

PROGRAMME

INTERNATIONAL CONFERENCE ON  
**NEGATIVE CO<sub>2</sub>**  
**EMISSIONS**

GOTHENBURG, SWEDEN  
MAY 22-24, 2018



CENTER FOR  
CARBON  
REMOVAL



## Scientific Committee

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Chalmers University of Technology, Sweden

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### Fuss, Sabine

Mercator Research Institute on Global Commons and Climate Change, Germany

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### Pröll, Tobias

University of Natural Resources and Life Sciences, Wien, Austria

### Renforth, Phil

Cardiff University, UK

### Rogelj, Joeri

International Institute for Applied Systems Analysis (IIASA), Austria

### Smith, Pete

University of Aberdeen, UK

### Sterner, Thomas

Gothenburg University, Sweden

### van Vuuren, Detlef

Utrecht University, The Netherlands

### Wilcox, Jennifer

Colorado School of Mines, US

## Dear friends and colleagues,

### It is a great pleasure to welcome you to Gothenburg and the 1<sup>st</sup> International Conference on Negative CO<sub>2</sub> emissions.

The conference received 231 abstracts, resulting in approximately 150 oral presentations and 30 poster presentations. Around 250 delegates from 30 countries will enjoy a three-day conference programme, including keynote lectures, panel discussions, and social events aimed at making new friends and promoting collaboration. A welcome reception by the City of Gothenburg will be held at Universeum, a science centre well known for its indoor rainforest and aquarium. We would like to express our sincere gratitude to everyone who contributed in making this conference possible. We want to acknowledge the scientific committee and supporting colleagues for

valuable efforts in the reviewing of abstracts. We would like to express our gratitude towards our sponsors, and we would especially like to acknowledge Chalmers Energy Area of Advance, whose generous support allowed us to host this event.

Thank you for attending and participating in the 1<sup>st</sup> International Conference on Negative CO<sub>2</sub> emissions. **We wish you an interesting, insightful, and fun conference!**

**Carl Linderholm (Chair)**

**Malin Hanning**

**Anders Lyngfelt**

**Matthias Schmitz**

	<b>Monday</b> May 21	<b>Tuesday</b> May 22	<b>Wednesday</b> May 23	<b>Thursday</b> May 24
08:00 -08:30		<b>REGISTRATION</b>		
		Welcome addresses		
08:30 -10:30		Keynotes	Keynotes	Keynotes
10:30 -11:00		<b>BREAK</b>	<b>BREAK</b>	<b>BREAK</b>
11:00 -12:00		Technical sessions	Technical sessions	Technical sessions
12:00 -12:20			Poster session & Meet Today's Presenters	
12:20 -13:00		Meet Today's Presenters	Meet Today's Presenters	Meet Today's Presenters
13:00 -14:00		<b>LUNCH</b>	<b>LUNCH</b>	<b>LUNCH</b>
14:00 -15:00		Technical sessions	Technical sessions	Technical sessions
15:00 -15:40		Keynote	Panel	Panel
15:40 -16:10		<b>BREAK</b>	<b>BREAK</b>	<b>BREAK</b>
16:10 -16:50		Keynote	Technical sessions	Technical sessions
16:50 -17:30		Panel	Technical sessions	Technical sessions
18:30	Registration and Welcome Reception at Chalmers	Reception by the City of Gothenburg at Universeum	Conference Dinner at Chalmers	

## Keynote speakers

## Keynote 1


**Negative CO<sub>2</sub> emissions  
- why, when and how  
much?**

Tuesday, May 22, 09:10

**James  
Hansen**

 Professor,  
Columbia University

Dr. James Hansen, formerly Director of the NASA Goddard Institute for Space Studies, is an Adjunct Professor at Columbia University's Earth Institute. Dr. Hansen is best known for his testimony on climate change in the 1980s that helped raise awareness of global warming. He is a member of the U.S. National Academy of Sciences. Dr. Hansen is recognized for speaking truth to power and outlining actions needed to protect the future of young people.

## Keynote 2


**The Necessity and the  
Allure of Negative CO<sub>2</sub>  
Emissions - A Question  
of Balance**

Tuesday, May 22, 09:50

**Anders  
Lyngfelt**

 Professor,  
Chalmers University of  
Technology

Fluidized-bed combustion is the basis for the research of Anders Lyngfelt. Since 1998 he is developing a process for carbon dioxide capture, chemical-looping combustion (CLC), which is also a fundamentally new principle for burning fuels with inherent capture of CO<sub>2</sub>. His group of researchers has more than 4000 h of operational experience of chemical-looping combustion in pilots up to 100 kW, using gaseous, solid and liquid fuels. He is in the Clarivate Analytics' list of highly cited researchers.

## Keynote 3


**Geological storage  
of carbon dioxide for  
negative emissions**

Tuesday, May 22, 15:00

**Sally M.  
Benson**

 Professor, Energy  
Resources Engineering;  
Co-Director, Precourt  
Institute for Energy; Director,  
Global Climate & Energy  
Project, Stanford University

Sally M. Benson, who joined Stanford University in 2007, is the co-director of Stanford's Precourt Institute for Energy and the director of the Global Climate and Energy Project (GCEP). A Professor in the Department of Energy Resources Engineering in the School of Earth, Energy & Environmental Sciences, she studies technologies and pathways to reducing greenhouse gas emissions.

Prior to joining GCEP, Benson was a staff scientist in the Earth Sciences Division at Lawrence Berkeley National Laboratory (LBNL). In 2004, she completed a four-year term as Deputy Director of Operations at the lab. Benson also served as Division Director for Earth Sciences and Associate Laboratory Director for Energy Sciences at LBNL.

A ground water hydrologist and reservoir engineer, Benson has conducted research to address a range of issues related to energy and the environment. Her research interests include geologic storage of CO<sub>2</sub> in deep underground formations, technologies and energy systems for a low-carbon future, and geotechnical instrumentation for subsurface characterization and monitoring.

The author or co-author of over 160 scientific publications, Benson is a member of the American Geophysical Union, the Society of Petroleum Engineers, the American Association for the Advancement of Science, and the American Chemical Society.

## Keynote 4



### CO<sub>2</sub> capture technologies status in the real world and the road for negative emissions

Tuesday, May 22, 16:10

#### Michael Monea

P.Eng., P.Geo., ICD.D,  
President and CEO,  
The International CCS  
Knowledge Centre

Michael (Mike) Monea is the President and CEO of the International CCS Knowledge Centre a non-profit organization which he helped establish with BHP and SaskPower. As a world-leading scientist, research and development is a key component in Mike's mission to help reduce greenhouse gases through CCS technologies.

Prior to the Knowledge Centre, Mike was the President of CCS Initiatives at SaskPower where he was in charge of creating and building the world's first carbon capture plant for a coal electric unit, infamously known as Boundary Dam 3.

## Keynote 5



### What we know and do not know about negative emissions

Wednesday, May 23, 08:30

#### Sabine Fuss

Ph.D.,  
Mercator Research Institute

Sabine Fuss has a PhD in economics from the University of Maastricht, the Netherlands, where she was located at the Economics Faculty and UNU-MERIT. She currently leads the working group on Sustainable Resource Management and Global Change at the Mercator Research Institute on Global Commons and Climate Change. She also holds a guest affiliation with the International Institute for Applied Systems Analysis' Ecosystems Services and Management Program and is member of the steering committee at the Global Carbon Project. Her research focuses on the functioning and design of instruments for sustainable resource management and the provision of public goods with

special interest in climate change mitigation and, in particular, negative emissions. She has authored 60 peer-reviewed journal papers and is a lead author for the IPCC.

## Keynote 6



### An integrated assessment modeling perspective on negative CO<sub>2</sub> emissions: Why do most models find NETs so attractive?

Wednesday, May 23, 09:10

#### Detlef van Vuuren

Professor,  
Utrecht University

Detlef van Vuuren (1970) is a senior researcher at PBL Netherlands Environmental Assessment Agency and a professor in Integrated Assessment of Global Environmental Change at the Faculty of Geosciences, Utrecht University. His research concentrates on response strategies to global environmental and sustainable development problems using integrated assessment models. In this context, he leads the IMAGE integrated assessment modelling team. In total, Detlef van Vuuren published more than 260 articles in refereed journals including Nature, Science and PNAS and he is included in the list of the world's most highly cited researchers. Detlef van Vuuren is involved in steering groups of several international research organizations such as the Integrated Assessment Modelling Consortium (IAMC), the Global Carbon Project (GCP) and the World in 2050 (TWI2050). He has also participated in several assessments as (coordinating) lead author including those of IPCC. In support of IPCC, Detlef van Vuuren had a coordinating role in the development of the Representative Concentration Pathways (RCPs). Over the last decade, Detlef van Vuuren was involved in several publications on negative emissions, among which the publication of RCP2.6 – the marker 2 degree C scenario used by IPCC. In two recent publications in Nature Energy and Nature Climate Change, Detlef van Vuuren is aiming to support a more open debate on negative emissions among others by exploring what it would take to reduce the use of negative emissions.

## Keynote 7


**Integration of Carbon Dioxide Removal into the European Union's climate policy**

Wednesday, May 23, 09:50

**Oliver Geden**

Head of the EU Research Division, German Institute for International and Security Affairs (SWP)

Dr Oliver Geden is Head of the EU Research Division at the German Institute for International and Security Affairs (SWP), Research Associate at the Institute for Science, Innovation and Society, University of Oxford, and currently visiting scholar at the Max Planck Institute for Meteorology. During his time at SWP he has been seconded to the Federal Foreign Office and the Federal Ministry for Economic Affairs and Energy. Recently, he has been selected as lead author for IPCC AR6, WG3, ch12.

## Keynote 8


**Direct Air Capture**

Thursday, May 24, 08:30

**Jennifer Wilcox**

Professor, Colorado School of Mines

Jennifer Wilcox is an Associate Professor in the Chemical and Biological Engineering Department at the Colorado School of Mines. Her Ph.D. in Chemical Engineering in 2004 is from the University of Arizona, and her B.A. in Mathematics in 1998 is from Wellesley College. She received an ARO Young Investigator Award, an ACS PRF Young Investigator Award, and an NSF CAREER Award. Within her research group, she focuses on trace metal and CO<sub>2</sub> capture. Her research involves the coupling of theory to experiment to test newly designed materials for sorbent or catalytic potential. She has served on a number of committees including the National Academy of Sciences and the American Physical Society to assess CO<sub>2</sub> capture methods and impacts on climate. She is the author of the first textbook on Carbon Capture, published in March 2012.

## Keynote 9


**Negative emissions from soil management**

Thursday, May 24, 08:50

**Pete Smith**

Professor, University of Aberdeen

Pete Smith is the Professor of Soils and Global Change at the Institute of Biological and Environmental Sciences at the University of Aberdeen (Scotland, UK) and Science Director of the Scottish Climate Change Centre of Expertise (ClimateXChange).

Since 1996, he has served as Convening Lead Author, Lead Author and Author for the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. He was the Convening Lead Author of the Agricultural Mitigation chapter of the IPCC Fourth Assessment Report and for the Agriculture and Forestry Mitigation chapter of the IPCC Fifth Assessment, and for the IPCC Special Report on Climate Change and Land. He has coordinated and participated in many national and international projects on soils, agriculture, bioenergy, food security, greenhouse gases, climate change, mitigation and impacts, greenhouse gas removal / negative emissions and ecosystem modelling.

He is a Fellow of the Royal Society of Biology, a Fellow of the Institute of Soil Scientists, a Fellow of the Royal Society of Edinburgh, a Foreign Fellow of the Indian National Science Academy and a Fellow of the Royal Society (London).

He has published >400 peer-reviewed journal papers with total citations of >19000 with an H-index of 73. He is a Highly Cited Researcher: (<http://hcr.stateofinnovation.com/>).

## Keynote 10


**Afforestation/  
reforestation and global  
biomass resources for  
negative CO<sub>2</sub> emission**

Thursday, May 24, 09:30

**Almut  
Arneth**

 Professor,  
Karlsruhe Institute of  
Technology

Almut Arneth is Professor of Plant-Atmosphere Interactions at the Karlsruhe Institute of Technology, department of Geography and Geoecology and leads the Division Ecosystem-Atmosphere Interactions at the KIT department Atmospheric Environmental Research. Her research focuses on terrestrial ecosystem state and functioning in response to climate change (including changes in atmospheric CO<sub>2</sub> concentration) and land-use change. She uses chiefly process-based dynamic models of ecosystem processes that can be applied on regional to global scales and over years to centuries to investigate these interactions. She also contributes actively to efforts to develop coupled Human-Environment models, aiming to arrive at much improved identification of feedbacks that exist between ecosystem and socio-economic processes in the land-use change system.

She coordinated the European Commission funded LUC4C project (Land-use change: assessing the net climate forcing and options for climate change mitigation and adaptation ([www.luc4c.eu](http://www.luc4c.eu)) and has contributed in leading roles in multiple other national and EC-funded projects on the topic. She also contributes to a number of international research initiatives including being:

- Coordinating lead author to the Global Assessment of the Intergovernmental Science-Policy Platform on Biodiversity & Ecosystem Services (IPBES);
- Coordinating lead author to the IPCC special report on climate change, desertification, land degradation, sustainable land management, food security and greenhouse gas fluxes in terrestrial ecosystems
- Lead author of the IPCC 6<sup>th</sup> Assessment Report, WG II
- Member of the scientific steering committee of the Future Earth AIMES project (Analysis & Modelling of the Earth System);

- Member of the EC Scientific Advisory Group Horizon 2020, societal challenge 5 (Climate action, resource efficiency and raw materials).
- Member of the scientific steering committee of LUMIP, the land-use change impact model inter-comparison project under the auspices of CMIP6, contributing to AR6.

## Keynote 11


**Enhanced Weathering**

Thursday, May 24, 10:10

**Phil  
Renforth**

 Ph.D.,  
Cardiff University

Dr. Phil Renforth is an engineer and geochemist interested in understanding how rocks and minerals may be used to sequester carbon, and leads the Carbonate Systems Engineering Group at Cardiff University. Renforth is a PI on the RCUK-funded research project “Greenhouse Gas Removal in the Iron and Steel Industry,” which aims to explore atmospheric CO<sub>2</sub> sequestration using iron and steel slag. Generally, his research examines the carbonation of alkaline waste materials (including cement, ash, red mud, caustic waste, etc.), and the enhanced weathering of ‘natural’ materials. He is also interested in understanding geochemical carbon sequestration in the ocean by increasing ocean alkalinity. Renforth teaches modules on engineering geology and soil mechanics in the School of Earth and Ocean Sciences at Cardiff University.

