main industry related to this conference is both ferrous and non-ferrous.

Website <http://www.molten2020.org/>

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## The TMS novice, by PhD candidate Kamilla Arnesen



Photo: David D. E. Brennhagen

### Day 0 – Saturday March 9th, 2019

04.00 00 in the middle of the night – start of the journey. There is no other reason for getting up this early than traveling.... The bus to the airport left at 04.00 in the morning. I apologise if anyone tried to be nice and say something to me - I am not a morning person, when the morning starts at night. The plane took us to Stockholm, then the windy city of Chicago and finally San Antonio, Texas, the city hosting TMS 2019, 148th Annual Meeting and Exhibition. We arrived in San Antonio Saturday night. After a long day of traveling we did some hunting for groceries and took a stroll along the Riverwalk.

Sunday was spent sightseeing and checking in to the conference at the Henry B. González Convention Center. Some of us went to check out the local talent at a basketball match and some went to the Presidents` Welcoming Reception, the kick off, for an informal start prior to the technical program starting the next day.

### Day 1 of the Conference – Monday 11<sup>th</sup> of March.

The SFI Metal Production group and Norwegian delegates all in all counted about 80 people attending TMS, which is quite impressive in my opinion. The days consisted of talks and sessions and a tip is to spend some time beforehand to get familiar with all the topics to choose between. I spent the most of my day at the Light Metal and Energy & Environment session. “A Vision for the Next Decade” was the theme for the Light Metals Keynote session, with the topics; Trends, risks, challenges and changes for the aluminium industry the next decade. A student poster session, with several Metal Production contributions, ended my first day at TMS. Joyous congratulations to Are Bergin, for going home with the first prize for his poster on “Conventional Ceramic Foam Filters (CFFs) - Chemical Reactivity and Thermal Stability”, in the Light Metals graduate student poster session.



Photo: Cathrine K. W. Solem

### Day 2 – Tuesday 12<sup>th</sup> of March.

Tuesday started out as an exciting day for many SFI participants. At the Cast Shop session many of Metal Production related projects were presented, including Nicholas Smith and Massoud Hassanabadi, who just finished (NS) and is soon to finish (MH) their PhDs. I spent a lot of my time expanding my knowledge about the production of aluminium and the important support systems, including recycling. Luckily, this worked out well as the REWAS symposium was co-located with TMS and focused on Manufacturing the Circular Materials Economy. The day ended with a celebratory dinner for Kristian Etienne Einarsrud, who turned 35 years old. Best wishes and hope you had a birthday worth remembering!

...to be continued on next page



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### *Day 3 – Wednesday 13th of March*

Today I experienced an exciting benefit by attending such a large conference. The conference cover so much related to the material science world and if you spend some time looking through the program, there is much to discover. For me, I highly enjoyed a talk about developing new excavation tools and material development for future NASA landers, using 3D printing. A well spent 30 minutes of learning!

Today, was also a big day for the before mentioned Kristian Etienne Einarsrud. He was a recipient of the Young Leaders Professional Development Award and received the price at the Light Metals Division Luncheon.

For dinner today, many of us (NTNU PhD Students) wanted to find some real Texas BBQ. After a 30-minute walk - which according to the hotel was too long and we were recommended to take a taxi - ended up at Augie's BBQ. A local, canteen style restaurant with excellent food. Well worth the trip .



*Photo: Cathrine K. W.Solem*

### *Day 4 – Thursday 14th of March*

It is already the last day of the conference and the time has come to choose the last talks to attend. I find myself going from talks about environmental issues in the aluminium industry, to by-product processing of rare earth metals, and further on to a new topic for me, properties of bulk metallic glasses. I think this last day has been a good representation of the vastness of this conference. There is always something to learn, a new technique, something old coming “back in style”, reminding us that our work is in constant development. One session that I remember particularly well is “Rethinking Production”, a REWAS session about being flexible, adjust and constantly finding new ways and solutions and move forward. As a new PhD student, this is something I will keep in mind as I continue my own research.

I finish this travel log with a picture of Are and me having dinner with the grown-ups:)



*Photo: Cathrine K. W.Solem*

Thanks to all my friends and collages for a wonderful trip and experience. I am looking forward to next year, TMS 2020 in San Diego, California.

Best wishes,

Kamilla Arnesen

*PS. I also wish to congratulate the NTNU blade-smithing team for their Historical Accuracy award, reproducing a pattern welded Viking sword.*

# Miscellaneous

**The Gemini Centre** is a model for strategic interaction between parallel professions at NTNU, SINTEF, the University of Oslo and St. Olavs Hospital. The aim is to build larger and more robust academic environments with higher quality that will be better able to seize and develop new opportunities. Through this, the partners will increase the competitiveness and value creation of the community the Gemini centres work in line with the vision: International outstanding together.

**Hydrochemical process technology in the circular economy (HyProS)** is one of the recent started Gemini Center. Partners are NTNU by NV Faculty, UiO by MatNat Faculty and SINTEF Industry. For more information about HyProS contact Egil Skybakmoen (SINTEF Industry) or Jafar Safarian (NTNU).



**The Annual Report 2018** is finished.

Do you want a paper copy, please contact  
marianne.lenes@ntnu.no.

Interesting article «**Ny metode for å lagre energien fra sol og vind**» with Professor Merete Tangstad origin from the H2020 project Amadeus .

<https://gemini.no/2019/05/sol-og-vind-kan-lagres-i-en-boks/>





# Coming events

## May 15-16, 2019

Dross Workshop, Trondheim Norway

## June 5, 2019

Seminar "Scaling/fouling in the metal industry", Trondheim Norway

## October 1, 2019

Controlled Tapping day, Trondheim Norway

## October 2 2019

Reduced CO<sub>2</sub> day, Trondheim Norway

## October 7-10, 2019

INTPART CaNAI meeting and 2nd Summer School

Université Laval, Quebec City. I

In cooperation with REGAL student day <https://www.regal-aluminium.ca/en/jer-en/jer-2019/>

## October 14-18, 2019

SFI-Metal Production and FME-SUSOLTECH Centers organize a full week event in Trondheim on:

**Theories and processes for the production, refining and recycling of silicon** with the overall program :

- Course module 1: MG-Si production process ( 14-15 October)
- Course module 2: Silicon refining and SoG-Si feedstock production (16-17 October)
- Solar Industry Forum: Material loss and recycling/PV silicon production and use. (Friday 18 October).

## November 5-6, 2019

SFI Metal Production Autumn Meeting, Trondheim Norway.



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Entrance Bergbygget,  
Gløshaugen

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