## Tuesday, May 22

	RunAn	Palmstedt	Scania	SB-H1/H3	SB-H2
08:00 -08:30	REGISTRATION outside RunAn				
	Welcome				
08:30 -10:30	Keynote 1: J. Hansen				
	Keynote 2: A. Lyngfelt				
10:30 -11:00	BREAK				
11:00 -12:20	1 A BECCS in Sweden	1 B Policy	1 C Agriculture	1 D CLC pilots/ experiments	1 E Other NETs
12:20 -13:00	Meet Today's Presenters				
13:00 -14:00	LUNCH				
14:00 -15:00	2 A BECCS in Nordic countries	2 B Systematic technology assessment	2 C Policy	2 D Incentives	2 E BECCS - Regional examples
15:00 -15:40	Keynote 3: S. Benson				
15:40 -16:10	BREAK				
16:10 -16:50	Keynote 4: M. Monea				
16:50 -17:30	Panel I				

- Policy
- BECCS
- Modelling & Incentives
- Biospheric storage
- Other NETs



## Wednesday, May 23

	RunAn	Palmstedt	Scania	SB-H3	SB-H2
	Keynote 5: S. Fuss				
08:30 -10:30	Keynote 6: D. van Vuuren				
	Keynote 7: O. Geden				
10:30 -11:00	BREAK				
11:00 -12:00	<b>3 A</b> Incentives	<b>3 B</b> BECCS - CLC pilots	<b>3 C</b> Soil/Biochar	<b>3 D</b> Policy	
12:00 -13:00	Poster session & Meet Today's Presenters				
13:00 -14:00	LUNCH The Wednesday lunch carbon footprint will be offset in Swedish farmland by ECOERA.				
14:00 -15:00	<b>4 A</b> Policy	<b>4 B</b> Modelling	<b>4 C</b> BECCS in Industry	<b>4 D</b> Forestry	<b>4 E</b> Weathering
15:00 -15:40	Panel II				
15:40 -16:10	BREAK				
16:10 -17:30	<b>5 A</b> Modelling	<b>5 B</b> Policy	<b>5 C</b> Direct Air Capture	<b>5 D</b> BECCS - CLC	<b>5 E</b> Soil/Biochar

## Thursday, May 24

	RunAn	Palmstedt	Scania	SB-H1/H3	SB-H2
	K 8: J. Wilcox				
08:30	Keynote 9: P. Smith				
-10:30	Keynote 10: A. Arneth				
	K 11: P. Renforth				
10:30	BREAK				
-11:00	BREAK				
11:00	6 A Forestry	6 B Weathering	6 C Policy	6 D Modelling	6 E Oxy- and Post-combustion
-12:20					
12:20	Meet Today's Presenters				
-13:00	Meet Today's Presenters				
13:00	LUNCH				
-14:00	LUNCH				
14:00	7 A BECCS - Power plants	7 B Forestry	7 C Direct Air Capture	7 D Policy	7 E Modelling
-15:00					
15:00	Panel III				
-15:40	Panel III				
15:40	BREAK				
-16:10	BREAK				
16:10	8 A Modelling	8 B BECCS - CLC	8 C Agriculture	8 D Other NETs	8 E Policy/BECCS
-17:30					

- Policy
- BECCS
- Modelling & Incentives
- Biospheric storage
- Other NETs

1A

**BECCS in Sweden**

Tuesday, May 22, 11:00-12:20

**INVITED LECTURE:****Swedish Climate Policies and the Role of Negative CO<sub>2</sub> Emissions**

State Secretary for National and International Climate Policy Eva SVEDLING

Swedish Ministry for Foreign Affairs

**Cost effectiveness of BECCS: policy implications and the case of Stockholm**

Fabian LEVIHN<sup>1,2</sup>, Linus LINDE<sup>3</sup>,  
Kåre GUSTAVSSON<sup>1,2</sup>, Erik Dahlén<sup>1</sup>

<sup>1</sup> Stockholm Exergi AB, Stockholm, Sweden

<sup>2</sup> Royal Institute of Technology (KTH), Stockholm, Sweden

<sup>3</sup> 2050 Consulting AB, Stockholm, Sweden

**Mapping policy incentives for bioenergy with carbon capture and storage at different scales**

Mathias FRIDAHL<sup>1,3</sup>, Rob BELLAMY<sup>2</sup>,  
Anders HANSSON<sup>1</sup>, Simon HAIKOLA<sup>4</sup>

<sup>1</sup> The Centre for Climate Science and Policy Research (CSPR), Department of Thematic Studies – Environmental Change, Linköping University, Sweden

<sup>2</sup> Institute for Science, Innovation and Society (InSIS), University of Oxford, UK

<sup>3</sup> Forum for Reforms, Entrepreneurship and Sustainability, Stockholm, Sweden

<sup>4</sup> Department of Thematic Studies – Technology and Social Change, Linköping University, Sweden

**Techno-Economic Assessment of Bio-Energy with CO<sub>2</sub> Capture - Applications to the Swedish Process Industry**

Stefania Osk GARDARSDOTTIR, Fredrik NORMANN,  
Filip JOHANSSON

Department of Space, Earth and Environment, Chalmers University of Technology, Sweden

1B

**Policy**

Tuesday, May 22, 11:00-12:20

**Tracking progress to “well below 2°C” in overshoot scenarios**

Glen PETERS<sup>1</sup>, Oliver GEDEN<sup>2,3</sup>,  
Andreas LÖSCHEL<sup>4</sup>

<sup>1</sup> CICERO Center for International Climate Research, Oslo, Norway

<sup>2</sup> German Institute for International and Security Affairs (SWP), Berlin, Germany

<sup>3</sup> Max Planck Institute for Meteorology (MPI-M), Hamburg, Germany

<sup>4</sup> Center for Applied Economic Research (CAWM), University of Münster, Münster, Germany

**‘Full’ vs. ‘limited CDR’ – how to get EU climate policymakers on Board**

Oliver GEDEN<sup>1,2</sup>, Glen PETERS<sup>3</sup>, Vivian SCOTT<sup>4</sup>

<sup>1</sup> Max Planck Institute for Meteorology (MPI-M), Hamburg, Germany

<sup>2</sup> German Institute for International and Security Affairs (SWP), Berlin, Germany

<sup>3</sup> Centre for International Climate and Environmental Research (CICERO), Oslo, Norway

<sup>4</sup> University of Edinburgh, School of Geosciences, UK

**The politics of anticipation: The IPCC and the Negative Emissions Technologies experience**

Silke BECK<sup>1</sup>, Martin MAHONY<sup>2</sup>

<sup>1</sup> Department of Environmental Politics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

<sup>2</sup> School of Environmental Sciences, University of East Anglia, UK

**The evolving promises of NETs: a cultural political economy perspective on the problem of mitigation deterrence**

MCLAREN, TYFIELD, MARKUSSON

Lancaster Environment Centre, Lancaster University, UK

1C

**Biospheric storage – Agriculture**

Tuesday, May 22, 11:00-12:20

**Biomass production in plantations: Land constraints increase dependency on irrigation water**

Yvonne JANS<sup>1,2</sup>, Göran BERNDES<sup>3</sup>, Jens HEINKE<sup>1</sup>,  
Wolfgang LUCHT<sup>1,2</sup>, Dieter GERTEN<sup>1,2</sup>

<sup>1</sup> Potsdam Institute for Climate Impact Research, Germany

<sup>2</sup> Department of Geography, Humboldt-Universität zu Berlin, Germany

<sup>3</sup> Department of Space, Earth and Environment, Chalmers University of Technology, Gothenburg, Sweden

### Sustainable Feedstocks for Carbon-Negative Bioenergy: A Landscape Design Case Study

John FIELD<sup>1</sup>, Keith PAUSTIAN<sup>1,2</sup>

<sup>1</sup> Natural Resource Ecology Laboratory, Colorado State University, CO, USA

<sup>2</sup> Dept. of Soil & Crop Sciences, Colorado State University, CO, USA

### Deeply Rooted: Evaluating Plant Rooting Depth as a Means for Enhanced Soil Carbon Sequestration

Jennifer PETT-RIDGE, Erin NUCCIO, Karis MCFARLANE

Lawrence Livermore National Laboratory, Livermore, California, USA

### Biochar-N dynamics: Can we solve the N dilemma of C sequestration?

#### A review and conceptual framework for meeting the SDGs and generating NE

Claudia KAMMANN<sup>1</sup>, Nikolas HAGEMANN<sup>2</sup>, Maria Luz CAYUELA<sup>3</sup>, Constanze WERNER<sup>4</sup>, Dieter GERTEN<sup>4,5</sup>, Wolfgang LUCHT<sup>4,5</sup> und Hans-Peter SCHMIDT<sup>2</sup>

<sup>1</sup> Department of Applied Ecology, Hochschule Geisenheim University, Germany

<sup>2</sup> Ithaka Institute, Hamburg, Germany

<sup>3</sup> Department of Soil and Water Conservation and Organic Waste Management, CEBAS-CSIC, Murcia, Spain

<sup>4</sup> Potsdam Institute for Climate Impact Research (PIK), Research Domain I: Earth System Analysis, Germany

<sup>5</sup> Humboldt-Universität zu Berlin, Geography Department, Berlin, Germany

1D

## BECCS – CLC pilots/experiments

Tuesday, May 22, 11:00-12:20

### Experimental investigation of chemical-looping combustion and chemical-looping gasification of biomass-based fuels using steel converter slag as oxygen carrier

Patrick MOLDENHAUER, Carl LINDERHOLM, Magnus RYDÉN, Anders LYNGFELT

Chalmers University of Technology, Gothenburg, Sweden

### Autothermal Chemical Looping Reforming of Bioethanol for Hydrogen Production

Francisco GARCÍA-LABIANO<sup>1</sup>, Enrique GARCÍA-DÍEZ<sup>1</sup>, Luis F. DE DIEGO<sup>1</sup>, Juan ADÁNEZ<sup>1</sup>, Juan A.C. RUÍZ<sup>2</sup>

<sup>1</sup> Instituto de Carboquímica (ICB-CSIC), Zaragoza, Spain

<sup>2</sup> Centro de Tecnologias do Gás e Energias Renováveis (CTGAS-ER), Natal, Brazil

### Biomass combustion by Chemical Looping with Oxygen Uncoupling process: experiments with Cu-based and Cu-Mn mixed oxide as oxygen carriers

Iñaki ADÁNEZ-RUBIO<sup>1,2</sup>, Antón PÉREZ-ASTRAY<sup>1</sup>, Alberto ABAD<sup>1</sup>, Pilar GAYÁN<sup>1</sup>, Luis F. DE DIEGO<sup>1</sup>, Juan ADÁNEZ<sup>1</sup>

<sup>1</sup> Instituto de Carboquímica (ICB-CSIC), Zaragoza, Spain

<sup>2</sup> Dept. of Chemical and Environmental Engineering, University of Zaragoza

### High volatiles conversion in a dual stage fuel reactor system for Chemical Looping Combustion of wood biomass

Johannes HAUS<sup>1</sup>, Yi Feng<sup>2</sup>, Ernst-Ulrich HARTGE<sup>1</sup>, Stefan HEINRICH<sup>1</sup>, Joachim WERTHER<sup>1</sup>

<sup>1</sup> Hamburg University of Technology, Hamburg, Germany

<sup>2</sup> Zhejiang University, Hangzhou, China

1E

## Other NETs

Tuesday, May 22, 11:00-12:20

### Carbon Dioxide Utilisation and Removal: Promise and Challenges

Cameron HEPBURN<sup>1,2</sup>, Ella ADLEN<sup>1</sup>, John BEDDINGTON<sup>1</sup>, Emily A. CARTER<sup>3</sup>, Pete SMITH<sup>4</sup>

<sup>1</sup> Oxford Martin School, University of Oxford, UK

<sup>2</sup> Smith School of Enterprise and the Environment, University of Oxford, UK

<sup>3</sup> School of Engineering and Applied Science, Princeton University, Princeton, USA

<sup>4</sup> Institute of Biological & Environmental Sciences, University of Aberdeen, UK

### Affordable CO<sub>2</sub> Negative Emission Through Hydrogen from Biomass, Ocean Liming and CO<sub>2</sub> Storage

Stefano CASERINI<sup>1</sup>, Beatriz BARRETO<sup>1</sup>, Caterina LANFREDI<sup>1</sup>, Giovanni

CAPPELLO<sup>2</sup>, Dennis ROSS MORREY<sup>2</sup>, Mario GROSSO<sup>1</sup>

<sup>1</sup> Politecnico di Milano, Dipartimento di Ingegneria Civile e Ambientale, Milano, Italy

<sup>2</sup> CO<sub>2</sub>Apps, Italy

**Sequestering carbon in solid materials**

John MCDONALD-WHARRY

School of Science and Engineering, University of Waikato, Hamilton, New Zealand

**Beyond Carbon Dioxide Removal: innovative breakthrough Negative Emissions Technologies for other GHGs Removal**Renaud de RICHTER<sup>1</sup>, Franz Dietrich OESTE<sup>2</sup>, Tingzhen MING<sup>3</sup>, Sylvain CAILLOL<sup>1</sup><sup>1</sup> Institute Charles Gerhardt, Montpellier, France<sup>2</sup> gM-Ingenieurbüro, Kirchhain, Germany.<sup>3</sup> School of Civil Engineering and Architecture, Wuhan University of Technology, China

2A

**BECCS in Nordic countries**

Tuesday, May 22, 14:00-15:00

**INVITED LECTURE:****Carbon Capture and Storage in Norway**

Kristin MYSKJA

Ministry of Petroleum and Energy

**The Nordic Countries Have Excellent Conditions for Bio-CCS**Ana SERDONER<sup>1</sup>, Keith WHIRISKEY<sup>1</sup>, Gøril TJETLAND<sup>2</sup>, Magnus RYDÉN<sup>2,3</sup> and Anders LYNGFELT<sup>3</sup><sup>1</sup> Bellona Europa, Brussels, Belgium<sup>2</sup> Bellona, Oslo, Norway<sup>3</sup> Chalmers University of Technology, Gothenburg, Sweden**Don't Panic – Why we believe the Nordics can go Net CO<sub>2</sub> Negative by 2040**Simon BRØNDUM ANDERSEN<sup>1</sup>, Kenneth KARLSSON<sup>1</sup>, Klaus SKYTTE<sup>1</sup>, Julia HANSSON<sup>2</sup>, Anders LYNGFELT<sup>2</sup><sup>1</sup> Technical University of Denmark, Copenhagen, Denmark<sup>2</sup> Chalmers University of Technology, Sweden

2B

**NETs – Systematic technology assessment**

Tuesday, May 22, 14:00-15:00

**Negative emissions – research landscape and synthesis**Jan C. MINX<sup>1,2</sup>, William F. LAMB<sup>1</sup>, Max W. CALLAGHAN<sup>1,2</sup>, Sabine FUSS<sup>1</sup>, Jérôme HILAIRE<sup>1,5</sup>, Felix CREUTZIG<sup>1,3</sup>, Thorben AMANN<sup>4</sup>, Tim BERINGER<sup>1</sup>, Wagner DE OLIVEIRA GARCIA<sup>4</sup>, Jens HARTMANN<sup>4</sup>, Tarun KHANNA<sup>1</sup>, Dominic LENZI<sup>1</sup>, Gunnar LUDERER<sup>5</sup>, Gregory F. NEMET<sup>6</sup>, Joeri ROGELJ<sup>7,8</sup>, Pete SMITH<sup>9</sup>, Jose Luis Vicente VICENTE<sup>1</sup>, Jennifer WILCOX<sup>10</sup>, Maria DEL MAR ZAMORA<sup>1</sup><sup>1</sup> Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany<sup>2</sup> School of Earth and Environment, University of Leeds, UK<sup>3</sup> Technische Universität Berlin, Germany<sup>4</sup> Institut für Geologie, Center for Earth System Research and Sustainability (CEN), Universität Hamburg, Germany<sup>5</sup> Potsdam Institute for Climate Impact Research, Potsdam, Germany<sup>6</sup> La Follette School of Public Affairs, University of Wisconsin, Madison, USA<sup>7</sup> ENE Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria<sup>8</sup> Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland<sup>9</sup> Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland, UK<sup>10</sup> Department of Chemical and Biological Engineering, Colorado School of Mines, Golden, USA**Negative emissions - Costs, potentials and side effects**Sabine FUSS<sup>1</sup>, William F. LAMB<sup>1</sup>, Max W. CALLAGHAN<sup>1</sup>, Jérôme HILAIRE<sup>1,5</sup>, Felix CREUTZIG<sup>1,3</sup>, Thorben AMANN<sup>4</sup>, Tim BERINGER<sup>1</sup>, Wagner de Oliveira GARCIA<sup>4</sup>, Jens HARTMANN<sup>4</sup>, Tarun KHANNA<sup>1</sup>, Gunnar LUDERER<sup>5</sup>, Gregory F. NEMET<sup>6</sup>, Joeri ROGELJ<sup>7,8</sup>, Pete SMITH<sup>9</sup>, José Luis VICENTE VICENTE<sup>1</sup>, Jennifer WILCOX<sup>10</sup>, Maria del Mar ZAMORA<sup>1</sup>, Jan C. MINX<sup>1,2</sup><sup>1</sup> Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany<sup>2</sup> School of Earth and Environment, University of Leeds, UK<sup>3</sup> Technische Universität Berlin, Germany<sup>4</sup> Universität Hamburg, Germany

<sup>5</sup> Potsdam Institute for Climate Impact Research, Germany

<sup>6</sup> La Follette School of Public Affairs, University of Wisconsin, Madison, USA

<sup>7</sup> International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

<sup>8</sup> Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

<sup>9</sup> Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland, UK

<sup>10</sup> Department of Chemical and Biological Engineering, Colorado School of Mines, USA

### Negative emissions - Part 3: Innovation and upscaling

Gregory F. NEMET<sup>1</sup>, Max W. CALLAGHAN<sup>2</sup>, Felix CREUTZIG<sup>2,3</sup>, Sabine FUSS<sup>2</sup>, Jens HARTMANN<sup>5</sup>, Jérôme HILAIRE<sup>2,6</sup>, William F. LAMB<sup>2</sup>, Jan C. MINX<sup>2,4</sup>, Sophia ROGERS<sup>1</sup>, Pete SMITH<sup>7</sup>

<sup>1</sup> La Follette School of Public Affairs, University of Wisconsin, Madison, USA

<sup>2</sup> Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany

<sup>3</sup> Technische Universität Berlin, Germany

<sup>4</sup> School of Earth and Environment, University of Leeds, UK

<sup>5</sup> Universität Hamburg, Germany

<sup>6</sup> Potsdam Institute for Climate Impact Research, Potsdam, Germany

<sup>7</sup> Institute of Biological and Environmental Sciences School of Biological Sciences, University of Aberdeen, Scotland, UK

2C

### Policy

Tuesday, May 22, 14:00-15:00

#### Land degradation neutrality will deliver large-scale negative emissions

Annette COWIE<sup>1</sup>, Barron J. ORR<sup>2</sup>, Johns Muleso KHARIKA<sup>2</sup>

<sup>1</sup> NSW Department of Primary Industries, Livestock Industries Centre, Australia

<sup>2</sup> United Nations Convention to Combat Desertification (UNCCD), Germany

#### New Carbon Economy Consortium Research Roadmap

Noah DEICH, Jane ZELIKOVA

Center for Carbon Removal

### An Earth Systems Governance perspective on negative emission technologies

Jesse REYNOLDS<sup>1</sup>, Matthias HONEGGER<sup>2</sup>

<sup>1</sup>Utrecht Centre for Water, Oceans and Sustainability Law, Utrecht University, The Netherlands

<sup>2</sup>Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands

2D

### Incentives

Tuesday, May 22, 14:00-15:00

#### Using RPSs and FITs to Accelerate Development of Negative Emissions Technologies

Anthony E. CHAVEZ

Chase College of Law, Northern Kentucky University, USA

#### Geoengineering and the blockchain: coordinating CDR & SRM to tackle future emissions

Andrew LOCKLEY, D'Maris COFFMAN

Bartlett School, UCL, London, UK

#### Carbon Dioxide Removal and Tradeable Put Options

Andrew LOCKLEY, D'Maris COFFMAN

Bartlett School, UCL, London, UK

2E

### BECCS – Regional examples

Tuesday, May 22, 14:00-15:00

#### Near-term Potential for Carbon-Negative Bioenergy in the United States and Pathways of Meeting the Potential

Ejeong BAIK<sup>1</sup>, Daniel L. SANCHEZ<sup>2</sup>, Peter A. TURNER<sup>2</sup>, Katharine J. MACH<sup>3</sup>, Christopher B. FIELD<sup>4</sup>, Sally M. BENSON<sup>5</sup>

<sup>1</sup> Department of Energy Resources Engineering, Stanford University, USA

<sup>2</sup> Department of Global Ecology, Carnegie Institution for Science, USA

<sup>3</sup> Department of Earth System Science, Stanford University, USA

<sup>4</sup> Stanford Woods Institute for the Environment, Stanford University, USA

## Bioenergy with Carbon Capture and Storage (BECCS) in the UK: Contrasting Land-use Scenarios and Implications for Natural Capital

Caspar DONNISON<sup>1</sup>, Robert A. HOLLAND<sup>1</sup>,  
Astley HASTINGS<sup>2</sup>, Lindsay-Marie ARMSTRONG<sup>3</sup>,  
Felix EIGENBROD<sup>4</sup>, Gail TAYLOR<sup>1,5</sup>

<sup>1</sup> Centre for Biological Sciences, University of Southampton, UK

<sup>2</sup> Institute of Biological and Environmental Sciences, University of Aberdeen, UK

<sup>3</sup> School of Engineering Sciences, University of Southampton, UK

<sup>4</sup> Geography and Environment, University of Southampton, UK

<sup>5</sup> Department of Plant Sciences, University of California, Davis, USA

## The role of biomass for negative emissions in Germany

Nora SZARKA<sup>1</sup>, Daniela THRÄN<sup>1,2</sup>

<sup>1</sup> DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Leipzig, Germany

<sup>2</sup> UFZ Helmholtz Centre for Environmental Research GmbH, Leipzig, Germany

3A

## Incentives

Wednesday, May 23, 11:00-12:00

### European Union's post-2020 climate policy and the incentives to use forests for climate change mitigation

Aapo RAUTIAINEN<sup>1</sup>, Jussi LINTUNEN<sup>1</sup>, Johanna POHJOLA<sup>2</sup>, Jani LATURI<sup>1</sup>, Jussi UUSIVUORI<sup>1</sup>

<sup>1</sup> Natural Resources Institute Finland (Luke), Helsinki, Finland

<sup>2</sup> Finnish Environment Institute (SYKE), Helsinki, Finland

### Making Negative Emissions Economically Feasible: The View from California

Roger D. AINES, Sean T. MCCOY

Lawrence Livermore National Laboratory, Livermore, California, USA

### The Financing of Future Negative Emissions – Bringing it All Back Home or Tangled up in Blue?

Anders LYNDFELT

Chalmers University of Technology, Gothenburg, Sweden

3B

## BECCS – CLC pilots

Wednesday, May 23, 11:00-12:00

### Biomass Combustion with CO<sub>2</sub> Capture by Chemical Looping: Experimental results in a 50 kWth Pilot plant

Albérto ABAD, Raúl PÉREZ-VEGA,  
Antón PÉREZ-ASTRAY, Teresa MENDIARA,  
Luis F. DE DIEGO, Francisco GARCÍA-LABIANO,  
Pilar GAYÁN, María T. IZQUIERDO, Juan ADÁNEZ  
Instituto de Carboquímica (ICB-CSIC), Zaragoza, Spain

### Operational Experience of CO<sub>2</sub> Capture Using Chemical-Looping Combustion of Biomass-Based Fuels in a 100 kW Unit

Matthias SCHMITZ, Carl LINDERHOLM,  
Anders LYNDFELT

Chalmers University of Technology, Gothenburg, Sweden

### Chemical Looping Combustion of wood pellets in a 150 kWth CLC reactor

Øyvind LANGØRGEN, Inge SAANUM

SINTEF Energy Research, Trondheim, Norway

3C

## Biospheric storage – Soil/Biochar

Wednesday, May 23, 11:00-12:00

### Technologies for maximising biochar's carbon sequestration potential

Ondrej MAŠEK, Wolfram BUSS

UK Biochar Research Centre, School of GeoSciences, University of Edinburgh, UK

### The FP7 EuroChar project: Biochar as a Negative Emission Technology

L. GENESIO<sup>1</sup>, F. VACCARI<sup>1</sup>, S. BARONTI<sup>1</sup>,  
A. MAIENZA<sup>1</sup>, I. CRISCUOLI<sup>1,2</sup>, G. ALBERTI<sup>3</sup>,  
E. LUGATO<sup>1,4</sup>, M. VENTURA<sup>2</sup>, G. TONON<sup>2</sup>,  
B. GLASER<sup>5</sup>, G. TAYLOR<sup>6</sup>, C. RUMPELL<sup>7</sup>, A. POZZI<sup>8</sup>,  
R. MASS<sup>9</sup>, J. WOODS<sup>10</sup>, F. MIGLIETTA<sup>1</sup>

<sup>1</sup> IBIMET-CNR, Italy

<sup>2</sup> Libera Università di Bolzano, Italy

<sup>3</sup> Università di Udine, Italy

<sup>4</sup> JRC, Italy

<sup>5</sup> Halle University, Germany

<sup>6</sup> Southampton University, UK

<sup>7</sup> UPMC-INRA-CNRS, France

<sup>8</sup> AGT, Italy

<sup>9</sup> Carbon Solutions, Germany

<sup>10</sup> Imperial College, UK

### Modelling the biogeochemical potential of biomass pyrolysis systems as a negative emission technology

C WERNER<sup>1</sup>, H-P SCHMIDT<sup>2</sup>, D GERTEN<sup>1,3</sup>,  
W LUCHT<sup>1,3,4</sup>, C KAMMANN<sup>5</sup>

<sup>1</sup> Potsdam Institute for Climate Impact Research, Potsdam, Germany

<sup>2</sup> Ithaka Institute for Carbon Strategies, Hamburg, Germany

<sup>3</sup> Humboldt-Universität zu Berlin, Department of Geography, Berlin, Germany

<sup>4</sup> Integrative Research Institute on Transformations of Human-Environment Systems, Berlin, Germany

<sup>5</sup> Hochschule Geisenheim University, WG Climate Change Research for Special Crops, Department of Soil Science and Plant Nutrition, Geisenheim, Germany

3D

### Policy

Wednesday, May 23, 11:00-12:00

#### Immediate deployment opportunities for negative emissions with BECCS: a Swedish case study

Henrik KARLSSON<sup>1</sup>, Timur DELAHAYE<sup>1</sup>,  
Filip JOHNSON<sup>2</sup>, Jan KJÄRSTAD<sup>2</sup>, Johan ROOTZÉN<sup>2</sup>

<sup>1</sup> Biorecro AB, Stockholm, Sweden

<sup>2</sup> Department of Space, Earth and Environment, Chalmers University of Technology, Gothenburg, Sweden

#### UK Policy Dynamics and the Development of Negative Emissions Technologies

Peter HEALEY<sup>1</sup>, Tim KRUGER<sup>2</sup>

<sup>1</sup> Institute for Science, Innovation and Society, University of Oxford, UK

<sup>2</sup> Oxford Martin School, University of Oxford, UK

#### Challenges and required R&D regarding negative CO<sub>2</sub> emissions

Frans VAN DIJEN

4A

### Policy

Wednesday, May 23, 14:00-15:00

#### Investigating Moral Hazard and Other Imagined Threats of Negative Emissions Technologies

David M REINER

Energy Policy Research Group, Judge Business School, University of Cambridge, UK

### Limits to the Compensation of Greenhouse Gas Emissions through Carbon Dioxide Sequestration in Plants

Josef SPITZER<sup>1</sup>, David Neil BIRD<sup>2</sup>, Annette COWIE<sup>3</sup>,  
Helmut HABERL<sup>4</sup>, Kim PINGOUD<sup>5</sup>,  
Hannes SCHWAIGER<sup>2</sup>

<sup>1</sup> Graz University of Technology, Graz, Austria

<sup>2</sup> Joanneum Research, Graz, Austria

<sup>3</sup> NSW Department of Primary Industries and University of New England, Armidale, Australia

<sup>4</sup> Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna, Austria

<sup>5</sup> Kim Pingoud Consulting, Espoo, Finland

#### Allocating negative emissions to countries

Glen PETERS<sup>1</sup>, Robbie ANDREW<sup>1</sup>, Oliver GEDEN<sup>2,3</sup>,  
Detlef VAN VUUREN<sup>4,5</sup>

<sup>1</sup> CICERO Center for International Climate Research, Oslo, Norway

<sup>2</sup> German Institute for International and Security Affairs (SWP), Berlin, Germany

<sup>3</sup> Max Planck Institute for Meteorology (MPI-M), Hamburg, Germany

<sup>4</sup> PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands

<sup>5</sup> Copernicus Institute for Sustainable Development, Utrecht University, Utrecht, The Netherlands

4B

### Modelling

Wednesday, May 23, 14:00-15:40

#### The value and institutional challenges of different carbon dioxide removal technologies for climate change mitigation

Jessica STREFLER, Nico BAUER, Florian  
HUMPENÖDER, David KLEIN, Elmar KRIEGLER

Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany

#### Estimating National Carbon Quotas and Modelling the Role of NETs in Compatible Emission Pathways at a Small Nation Scale

Barry McMULLIN<sup>1</sup>, Paul PRICE<sup>1</sup>, Michael B. JONES<sup>2</sup>,  
Alwynne H. MCGEEVER<sup>2</sup>

<sup>1</sup> Dublin City University, Dublin, Ireland

<sup>2</sup> University of Dublin, Trinity College, Dublin, Ireland



**Ocean carbon cycle feedbacks under negative emissions**

Jörg SCHWINGER, Jerry TJIPUTRA

Uni Research Climate, Bjerknes Centre for Climate Research, Bergen, Norway

**Energy transition pathways for the US coal sector under delayed climate policy actions**Piera PATRIZIO<sup>1</sup>, Sylvain LEDUC<sup>1</sup>, Sabine FUSS<sup>1,2</sup>, Florian KRAXNER<sup>1</sup><sup>1</sup> Ecosystems Services and Management Program (ESM), International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria<sup>2</sup> Working Group, Sustainable Resource Management and Global Change, Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany**The Effects of Carbon Dioxide Removal on the Carbon Cycle**David P. KELLER<sup>1</sup>, Andrew LENTON<sup>2,3</sup>, Emma W. LITTLETON<sup>4</sup>, Andreas OSCHLIES<sup>1</sup>, Vivian SCOTT<sup>5</sup>, Naomi E. VAUGHAN<sup>6</sup><sup>1</sup> GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany<sup>2</sup> CSIRO Oceans and Atmosphere, Hobart, Australia<sup>3</sup> Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Australia<sup>4</sup> College of Life and Environmental Sciences, University of Exeter, UK<sup>5</sup> School of GeoSciences, University of Edinburgh<sup>6</sup> Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

4C

**BECCS in Industry**

Wednesday, May 23, 14:00-15:40

**Impact analysis of CO<sub>2</sub> capture from pulp mills - effects on CO<sub>2</sub> emissions, costs and green electricity production**Ragnhild SKAGESTAD<sup>1</sup>, Jens WOLF<sup>2</sup>, Marie ANHEDEN<sup>2</sup>, Stefania Osk GARDARSDOTTIR<sup>3</sup>, Anette MATHISEN<sup>2</sup>, Fredrik NORMANN<sup>3</sup><sup>1</sup> SINTEF INDUSTRY, Porsgrunn, Norway<sup>2</sup> RISE Bioeconomy, Stockholm, Sweden<sup>3</sup> Chalmers University of Technology, Gothenburg, Sweden**A Strategy for Early Deployment of BECCS in Basic Industry - A Swedish Case Study**Johan ROOTZÉN<sup>1</sup>, Jan KJÄRSTAD<sup>1</sup>, Filip JOHNSON<sup>1</sup>, Henrik KARLSSON<sup>2</sup><sup>1</sup> Chalmers University of Technology, Gothenburg, Sweden<sup>2</sup> Biorecro AB, Stockholm, Sweden**Evaluation of Steel Mills as Carbon Sinks**

Maximilian BIERMANN, Alberto ALAMIA, Fredrik NORMANN, Filip JOHNSON

Chalmers University of Technology, Sweden

**Opportunities for achieving negative emissions from European iron and steel industry**Hana MANDOVA<sup>1</sup>, Sylvain LEDUC<sup>2</sup>, Piera PATRIZIO<sup>2</sup>, Chuan WANG<sup>3</sup>, Elisabeth WETTERLUND<sup>4</sup>, William GALE<sup>1</sup>, Florian KRAXNER<sup>2</sup><sup>1</sup> University of Leeds, Leeds, UK<sup>2</sup> International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria<sup>3</sup> Swerea MEFOS, Sweden<sup>4</sup> Energy Engineering, Division of Energy Science, Luleå University of Technology, Sweden**Pulp Mill as BioCCU**

Katja KUPARINEN, Esa VAKKILAINEN, Tero TYNJÄLÄ

Lappeenranta University of Technology, Finland

4D

**Biospheric storage – Forestry**

Wednesday, May 23, 14:00-15:40

**The Mitigation Potential of Large-Scale Tropical Forest Restoration: Assessing the Promise of the Bonn Challenge**Charlotte E. WHEELER<sup>1,2</sup> Edward MITCHARD<sup>1</sup> Alexander KOCH<sup>2</sup>, Simon L. LEWIS<sup>2,3</sup><sup>1</sup> School of GeoSciences, University of Edinburgh, UK<sup>2</sup> Department of Geography, University College London, UK<sup>3</sup> School of Geography, University of Leeds, UK**Climate Change Mitigation Potential of Biomass Based Heat and Power Production**Torun HAMMAR<sup>1</sup>, Johan STENDAHL<sup>2</sup>, Cecilia SUNDBERG<sup>1,3</sup>, Hampus HOLMSTRÖM<sup>4</sup>, Per-Anders HANSSON<sup>1</sup><sup>1</sup> Dept. of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden.<sup>2</sup> Dept. of Soil and Environment, SLU, Uppsala, Sweden<sup>3</sup> Dept. of Sustainable Development, Environmental Science and Engineering, KTH Royal Institute of Technology, Stockholm, Sweden

<sup>4</sup> Department of Forest Resource Management, SLU, Umeå, Sweden

### On the trade-offs and synergies between forest carbon sequestration and substitution

Sampo SOIMAKALLIO<sup>1</sup>, Tuomo KALLIOKOSKI<sup>2</sup>, Aleksi LEHTONEN<sup>3</sup>, Olli SALMINEN<sup>3</sup>

<sup>1</sup> Finnish Environment Institute SYKE, Helsinki, Finland

<sup>2</sup> University of Helsinki, Finland

<sup>3</sup> Natural Resources Institute Finland (Luke), Helsinki, Finland

### The temporal greenhouse gas impacts of forest-based bioenergy within a cumulative emissions framing

Mirjam RÖDER<sup>1</sup>, Evelyne THIFFAULT<sup>2</sup>, Celia MARTÍNEZ-ALONSO<sup>3</sup>, Patricia THORNLEY<sup>1</sup>

<sup>1</sup> Supergen Bioenergy Hub, Tyndall Centre for Climate Change Research, School of Mechanical, Aerospace & Civil Engineering, University of Manchester, UK

<sup>2</sup> Research Centre on Renewable Materials, Department of wood and forest sciences, Laval University, Quebec City, Canada.

<sup>3</sup> CETEMAS, Forest and Wood Technology Research Centre, Sustainable Forest Management Area, Asturias, Spain

<sup>4</sup> Centre for Forest Research, Montreal, Canada.

### The risks of large-scale biosequestration in the context of Carbon Dioxide Removal

Coraina DE LA PLAZA<sup>1</sup>, Oliver MUNNION<sup>2</sup>, Simon FISCHER<sup>1</sup>, Simone LOVERA<sup>3</sup>

<sup>1</sup> Global Forest Coalition, Amsterdam, The Netherlands

<sup>2</sup> Global Forest Coalition, Coimbra, Portugal

<sup>3</sup> Global Forest Coalition, Asunción, Paraguay

4E

## NETs – Weathering

Wednesday, May 23, 14:00-15:00

### An intrusive investigation of the weathering of legacy iron and steel wastes at Consett, County Durham, UK

Huw PULLIN<sup>1</sup>, Devin SAPSFORD<sup>2</sup>, Will MAYES<sup>3</sup>, Phil RENFORTH<sup>1</sup>

<sup>1</sup> School of Earth and Ocean Sciences, Cardiff University, UK

<sup>2</sup> School of Engineering, Cardiff University, UK

<sup>3</sup> School of Environmental Sciences, University of Hull, UK.

### Development of in-situ high pressure (20 MPa) high temperature (773 K) infrared spectroscopy for monitoring silicate weathering

Greg MUTCH<sup>1</sup>, James ANDERSON<sup>2</sup>, David VEGA-MAZA<sup>2</sup>

<sup>1</sup> Newcastle University, Newcastle upon Tyne, UK

<sup>2</sup> University of Aberdeen, King's College, Aberdeen, UK

### Safely & Economic Sequestering CO<sub>2</sub> with Olivine

Pol KNOPS<sup>1</sup>, Eddy L. WIJNKER<sup>2</sup>

<sup>1</sup> Green Minerals, Netherlands

<sup>2</sup> greenSand, Netherlands

5A

## Modelling

Wednesday, May 23, 16:10-17:30

### Energy system implications of negative emission technologies

Felix CREUTZIG<sup>1</sup>, Christian BREYER<sup>2</sup>, Jérôme HILAIRE<sup>1</sup>, Jan MINX<sup>1</sup>, Glen PETERS<sup>3</sup>

<sup>1</sup> Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany

<sup>2</sup> Lappeenranta University of Technology, Lappeenranta, Finland

<sup>3</sup> Center for International Climate and Environmental Research, Oslo, Norway

### Biomass in the electricity system: complement to variable renewables or carbon sink?

Viktor JOHANSSON<sup>1</sup>, Mariliis LEHTVEER<sup>1,2</sup>, Lisa GÖRANSSON<sup>1</sup>

<sup>1</sup> Department of Space, Earth and Environment, Chalmers University of Technology, Sweden

<sup>2</sup> The Centre for Climate Science and Policy Research (CSPR), Department of Thematic Studies – Environmental Change, Linköping University, Sweden

### Potential Impacts of Land-Based Negative Emissions Technologies on Biodiversity and Ecosystem Services

Pete SMITH

Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland, UK

### Global energy sector emission reductions and bioenergy use: overview of the bioenergy demand phase of the EMF 33 model comparison

Nico BAUER<sup>1</sup>, Steven K. ROSE<sup>2</sup>, Shinichiro FUJIMORI<sup>3</sup>, Detlef P. VAN VUUREN<sup>4,5</sup>, John WEYANT<sup>6</sup>, Marshall WISE<sup>7</sup>, Yiyun CUI<sup>7</sup>, Vassilis DAIIOGLOU<sup>4</sup>,

Matthew GIDDEN<sup>8</sup>, Etsushi KATO<sup>9</sup>, Alban KITOUS<sup>10</sup>, Florian LEBLANC<sup>11</sup>, Ron SANDS<sup>12</sup>, Fuminori SANO<sup>13</sup>, Jessica STREFLER<sup>1</sup>, Junichi TSUTSUI<sup>14</sup>, Ruben BIBAS<sup>11</sup>, Oliver FRICKO<sup>8</sup>, Tomoko HASEGAWA<sup>3</sup>, David KLEIN<sup>1</sup>, Atsushi KUROSAWA<sup>9</sup>, Silvana MIMA<sup>15</sup>, Matteo MURATORI<sup>16</sup>

<sup>1</sup> Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany

<sup>2</sup> Electric Power Research Institute, Washington, DC, USA

<sup>3</sup> National Institute for Environmental Studies (NIES), Japan

<sup>4</sup> Netherlands Environmental Assessment Agency (PBL), The Netherlands

<sup>5</sup> Copernicus institute for sustainable development, Utrecht University, The Netherlands

<sup>6</sup> Stanford University, CA, USA

<sup>7</sup> Pacific Northwest National Laboratory (PNNL), MD, United States

<sup>8</sup> International Institute for Applied Systems Analysis (IIASA), Austria

<sup>9</sup> The Institute of Applied Energy, Tokyo, Japan

<sup>10</sup> Joint Research Center (JRC), Seville, Spain

<sup>11</sup> Centre International de Recherche sur l'Environnement et le Développement, Paris, France

<sup>12</sup> US Department of Agriculture, Washington DC, USA

<sup>13</sup> Research Institute of Innovative Technology for the Earth (RITE), Kyoto, Japan

<sup>14</sup> Central Research Institute of Electric Power Industry (CRIEPI), Tokyo, Japan

<sup>15</sup> University of Grenoble, France

<sup>16</sup> National Renewable Energy Laboratory (NREL), Golden, CO, USA

<sup>4</sup> School of Regulation and Global Governance, Australian National University, Canberra, Australia

<sup>5</sup> National Centre for the Public Awareness of Science, Australian National University, Canberra, Australia

<sup>6</sup> Crawford School of Public Policy, Australian National University, Canberra, Australia

<sup>7</sup> College of Law, Australian National University, Canberra, Australia

<sup>8</sup> Centre for Aboriginal Economic Policy Research, Australian National University, Canberra, Australia

<sup>9</sup> Research School of Psychology, Australian National University, Canberra, Australia

### Fast-growing dependence on negative emissions

Jan C. MINX<sup>1,2</sup>, Gunnar LUDERER<sup>3</sup>, Felix CREUTZIG<sup>1,4</sup>, Sabine FUSS<sup>1</sup> and Ottmar EDENHOFER<sup>1,3,4</sup>

<sup>1</sup> Mercator Research Institute on Global Commons and Climate Change (MCC), Berlin, Germany

<sup>2</sup> School of Earth and Environment, University of Leeds, UK

<sup>3</sup> Potsdam Institute for Climate Impact Research, Potsdam, Germany

<sup>4</sup> Technische Universität Berlin, Germany

### Accounting for Negative CO<sub>2</sub> Emissions

Eric MARLAND<sup>1</sup>, Gregg MARLAND<sup>2</sup>, Jason HOYLE<sup>3</sup>, Tamara KOWALCZYK<sup>4</sup>, Tatyana RUSEVA<sup>5</sup>, Lindsey WISE<sup>1</sup>

<sup>1</sup> Department of Mathematical Sciences, Appalachian State University, USA

<sup>2</sup> Department of Geological and Environmental Sciences, Appalachian State University, USA

<sup>3</sup> Appalachian Energy Center, Appalachian State University, USA

<sup>4</sup> Department of Accounting, Appalachian State University, USA

<sup>5</sup> Department of Government and Justice Studies, Appalachian State University, USA

### Understanding the need for policy action on Greenhouse Gas Removal in addressing Climate Change: Initial Case for a Robust Decision Making Approach

Mark WORKMAN<sup>1</sup>, Jim MALTBY<sup>2</sup>, Geoff DARCH<sup>3</sup>

<sup>1</sup> Foresight Transitions and Energy Futures Lab, Imperial College London, UK

<sup>2</sup> Defence Science and Technology Laboratory, Porton Down, UK

<sup>3</sup> Anglian Water, Thorpe Wood, UK

5B

## Policy

Wednesday, May 23, 16:10-17:30

### We must learn from climate change to avoid politicisation and polarisation of negative emissions

R.M. COLVIN<sup>1</sup>, Luke KEMP<sup>2</sup>, Anita TALBERG<sup>3</sup>, Clare DE CASTELLA<sup>1</sup>, Christian DOWNIE<sup>4</sup>, Sharon FRIEL<sup>4</sup>, Will GRANT<sup>5</sup>, Mark HOWDEN<sup>1</sup>, Frank JOTZO<sup>6</sup>, Andrew MACINTOSH<sup>7</sup>, Francis MARKHAM<sup>8</sup>, Michael PLATOW<sup>9</sup>

<sup>1</sup> Climate Change Institute, Australian National University, Canberra, Australia

<sup>2</sup> Fenner School of Environment and Society, Australian National University, Canberra Australia

<sup>3</sup> Climate and Energy College, University of Melbourne, Australia

5C

**NETs – Direct Air Capture**

Wednesday, May 23, 16:10-17:30

**The role of direct air capture and bioenergy in net zero CCU fuel loops**Mijndert VAN DER SPEK, Daniel SUTTER,  
Cristina ANTONINI, Marco MAZZOTTI

Institute of Process Engineering, ETH Zurich, Switzerland

**CO<sub>2</sub> Direct Air Capture for effective Climate Change Mitigation: A new Type of Energy System Sector Coupling**Christian BREYER, Mahdi FASIHI,  
Arman AGHAHOSSEINI

Lappeenranta University of Technology, Finland

**Global Thermostat Low Cost Direct Air Capture Technology**Eric PING, Miles SAKWA-NOVAK,  
Peter EISENBERGER

Global Thermostat LLC, New York, USA

**Assessment of the Performance of a Bench Scale Direct Air Capture Device Operated at Outdoor Environment**

Cyril BAJAMUND, Jere ELFVING, Juho KAUPPINEN

VTT Technical Research Centre of Finland, Jyväskylä,  
Finland

5D

**BECCS – CLC**

Wednesday, May 23, 16:10-17:30

**Negative CO<sub>2</sub> – Halfway through the Nordic Energy Research flagship project**Magnus RYDÉN<sup>1</sup>, Anders LYNGFELT<sup>1</sup>, Øyvind  
LANGØRGEN<sup>2</sup>, Yngve LARRING<sup>3</sup>, Anders BRINK<sup>4</sup>,  
Maria ZEVENHOVEN<sup>4</sup>, Toni PIKKARAINEN<sup>5</sup>, Tomi J  
LINDROOS<sup>5</sup>, Keith WHIRISKEY<sup>6</sup>, Per KARMHAGEN<sup>7</sup><sup>1</sup> Chalmers University of Technology, Gothenburg, Sweden<sup>2</sup> SINTEF Energy Research, Trondheim, Norway<sup>3</sup> SINTEF Materials and Chemistry, Oslo, Norway<sup>4</sup> Åbo Akademi University, Åbo, Finland<sup>5</sup> VTT Technical Research Center of Finland Ltd, Esbo,  
Finland<sup>6</sup> The Bellona Foundation, Oslo, Norway<sup>7</sup> Sibelco Nordic AB, Göteborg, Sweden**The comparative chemical-looping combustion performance of synthetic ilmenite perovskite with mineral ilmenite**Nima KHAKPOOR, Davood KARAMI,  
Nader MAHINPEYDepartment of Chemical and Petroleum Engineering,  
University of Calgary, Canada**Behaviour of Devolatilising Biomass Particles in Fluidised Beds**

Z. W. M. BOND, J. S. DENNIS

University of Cambridge, Department of Chemical Engineering and Biotechnology, UK

**Use of cheap Mn- and Fe-based oxygen carriers in chemical-looping combustion (CLC) and gasification (CLG) with negative emissions of carbon dioxide**Tobias MATTISSON, Ye LI, Fredrik HILDOR, Carl  
LINDERHOLM

Chalmers University of Technology, Gothenburg, Sweden

5E

**Biospheric storage – Soil/Biochar**

Wednesday, May 23, 16:10-17:30

**Pyrogenic Carbon Capture & Storage (PyCCS)**Hans-Peter SCHMIDT<sup>1</sup>, Andrés ANCA-COUCÉ<sup>2</sup>,  
Nikolas HAGEMANN<sup>1,3</sup>, Constanze WERNER<sup>4</sup>,  
Dieter GERTEN<sup>4,5</sup>, Wolfgang LUCHT<sup>4,5</sup>,  
Claudia KAMMANN<sup>6</sup><sup>1</sup> Ithaka Institute, Hamburg, Germany<sup>2</sup> Institute of Thermal Engineering, Graz University of  
Technology, Graz, Austria<sup>3</sup> Environmental Analytics, Agroscope, Zurich, Switzerland<sup>4</sup> Potsdam Institute for Climate Impact Research (PIK),  
Research Domain I: Earth System Analysis, Potsdam,  
Germany<sup>5</sup> Humboldt-Universität zu Berlin, Geography  
Department, Berlin, Germany<sup>6</sup> Department of Applied Ecology, Hochschule Geisen-  
heim University, Geisenheim, Germany**Carbon-budget effects of biomass-based negative emission approaches – a high-level comparison**

Tobias PRÖLL, Florian ZEROBIN

University of Natural Resources and Life Sciences, Vien-  
na, Austria**System analysis of large-scale biochar production and use**

**for negative CO<sub>2</sub> emissions in Sweden**Elias AZZI<sup>1</sup>, Erik KARLTUN<sup>2</sup>, Cecilia SUNDBERG<sup>1,3</sup><sup>1</sup> Department of Sustainable Development, Environmental Engineering and Sciences, KTH Royal Institute of Technology, Sweden<sup>2</sup> Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden<sup>3</sup> Department of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden**CO<sub>2</sub>-Negative Cooking and Cultivation in Smallholder Farms in Africa - the Potential Role of Pyrolysis and Biochar**Cecilia SUNDBERG<sup>1,2</sup>, Erik KARLTUN<sup>3</sup>, James GITAU<sup>4</sup>, Thomas KÄTTERER<sup>5</sup>, Geoffrey KIMUTAI<sup>6</sup>, Yahia MAHMOUD<sup>7</sup>, Mary NJENGA<sup>4,8</sup>, Gert NYBERG<sup>9</sup>, Kristina ROING DE NOWINA<sup>3,10</sup>, Dries ROOBROECK<sup>6</sup>, Petra SIEBER<sup>2</sup><sup>1</sup> Department of Sustainable Development, Environmental Science and Engineering (SEED), KTH - Royal Institute of Technology, Stockholm, Sweden<sup>2</sup> Department of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden<sup>3</sup> Department of Soil and Water, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden<sup>4</sup> Wangari Maathai Institute for Peace and Environmental Studies, University of Nairobi, Nairobi, Kenya<sup>5</sup> Department of Ecology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden<sup>6</sup> IITA, Nairobi, Kenya<sup>7</sup> Department of Human Geography, Lund University, Lund, Sweden<sup>8</sup> World Agroforestry Centre (ICRAF), Nairobi, Kenya<sup>9</sup> Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), Umeå, Sweden<sup>10</sup> CIFOR, Nairobi, KenyaFrancesco CHERUBINI<sup>1</sup><sup>1</sup> Industrial Ecology Programme, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway<sup>2</sup> Department of Environmental Sciences, University of Helsinki, Finland**Combining Forest Plot Data and Remotely-Sensed Biomass Maps for Improved Estimates of the Carbon Sink in Tropical Regrowth Forests**Danaë M.A. ROZENDAAL<sup>1</sup>, Lourens POORTER<sup>2</sup>, Daniela K. REQUENASUAREZ<sup>1</sup>, Angélica M. ALMEYDA ZAMBRANO<sup>3</sup>, Frans BONGERS<sup>2</sup>, Eben N. BROADBENT<sup>4</sup>, Robin L. CHAZDON<sup>5</sup>, Veronique DE SY<sup>1</sup>, Erika ROMIJN<sup>1</sup>, Martin HEROLD<sup>1</sup><sup>1</sup> Laboratory of Geo-Information Science and Remote Sensing, Wageningen University, The Netherlands<sup>2</sup> Forest Ecology and Forest Management Group, Wageningen University, The Netherlands<sup>3</sup> Department of Tourism, Recreation & Sport Management, University of Florida, Gainesville, USA<sup>4</sup> School of Forest Resources and Conservation, University of Florida, Gainesville, USA<sup>5</sup> Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA**Do biophysical effects thwart mitigation potential of boreal forest management?**Eero NIKINMAA<sup>1†</sup>, Tuomo KALLIOKOSKI<sup>1,2</sup>, Kari MINKKINEN<sup>1</sup>, Jaana BÄCK<sup>1</sup>, Michael BOY<sup>2</sup>, Yao GAO<sup>3</sup>, Nina JANASIK-HONKELA<sup>4</sup>, Janne I. HUKKINEN<sup>4</sup>, Maarit KALLIO<sup>5</sup>, Markku KULMALA<sup>2</sup>, Nea KUUSINEN<sup>1</sup>, Annikki MÄKELÄ<sup>1</sup>, Brent D. MATTHIES<sup>1</sup>, Mikko PELTONIEMI<sup>5</sup>, Risto SIEVÄNEN<sup>5</sup>, Ditte TAIPALE<sup>1,2,7</sup>, Lauri VALSTA<sup>1</sup>, Anni VANHATALO<sup>1</sup>, Martin WELP<sup>6</sup>, Luxi ZHOU<sup>2</sup>, Putian ZHOU<sup>2</sup>, Frank BERNINGER<sup>1</sup><sup>1</sup> Department of Forest Sciences, University of Helsinki, Finland<sup>2</sup> Department of Physics, University of Helsinki, Finland<sup>3</sup> Finnish Meteorological Institute, Helsinki, Finland<sup>4</sup> Department of Social Research, University of Helsinki, Finland<sup>5</sup> Natural Resources Institute Finland<sup>6</sup> FB Wald und Umwelt Hochschule für nachhaltige Entwicklung Eberswalde, Germany<sup>7</sup> Estonian University of Life Sciences, Department of Plant Physiology, Estonia<sup>†</sup> Prof. Eero Nikinmaa was the initiator of this study. He regrettably deceased before we finished the paper.

6A

**Biospheric storage – Forestry**

Thursday, May 24, 11:00-12:20

**Contribution of harvested wood products to negative emissions: historical trends in Norway, Sweden and Finland and future projections under the shared socioeconomic pathways**Cristina-Maria IORDAN<sup>1</sup>, Xiangping HU<sup>1</sup>, Anders ARVESEN<sup>1</sup>, Pekka KAUPPI<sup>2</sup>,

**A Method for Locating Sustainable BECCS Potentials**

Florian KRAXNER<sup>1</sup>, Piera PATRIZIO<sup>1</sup>,  
Dmitry SCHEPASCHENKO<sup>1</sup>, Sylvain LEDUC<sup>1</sup>,  
Sabine FUSS<sup>1,2</sup>, Linda SEE<sup>1</sup>, Ping YOWARGANA<sup>1</sup>,  
Bintang YUWONO<sup>1</sup>, Andrey KRASOVSKI<sup>1</sup>,  
Sennai MESFUN<sup>1</sup>, Georg KINDERMANN<sup>1</sup>,  
Kasparas SPOKAS<sup>3</sup>, Anders LUNNAN<sup>4</sup>,  
Anatoly SHVIDENKO<sup>1</sup>

<sup>1</sup> Center for Landscape Resilience (CLR), Ecosystems Services and Management Program (ESM), International Institute for Applied Systems Analysis (IIASA), Austria

<sup>2</sup> Working group Sustainable Resources Management and Global Change, Mercator Research Institute on Global Commons and Climate Change (MCC), Germany

<sup>3</sup> Civil and Environmental Engineering, Princeton University, USA

<sup>4</sup> Norwegian University of Life Sciences (NMBU), Norway

**6B****NETs – Weathering**

Thursday, May 24, 11:00-12:20

**Expanding Global, Negative-Emissions Energy: Electrogeochemical Conversion of Renewable Electricity to Negative-Emissions H<sub>2</sub>**

Greg H. RAU

Institute of Marine Sciences, University of California,  
Santa Cruz, USA

**Negative CO<sub>2</sub> emissions via enhanced silicate weathering in coastal environments**Filip J.R. MEYSMAN<sup>1,2</sup>, Francesc MONTSERRAT<sup>1</sup>

<sup>1</sup> Department of Biology, Universiteit Antwerpen,  
Belgium

<sup>2</sup> Department of Biotechnology, Technical University of  
Delft (TU Delft), The Netherlands

**Physiological responses of *Corallina* spp. to an increase in total alkalinity-an ex-situ study**Sarah GORE, Phil RENFORTH, Rupert PERKINS,  
Stephen BARKER

School of Earth and Ocean Sciences, Cardiff University,  
UK

**Multi-gigatonne net CO<sub>2</sub> sequestration in cropland soils amended with basalt?**

David BEERLING<sup>1</sup>, Euripides KANTZAS<sup>1</sup>,  
Peter WADE<sup>1</sup>, Mark LOMAS<sup>1</sup>, Joe QUIRK<sup>1</sup>,  
Binoy SARKAR<sup>1</sup>, Steve BANWART<sup>2</sup>, Shaun QUEGAN<sup>3</sup>

<sup>1</sup> Leverhulme Centre for Climate Change Mitigation,  
Department of Animal and Plant Sciences, University of

Sheffield, UK

<sup>2</sup> School of Earth and Environment, University of Leeds,  
UK

<sup>3</sup> Department of Mathematics and Statistics, University of  
Sheffield, UK

**6C****Policy**

Thursday, May 24, 11:00-12:20

**Defining Limits to Terrestrial Carbon Removal for 1.5 Degrees**Kate DOOLEY<sup>1</sup>, Sivan KARTHA<sup>2</sup>,

<sup>1</sup> University of Melbourne, Australia

<sup>2</sup> Stockholm Environment Institute, Sweden

**Carbon dioxide removal – the need to marry financial incentives with sustainable development**Matthias HONEGGER<sup>1,2,3</sup>

<sup>1</sup> IASS, Potsdam, Germany,

<sup>2</sup> Perspectives, Freiburg, Germany,

<sup>3</sup> University of Utrecht, Utrecht, The Netherlands

**Assessing the terrestrial capacity for Negative Emission Technologies at a small developed nation scale**

Alwynne H. MCGEEVER<sup>1</sup>, Paul PRICE<sup>2</sup>,  
Barry MCMULLIN<sup>2</sup>, Michael B. JONES<sup>1</sup>

<sup>1</sup> School of Natural Sciences, The University of Dublin,  
Trinity College Dublin, Ireland

<sup>2</sup> School of Electronic Engineering, Dublin City University,  
Ireland

**Co-authorship network in the BECCS (BioEnergy with Carbon Capture and Storage) research community**Audrey LAUDE<sup>1</sup>, Xavier GALIEGUE<sup>2</sup>

<sup>1</sup> Laboratoire REGARDS, Université de Reims  
Champagne-Ardenne, France

<sup>2</sup> Laboratoire d'Economie d'Orléans, Université  
d'Orléans, France

**6D****Modelling**

Thursday, May 24, 11:00-12:20

**Large uncertainty in carbon uptake potential of land-based climate-change mitigation efforts**

Andreas KRAUSE<sup>1</sup>, Thomas A. M. PUGH<sup>1,2</sup>,  
Anita D. BAYER<sup>1</sup>, Wei LI<sup>3</sup>, Felix LEUNG<sup>4</sup>,  
Alberte BONDEAU<sup>5</sup>, Jonathan C. DOELMAN<sup>6</sup>,

Florian HUMPENÖDER<sup>7</sup>, Peter ANTHONI<sup>1</sup>, Benjamin L. BODIRSKY<sup>7</sup>, Philippe CIAIS<sup>3</sup>, Christoph MÜLLER<sup>7</sup>, Guillermo MURRAY-TORTAROLO<sup>4</sup>, Stefan OLIN<sup>8</sup>, Alexander POPP<sup>7</sup>, Stephen SITCH<sup>4</sup>, Elke STEHFEST<sup>6</sup>, Almut ARNETH<sup>1</sup>

<sup>1</sup> Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU), Germany

<sup>2</sup> School of Geography, Earth & Environmental Sciences and Birmingham Institute of Forest Research, University of Birmingham, UK

<sup>3</sup> Laboratoire des Sciences du Climat et l'Environnement, CEA-CNRS-UVSQ, France

<sup>4</sup> College of Life and Environmental Sciences, University of Exeter, UK

<sup>5</sup> Mediterranean Institute for Biodiversity and Ecology, Aix-en-Provence, France

<sup>6</sup> Department of Climate, Air and Energy, Netherlands Environmental Assessment Agency, The Hague, The Netherlands

<sup>7</sup> Potsdam Institute for Climate Impact Research (PIK), Germany

<sup>8</sup> Department of Physical Geography and Ecosystem Science, Lund University, Sweden

### **Evaluating Different Implementations of the UN Climate Target in Integrated Assessment Models and the Effect on the Use of BECCS**

Daniel J.A. JOHANSSON<sup>1</sup>, Mariliis LEHTVEER<sup>1,2</sup>

<sup>1</sup> Department of Space, Earth and Environment, Chalmers University of Technology, Sweden

<sup>2</sup> The Centre for Climate Science and Policy Research (CSPR), Department of Thematic Studies – Environmental Change, Linköping University, Sweden

### **Relative effectiveness of forests and BECCS in stabilizing climate change at 1.5C**

Anna B. HARPER<sup>1</sup>, Tom POWELL<sup>2</sup>, Peter M. COX<sup>1</sup>, Joanna HOUSE<sup>3</sup>, Chris HUNTINGFORD<sup>4</sup>, Timothy M. LENTON<sup>2</sup>, Stephen SITCH<sup>2</sup>, Eleanor BURKE<sup>5</sup>, Sarah E. CHADBURN<sup>1,6</sup>, William J. COLLINS<sup>7</sup>, Edward COMYN-PLATT, Vassilis DAIIOGLOU<sup>8,9</sup>, Jonathan C. DOELMAN<sup>8</sup>, Garry HAYMAN<sup>4</sup>, Eddy ROBERTSON<sup>5</sup>, Detlef VAN VUUREN<sup>8,9</sup>, Andy WILTSHIRE<sup>5</sup>, Christopher P. WEBBER<sup>7</sup>, Ana BASTOS<sup>10</sup>, Lena BOYSEN<sup>11</sup>, Philippe CIAIS<sup>12</sup>, Narayanappa DEVARAJU<sup>12</sup>, Atul K. JAIN<sup>13</sup>, Andreas KRAUSE<sup>14</sup>, Ben POULTER<sup>15</sup>, Shijie SHU<sup>13</sup>

<sup>1</sup> College of Engineering, Mathematics, and Physical Sciences, University of Exeter, UK

<sup>2</sup> College of Life and Environmental Sciences, University of Exeter, UK

<sup>3</sup> School of Geographical Sciences, University of Bristol, UK

<sup>4</sup> Centre for Ecology and Hydrology, Wallingford, UK

<sup>5</sup> Met Office Hadley Centre, UK

<sup>6</sup> University of Leeds, UK

<sup>7</sup> Department of Meteorology, University of Reading, UK

<sup>8</sup> Department of Climate, Air and Energy, Netherlands Environmental Assessment Agency (PBL), The Hague, The Netherlands

<sup>9</sup> Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands

<sup>10</sup> Dept. of Geography, Ludwig Maximilians University Munich, Germany

<sup>11</sup> Land in the Earth System, Max Planck Institute for Meteorology, Hamburg, Germany

<sup>12</sup> Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, France

<sup>13</sup> Department of Atmospheric Sciences, University of Illinois, Urbana, USA

<sup>14</sup> Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU), Germany

<sup>15</sup> NASA GSFC, Biospheric Sciences Lab., Greenbelt, USA

### **Evaluating the use of biomass energy with carbon capture and storage in low emission scenarios**

Naomi E VAUGHAN<sup>1</sup>, Clair GOUGH<sup>2</sup>, Sarah MANDER<sup>2</sup>, Emma W LITTLETON<sup>3</sup>, Andrew WELFLE<sup>2</sup>, David E H J GERNAAT<sup>4,5</sup>, Detlef P VAN VUUREN<sup>4,5</sup>

<sup>1</sup> Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK

<sup>2</sup> Tyndall Centre for Climate Change Research, School of Mechanical, Aerospace and Civil Engineering, University of Manchester, UK

<sup>3</sup> College of Life and Environmental Sciences, University of Exeter, UK

<sup>4</sup> PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands

<sup>5</sup> Copernicus Institute for Sustainable Development, Utrecht University, Utrecht, The Netherlands

6E

**BECCS – Oxy- and Post-combustion**

Thursday, May 24, 11:00-12:20

**ASPEN simulation of a 100 MW solar powered thermo-chemical air separation system combined with an oxy-fuel power plant for BECCS**

Clemens F. PATZSCHKE, Husain BAHZAD, Matthew E. BOOT-HANDFORD, Paul S. FENNELL

Department of Chemical Engineering, Imperial College London, UK

**The effect of potassium salts and ash from biomass combustion on the degradation of monoethanolamine for carbon capture**Diarmaid CLERY<sup>1,2</sup>, Jenny JONES<sup>1</sup>, Douglas BARNES<sup>3</sup>, Muhammad AKRAM<sup>4</sup>, Christopher RAYNER<sup>2,3</sup><sup>1</sup> School of Chemical and Process Engineering, University of Leeds, UK<sup>2</sup> School of Chemistry, University of Leeds, UK<sup>3</sup> C-Capture Limited, Leeds Innovation Centre, UK<sup>4</sup> Energy 2050, Department of Mechanical Engineering, University of Sheffield, UK**The effect of flue gas recirculation on the formation of alkali- chlorides and sulfates in Oxy-BECCS power plants**

Thomas ALLGURÉN, Klas ANDERSSON, Fredrik NORMANN

Chalmers University of Technology, Gothenburg, Sweden

**Bio-Energy CCS (BECCS) via Oxy-FBC**

Margarita DE LAS OBRAS LOSCERTALES, Robert T. SYMONDS, Robin W. HUGHES, Ryan BURCHAT, Kelly ATKINSON

Natural Resources Canada, CanmetENERGY-Ottawa, Canada

7A

**BECCS – Power plants**

Thursday, May 24, 14:00-15:00

**Sustainability Constrains on Biomass Resources Significantly Limit BECCS Negative Emissions Potential**Kasparas SPOKAS<sup>1,2</sup>, Piera PATRIZIO<sup>2</sup>, Sylvain LEDUC<sup>2</sup>, Sennai MESFUN<sup>2</sup>, Florian, KRAXNER<sup>2</sup><sup>1</sup> Princeton University, Princeton, New Jersey, USA<sup>2</sup> International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria**Natural gas, biomass and carbon capture and storage for low carbon power plants**Constanza CUMICHEO<sup>1</sup>, Niall MAC DOWELL<sup>1,2</sup>, Nilay SHAH<sup>1</sup><sup>1</sup> Centre for Process Systems Engineering, Imperial College London, UK<sup>2</sup> Centre for Environmental Policy, Imperial College London, UK**Opportunities for efficiency enhancement of bioenergy with carbon capture and storage (BECCS)**Mai BUI<sup>1,2</sup>, Mathilde FAJARDY<sup>1,2</sup>, Niall MAC DOWELL<sup>1,2</sup><sup>1</sup> Centre for Environmental Policy, Imperial College London, UK<sup>2</sup> Centre for Process Systems Engineering, Imperial College London, UK

7B

**Biospheric storage – Forestry**

Thursday, May 24, 14:00-15:20

**Blue carbon strategies for climate change mitigation are most effective at the national scale**Pierre TAILLARDAT<sup>1,2</sup>, Daniel A. FRIESS<sup>1</sup>, Massimo LUPASCU<sup>1</sup><sup>1</sup> Department of Geography, National University of Singapore<sup>2</sup> Tropical Marine Science Institute (TMSI), National University of Singapore**An integrated assessment of the potential of negative emissions of boreal forests - economic costs and environmental benefits**Anna REPO<sup>1,2</sup>, Kyle EYVINDSON<sup>1</sup>, Juha VUORIKKO<sup>1</sup>, Mikko MÖNKKÖNEN<sup>1</sup><sup>1</sup> Department of Biological and Environmental Science, University of Jyväskylä, Finland<sup>2</sup> Finnish Environment Institute, Climate Change Programme, Helsinki, Finland**Contribution of the land sector to a 1.5°C World**Stephanie ROE<sup>1,2</sup>, Deborah LAWRENCE<sup>1</sup>, Charlotte STRECK<sup>2</sup>, Michael OBERSTEINER<sup>3</sup>, Stefan FRANK<sup>3</sup>, Petr HAVLÍK<sup>3</sup>, María José Sanz SÁNCHEZ<sup>4</sup>, Bronson GRISCOM<sup>5</sup>, Jo HOUSE<sup>6</sup>, Nancy HARRIS<sup>7</sup>, Mykola GUSTF<sup>3</sup>, Jonathan SANDERMAN<sup>8</sup>, Pete SMITH<sup>9</sup><sup>1</sup> University of Virginia, Department of Environmental Sciences, Charlottesville, USA<sup>2</sup> Climate Focus, Berlin, Germany



<sup>3</sup> International Institute for Applied Systems Analysis, Laxenburg, Austria

<sup>4</sup> Basque Centre for Climate Change, Leioa, Spain

<sup>5</sup> The Nature Conservancy, Arlington, USA

<sup>6</sup> University of Bristol, School of Geographical Sciences, UK

<sup>7</sup> World Resources Institute, Washington, DC, USA

<sup>8</sup> Woods Hole Research Center, Falmouth, USA

<sup>9</sup> University of Aberdeen, Institute of Biological and Environmental Sciences, Scotland, UK

### Bioenergy from Degraded Land in Africa: Sustainable and Technical Potential under Bonn Challenge Pledges

Tijmen VAN LOON<sup>1</sup>, Jeffrey SKEER<sup>2</sup>

<sup>1</sup> Utrecht University, Utrecht, The Netherlands

<sup>2</sup> International Renewable Energy Agency, Bonn, Germany

7C

### NETs – Direct Air Capture

Thursday, May 24, 14:00-15:20

#### Comparative assessment and optimization of direct air capture via absorption and adsorption processes

Francesco SABATINO<sup>1</sup>, Matteo GAZZANI<sup>2</sup>, Alexa GRIMM<sup>2</sup>, Fausto GALLUCCI<sup>1</sup>, Martin VAN SINT ANNALAND<sup>1</sup>, Gert Jan KRAMER<sup>2</sup>

<sup>1</sup> Technische Universiteit Eindhoven, Department of Chemical Engineering and Chemistry, Eindhoven, The Netherlands

<sup>2</sup> Universiteit Utrecht, Copernicus Institute of Sustainable Development, Utrecht, The Netherlands

#### Prospects for Direct Air Capture using Amine Adsorbents

Anshuman SINHA, Lalit DARUNTE, David S. SHOLL, Matthew J. REALFF, Christopher W. JONES

School of Chemical & Biomolecular Engineering, Georgia Institute of Technology, USA

#### CO<sub>2</sub> Capture from Air via Lime-Based Sorbents

Mohammad SAMARI<sup>1</sup>, Firas RIDHA<sup>2</sup>, Vasilije MANOVIC<sup>3</sup>, Arturo MACCHI<sup>1</sup>, E.J. ANTHONY<sup>3</sup>

<sup>1</sup> Centre for Catalysis Research and Innovation, Department of Chemical and Biological Engineering, University of Ottawa, Canada.

<sup>2</sup> CanmetENERGY, Ottawa, Canada

<sup>3</sup> Centre for Power Engineering, Cranfield University, UK

### Achieving low-cost CO<sub>2</sub> removal and its policy implications

Tim KRUGER<sup>1,2</sup>

<sup>1</sup> Oxford Martin School, University of Oxford, UK

<sup>2</sup> Origen Power Ltd, Aldridge, Walsall, West Midlands, UK

7D

### Policy

Thursday, May 24, 14:00-14:40

#### Regenerate Earth, the practical drawdown of 20 billion tonnes of carbon back into soils annually, to rehydrate bio-systems and safely cool climates

Walter JEHNE

Regenerate Earth, Yarralumla, Australia

#### Ocean Surface Carbon Relocation (OSCAR™) Technology

Philip KITHIL

Atmocean, Inc., Santa Fe, USA

7E

### Modelling

Thursday, May 24, 14:00-15:20

#### Exploring the Trade-Offs in Negative Emissions via Bio-energy

Iikka HANNULA<sup>1</sup>, David M REINER<sup>2</sup>

<sup>1</sup> VTT Technical Research Centre of Finland Ltd

<sup>2</sup> EPRG, Judge Business School, University of Cambridge, UK

#### Techno-Economic and Reactivity Assessments of a Methane-Fuelled Chemical Looping Combustion Process Using Supported Bimetallic Oxygen Carrier (Cu-Ni/Al<sub>2</sub>O<sub>3</sub>): A Case Study to Produce 50 MW Power

Mansour Mohammedramadan TIJANI, Nader MAHINPEY

Department of Chemical and Petroleum Engineering, Schulich School of Engineering, University of Calgary, Canada

#### CO<sub>2</sub>-Payback Year in CO<sub>2</sub>-Roadmaps with Afforestation and BECCS

Per E. R. BJERAGER

University of Copenhagen, Denmark

**Assessment of CO<sub>2</sub> removal with the Australian Earth System Model, ACCESS-ESM**Tilo ZIEHN<sup>1</sup>, Andrew LENTON<sup>2</sup>, Rachel LAW<sup>1</sup><sup>1</sup> CSIRO Oceans and Atmosphere, Aspendale, Australia<sup>2</sup> CSIRO Oceans and Atmosphere, Hobart, Australia**8A****Modelling**

Thursday, May 24, 16:10-17:30

**Assessing Carbon Dioxide Removal Through Global and Regional Ocean Alkalinization under High and Low Emission Pathways.**Andrew LENTON<sup>1,2</sup>, Richard J. MATEAR<sup>2</sup>,  
David P. KELLER<sup>3</sup>, Vivian SCOTT<sup>4</sup>,  
Naomi E. VAUGHAN<sup>5</sup><sup>1</sup> CSIRO Oceans and Atmosphere, Hobart, Australia<sup>2</sup> Antarctic Climate and Ecosystems Co-operative  
Research Centre, Hobart, Australia<sup>3</sup> GEOMAR Helmholtz Centre for Ocean Research, Kiel,  
Germany<sup>4</sup> School of GeoSciences, University of Edinburgh,  
Edinburgh, UK<sup>5</sup> Tyndall Centre for Climate Change Research, School  
of Environmental Sciences, University of East Anglia,  
Norwich, UK.**Exploring the role and value of negative emissions technologies to the UK electricity system**Habiba DAGGASH<sup>1,2,3</sup>, Clara HEUBERGER<sup>2,3</sup>,  
Niall MAC DOWELL<sup>2,3</sup><sup>1</sup> Grantham Institute of Climate Change and the  
Environment, Imperial College London, UK<sup>2</sup> Centre for Environmental Policy, Imperial College  
London, UK<sup>3</sup> Centre for Process Systems Engineering, Imperial Col-  
lege London, UK**Designing optimal BECCS supply chains: a water-energy-carbon-land nexus' problem**Mathilde FAJARDY<sup>1,2</sup>, Niall MAC DOWELL<sup>1,2</sup><sup>1</sup> Centre for Environmental Policy, Imperial College  
London, UK<sup>2</sup> Centre for Process Systems Engineering, Imperial Col-  
lege London, UK**Efficient technologies and sustainable feedstock for BECCS deployment in mitigation pathways**

Etsushi KATO

Institute of Applied Energy, Tokyo, Japan

**8B****BECCS – CLC**

Thursday, May 24, 16:10-17:30

**The multipurpose dual fluidized-bed for biomass – providing ultimate flexibility to achieve the desired mix of heat/power, fuels, negative emissions, power grid stabilization, low NO<sub>x</sub> and benefits with respect to fouling/corrosion**Anders LYNGFELT, Tobias MATTISSON,  
Magnus RYDÉN, Carl LINDERHOLM

Chalmers University of Technology, Gothenburg, Sweden

**Assessment of the Potential for Negative CO<sub>2</sub> Emissions by the Utilization of Alternative Fuels in 2<sup>nd</sup> Generation CCS Processes**Martin HAAF, Peter OHLEMÜLLER,  
Jochen STRÖHLE, Bernd EPPLEInstitute for Energy Systems and Technology, Technische  
Universität Darmstadt, Germany**Bio-CLC, a Breakthrough in CO<sub>2</sub> Capture Cost?**Anders LYNGFELT<sup>1</sup>, Matti NIEMINEN<sup>2</sup>,  
Carl LINDERHOLM<sup>1</sup><sup>1</sup> Chalmers University of Technology, Gothenburg, Sweden<sup>2</sup> VTT Technical Research Center of Finland Ltd, Esbo,  
Finland**Techno-Economic Evaluation of BECCS via Chemical Looping Combustion of Woody Biomass in Japan - Costs, Challenges and Opportunities**Martin KELLER<sup>1</sup>, Kenji KAIBE<sup>1</sup>, Hiroyuki HATANO<sup>2</sup>,  
Junichiro OTOMO<sup>1</sup><sup>1</sup> Graduate School of Frontier Sciences, The University of  
Tokyo, Japan<sup>2</sup> Faculty of Science and Engineering, Chuo University,  
Japan**8C****Biospheric storage – Agriculture**

Thursday, May 24, 16:10-17:10

**Management strategies for soil carbon sequestration in cropland evaluated in long-term field experiments**

Martin A. BOLINDER, Thomas KÄTTERER

Swedish University of Agricultural Sciences, Department  
of Ecology, Uppsala, Sweden

### Modelling the Synergistic Relationship between Soil Organic Carbon and Crop Yields in a Climate Impact Perspective

Kajsa HENRYSON<sup>1</sup>, Cecilia SUNDBERG<sup>1,2</sup>,  
Thomas KÄTTERER<sup>3</sup>, Per-Anders HANSSON<sup>1</sup>

<sup>1</sup> Department of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

<sup>2</sup> Department of Sustainable Development, Environmental Science and Engineering, KTH Royal Institute of Technology, Stockholm, Sweden

<sup>3</sup> Department of Ecology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

### Carbon sink potential in Swiss agricultural soils

Sonja G. KEEL, Chloé WÜST-GALLEY, Jens LEIFELD

Agroscope, Agroecology and Environment, Climate and Agriculture, Zurich, Switzerland

8D

### Other NETs

Thursday, May 24, 16:10-16:50

### CO<sub>2</sub> Submarine Storage in Glass Containers: Life Cycle Assessment and Cost Analysis of Four Case Studies in the Cement Sector

Beatriz BARRETO, Stefano CASERINI,  
Giovanni DOLCI, Mario GROSSO

Politecnico di Milano, Dipartimento di Ingegneria Civile e Ambientale, Italy

### Biomass - Petroleum Switching for Negative Emissions

Henrik THUNMAN, Filip JOHNSSON,  
Martin SEEMANN

Chalmers University of Technology, Gothenburg, Sweden

8E

### POLICY/BECCS

Thursday, May 24, 16:10-17:30

### Who is driving BECCS research? A co-authorship network analysis

Alena HAHN<sup>1</sup>, Nora SZARKA<sup>1</sup>, Daniela THRÄN<sup>1,2</sup>

<sup>1</sup> German Biomass Research Centre (DBFZ), Leipzig, Germany

<sup>2</sup> Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany

### Unlocking negative emissions with BECCS: system-level challenges

Clair GOUGH<sup>1</sup>, Patricia THORNLEY<sup>1</sup>,  
Sarah MANDER<sup>1</sup>, Naomi VAUGHAN<sup>2</sup>,  
Amanda LEA-LANGTON<sup>1</sup>

<sup>1</sup> Tyndall Centre for Climate Change Research, School of Mechanical, Aerospace and Civil Engineering, University of Manchester, UK

<sup>2</sup> Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, UK

### Public perceptions of bioenergy with carbon capture and storage under different policy instrument framings

Rob BELLAMY<sup>1</sup>, Javier LEZAUN<sup>1</sup>, James PALMER<sup>2</sup>

<sup>1</sup> Institute for Science, Innovation and Society, University of Oxford, UK

<sup>2</sup> School of Geographical Sciences, University of Bristol, UK

### Governance of BECCS

Asbjørn TORVANGER

CICERO, Oslo, Norway

## Panels

### Panel I

#### **Bio-CCS – capture and storage of biogenic CO<sub>2</sub>**

Tuesday, May 22, 16:50-17:30

Discussion: Long-term storage safety and needed retention time. Resources/ conflicts and synergies/sustainability. Public perception. Financing.

Moderators: Stuart Haszeldine and Filip Johnsson

Panelists: Sally Benson, Jasmin Kemper, Florian Kraxner, Anders Lyngfelt, Mike Monea, Kristin Myskja, Jennifer Wilcox

### Panel II

#### **Modelling, policy and incentives**

Wednesday, May 23, 15:00-15:40

Discussion: How much negative emissions will be needed? How do we reach policy makers? Incentives.

Moderators: Glen Peters and Thomas Sterner

Panelists: Christian Azar, Josep Canadell, Sabine Fuss, Oliver Geden, James Hansen, Jan Minx, Naomi Vaughan, Detlef van Vuuren,

### Panel III

#### **Biospheric capture and storage of carbon, in vegetation and soils, including bio-char**

Thursday, May 24, 15:00-15:40

Discussion: Long-term storage safety and needed retention time. Incentives, surveillance and accounting. Availability of biomass: how much carbon can be stored in the biosphere and how much can be stored by BECCS on a yearly basis.

Moderators: Josep Canadell and Tobias Pröll

Panelists: Almuth Arneth, Göran Berndes, Philippe Ciais, Annette Cowie, Fabian Levihn

## Poster Presentations

Sorted by the surname of the first author.

### **The challenges of Bio-Energy with Carbon Capture and Storage**

Cristina ANTONINI, Mijndert VAN DER SPEK, Marco MAZZOTTI

*Institute of Process Engineering, ETH Zurich*

### **Direct air capture (DAC) OF CO<sub>2</sub> accomplished by different alkanolamines**

Francesco BARZAGLI<sup>1</sup>, Claudia GIORGI<sup>2</sup>, Fabrizio MANI<sup>1</sup>,  
Maurizio PERUZZINI<sup>1,3</sup>

<sup>1</sup> *National Research Council, ICCOM Institute, Florence, Italy*

<sup>2</sup> *University of Florence, Department of Chemistry, Florence, Italy*

<sup>3</sup> *National Research Council, DSCTM, Rome, Italy*

### **Synergies between BECCS and Biochar**

Wolfram BUSS<sup>1</sup>, Stina JANSSON<sup>2</sup>, Ondřej MAŠEK<sup>1</sup>

<sup>1</sup> *UK Biochar Research Centre, School of GeoSciences, University of Edinburgh, UK*

<sup>2</sup> *Department of Chemistry, Umeå University, Sweden*

### **Financial scenarios for global sustainability, climate change policy and ecological conservation**

Jofre CARNICER, Josep PEÑUELAS

*Ecology Unit, BEECA, University of Barcelona*

*Global Ecology Unit, CREAM- CSIC- UAB, Barcelona, Spain*

### **Planning for a carbon neutral community, Wayanad, Kerala, India**

Nidhin DAVIS K, Shibu K NAIR

*Climate Action, Thanal, India*

### **Targeting All Anthropogenic Carbon Dioxide Emissions**

Shannon A. FIUME

*Autofracture LLC, San Francisco, USA*

### **Mapping the cost of CCUS technologies: from partial capture to negative emissions**

Xavier GALIEGUE<sup>1</sup>, Audrey LAUDE<sup>2</sup>

<sup>1</sup> *Université d'Orléans, Laboratoire d'Economie d'Orléans, France*

<sup>2</sup> *Université de Reims Champagne Ardenne, Laboratoire REGARDS, France*

### **Perspectives on Bio-CCS: Possibilities, impossibilities, contradictions and social relations**

Anders HANSSON, Simon HAIKOLA, Pius YANDA, Mathias FRIDAHL,  
Jonas ANSHELM

*Linköping University, Department of Thematic Studies, Sweden*

**The Earth system response to negative emissions**

Christopher JONES

*Met Office Hadley Centre, Exeter, UK*

**Ranking the energy demand for negative emission technologies**

Ian S F JONES<sup>1</sup>, John RIDLEY<sup>2</sup>

<sup>1</sup> *University of Sydney Australia*

<sup>2</sup> *Ocean Nourishment Corporation, Australia*

**Engineering Artificial Thermal Mountains to Deliver Enhanced Desert Precipitation and Large-Scale Carbon Sinks**

George KNOX

*University of Glasgow, United Kingdom*

**Can partial capture speeds short time implementation of BECCS? Case of bioethanol production with geothermal energy**

Audrey LAUDE<sup>1</sup>, Xavier GALIEGUE<sup>2</sup>

<sup>1</sup> *Université de Reims Champagne Ardenne, REGARDS, France*

<sup>2</sup> *Université d'Orléans, Laboratoire d'Economie d'Orléans, France*

**Reaching the 2 °C target through afforestation**

Pekka LAURI, Olga TURKOVSKA, Michael OBERSTEINER,  
Georg KINDERMANN

*IIASA, Austria*

**Mixed farming systems as potential carbon sinks**

Beata E. MADARI<sup>1</sup>, Selma R. MAGGIOTTO<sup>2</sup>, Márcia T. M. CARVALHO<sup>1</sup>,  
Rubia S. CORRÊA<sup>1,3</sup>, Janaína M. OLIVEIRA<sup>1,3</sup>, João C. MEDEIROS<sup>1,4</sup>,  
Mellissa A.S. SILVA<sup>1</sup>, Pedro L.O.A. MACHADO<sup>1</sup>

<sup>1</sup> *Embrapa Rice and Beans, Brazil*

<sup>2</sup> *University of Brasília, Brazil*

<sup>3</sup> *Federal University of Goiás, Brazil*

<sup>4</sup> *Federal University of Piauí, Brazil*

**Combustion of Bio-H<sub>2</sub> in a gas turbine combustor adapting oxy-combustion technology for CO<sub>2</sub> capture**

Medhat A. NEMITALLAH

*KACST TIC for CCS, Mechanical Engineering Department, King Fahd  
University of Petroleum and Minerals, Dhahran, Saudi Arabia*

**Carbon and nutrient mining as future recycling strategy as well as carbon storage**

Christoph PFEIFER<sup>1</sup>, Gerhard SOJA<sup>2</sup>, Walter WENZEL<sup>1</sup>

<sup>1</sup> *University of Natural resources and Life Sciences, Vienna, Austria*

<sup>2</sup> *Austrian Institute of Technology, Austria*

**Greenhouse gas removal technologies - revenue capture potential in UK development scenarios: what they tell us**

Devon PLATT<sup>1</sup>, Mark WORKMAN<sup>1</sup>, Stephen HALL<sup>2</sup>

<sup>1</sup> *Imperial College London, Energy Futures Lab, UK*

<sup>2</sup> *University of Leeds, Sustainability Research Institute, UK*

**Characterization and assessment of PAH content in spent char to be used for soil amendment and carbon sequestration**

Giulia RAVENNI, Tobias P. THOMSEN, Jesper AHRENFELDT, Ulrik B. HENRIKSEN

*DTU, Department of Chemical and Biochemical Engineering, Roskilde, Denmark*

**Integrated Assessment of Carbon Dioxide Removal**

Wilfried RICKELS

*Kiel Institute for the World Economy, Germany*

**Negative Emissions: Interagency Institutional Context**

Gyami SHRESTHA<sup>1</sup>, Nancy CAVALLARO<sup>2</sup>, Zhiliang ZHU<sup>3</sup>

<sup>1</sup> *U.S. Carbon Cycle Science Program & UCAR, USA*

<sup>2</sup> *U.S. Department of Agriculture, USA*

<sup>3</sup> *U.S. Geological Survey, USA*

**Paris Agreement zero emissions goal is not consistent with 2°C and 1.5°C temperature targets**

Katsumasa TANAKA<sup>1</sup>, Brian O'NEILL<sup>2</sup>

<sup>1</sup> *Center for Global Environmental Research, National Institute for Environmental Studies (NIES), Tsukuba, Japan*

<sup>2</sup> *Climate and Global Dynamics Laboratory, National Center for Atmospheric Research (NCAR), Boulder, USA*

**The potential influence of negative emission technologies on the projected cumulative emissions of a decarbonized European industrial sector in 2030 and 2050**

S.E. TANZER, A. Ramirez RAMIREZ

*Department of Engineering Systems & Services, Faculty of Technology, Policy, and Management, TU Delft, The Netherlands*

**Techno-economic evaluation of bio-clc plant in a chp system: negative emissions combined with flexible carbon capture**

Tomi THOMASSON, Janne KÄRKI, Toni PIKKARAINEN

*VTT Technical Research Centre of Finland Ltd*

**Direct-fired oxy-biofuel supercritical CO<sub>2</sub> Brayton cycle power generation for negative CO<sub>2</sub> emissions**

Subith VASU, Jayanta KAPAT

*Center for Advanced Turbomachinery and Energy Research (CATER), Mechanical and Aerospace Engineering, University of Central Florida (UCF), USA*

**New biogeochemical processes reduce carbon budgets**

Andy WILTSHIRE<sup>1</sup>, Eleanor BURKE<sup>1</sup>, Chantelle BURTON<sup>1</sup>,  
Nic GEDNEY<sup>1</sup>, Chris JONES<sup>1</sup>, Spencer LIDDICOAT<sup>1</sup>,  
Eddy ROBERTSON<sup>1</sup>, Pierre FRIEDLINGSTEIN<sup>2</sup>

<sup>1</sup> *Met Office Hadley Centre, Exeter, UK.*

<sup>2</sup> *College of Engineering, Mathematics, and Physical Sciences, University of Exeter, UK*

**Negative emissions: moving beyond quantifying the potential to mapping the suitability in space and time**

Dominic WOOLF<sup>1,2</sup>, Johannes LEHMANN<sup>1,2</sup>, Annette COWIE<sup>3,4</sup>

<sup>1</sup> *College of Agriculture and Life Sciences, Cornell University, Ithaca NY, USA*

<sup>2</sup> *Atkinson Center for a Sustainable Future, Cornell University, Ithaca NY, USA*

<sup>3</sup> *School of Environmental and Rural Science, University of New England, Australia*

<sup>4</sup> *New South Wales Department of Primary Industries, Australia*

**Optimal deployment of bioenergy with CCS (BECCS) in the UK**

Di ZHANG<sup>1,2</sup>, Mai BUI<sup>1,2</sup>, Mathilde FAJARDY<sup>1,2</sup>, Niall MAC DOWELL<sup>1,2</sup>

<sup>1</sup> *Centre for Environmental Policy, Imperial College London, UK*

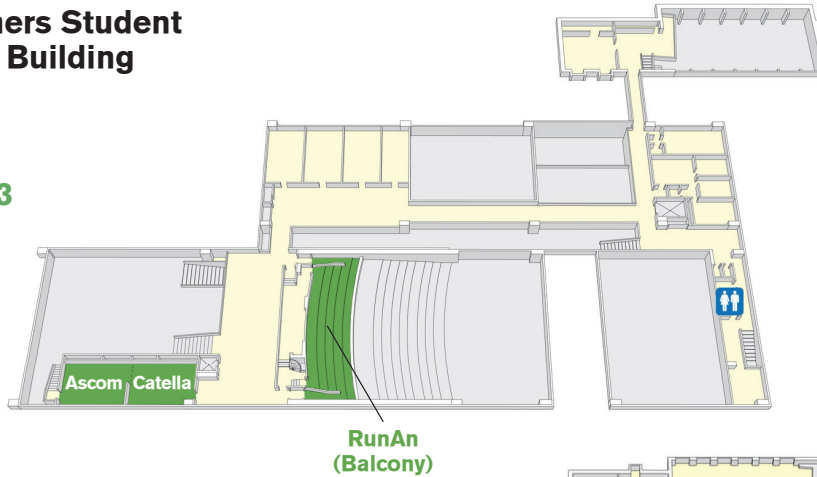
<sup>2</sup> *Centre for Process Systems Engineering, Imperial College London, UK*



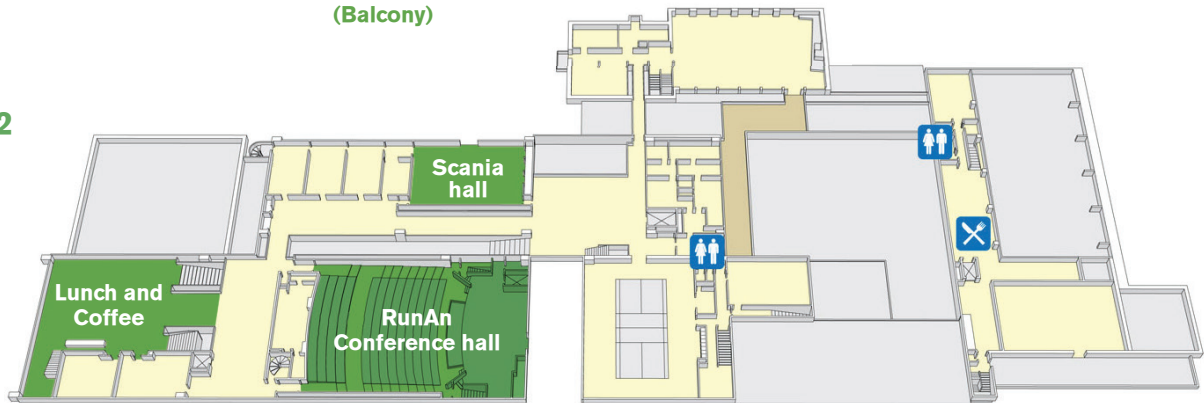


## Chalmers Student Union Building

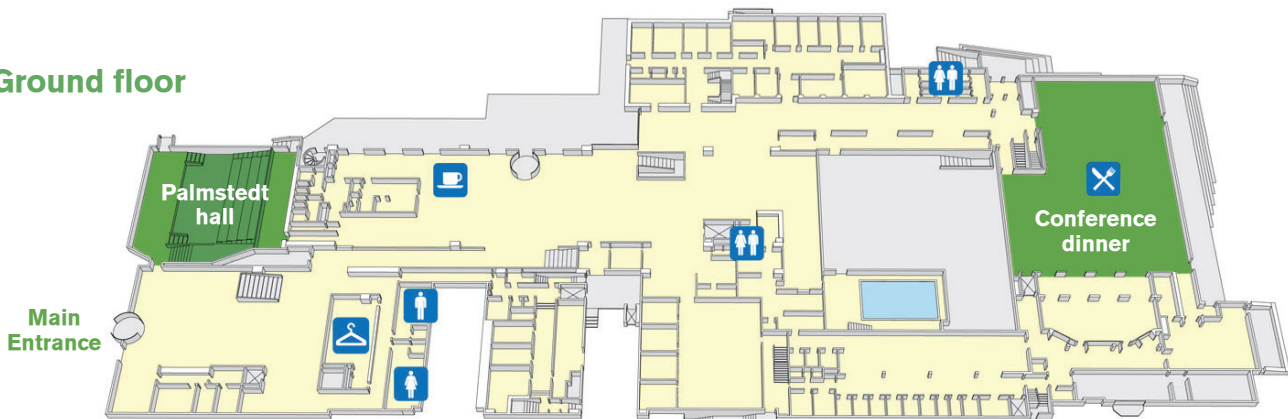
### Level 3



### Level 2



### Ground floor



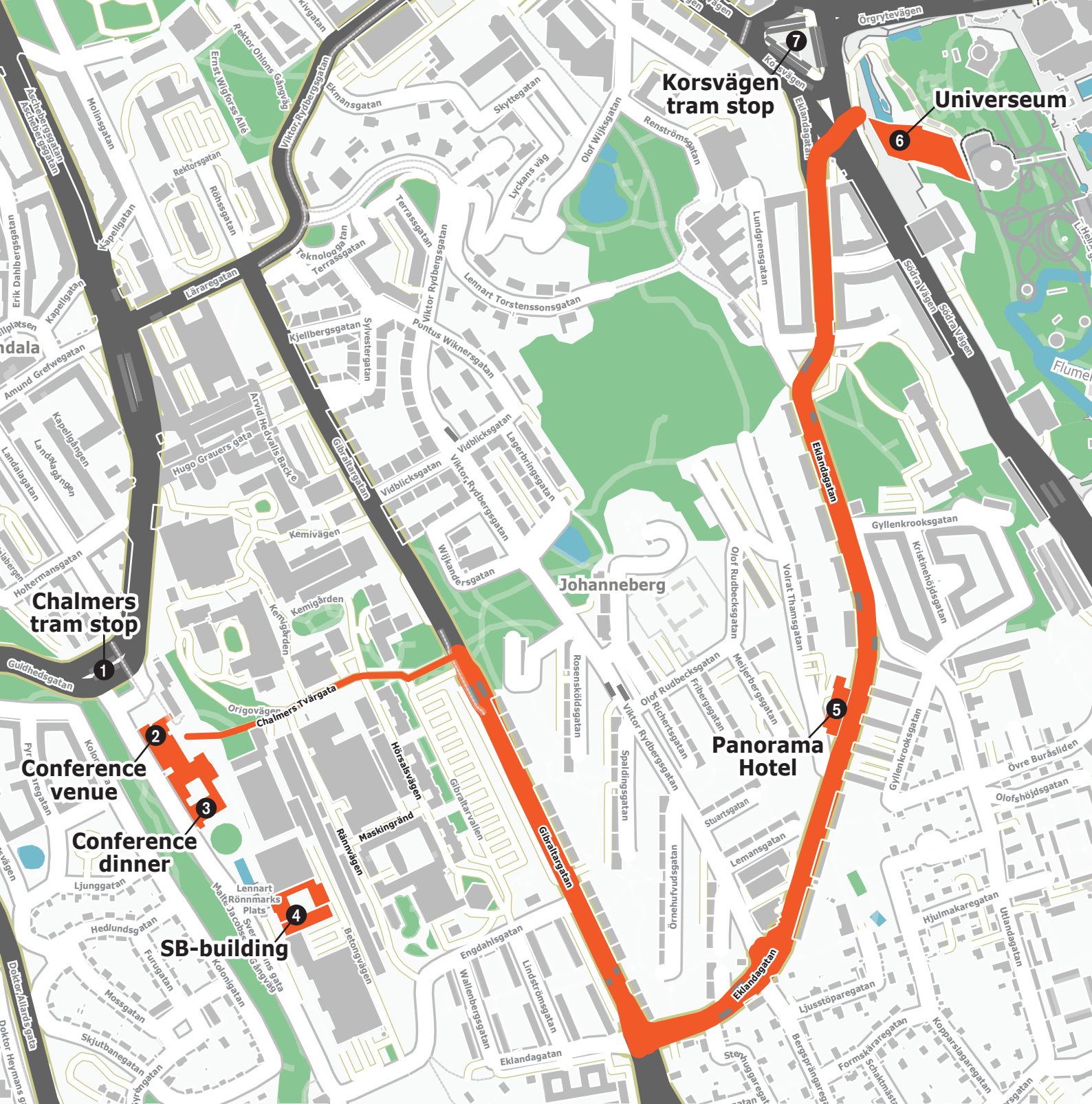
## Venue

The 1st International Conference on Negative CO<sub>2</sub> emissions will be held at Chalmers University of Technology in Gothenburg, Sweden. The conference venue is the Chalmers Student Union Building (Chalmers Kårhus) at campus Johanneberg. The venue is within walking distance (15-20 min) from Hotel Panorama and for those who prefer using public transport; the Chalmers bus and tram stop is located close by.

## Public transportation

If you want to use Gothenburg's public transport system, please have a look at the website of the operator Västtrafik for detailed information. It is also possible to rent bikes on a 30-minute basis for short rides in the center of Gothenburg. Look at the website of "Styr och Ställ" for more information.

Airport shuttle buses ("Flygbussarna") offer transfer between Göteborg Landvetter Airport and Gothenburg City - e.g. Korsvägen, see map - with departures approximately every 15 minutes.



2 Chalmers conference venue



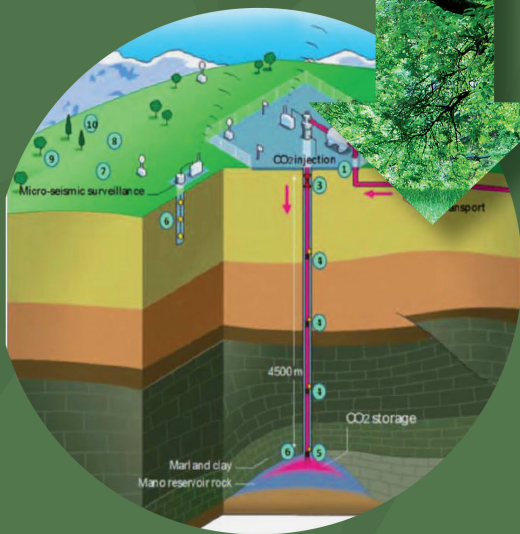
5 Panorama Hotel



4 SB-building



6 Universeum



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