



FutureGas
WP4

November
2019

WORK IN WP4

Main activities in WP4

Work carried out in relation to WP4 includes:

- ⇒ Journal papers
- ⇒ White papers
- ⇒ Popular Article
- ⇒ Conference proceedings
- ⇒ Awards
- ⇒ Presentations
- ⇒ Master Theses
- ⇒ Workshops

Journal Papers

Three papers have been published, two have been submitted to Journals and there is one more on the way.

- ⇒ **Potential role of renewable gas in the transition of electricity and district heating systems**
Re-submitted to Energy Strategy Reviews
- *Ida Græsted Jensen, Frauke Wiese, Rasmus Bramstoft, Marie Münster.*
Focus: The aim of this paper is to model RE-gas in a simplistic way and evaluate the potential role in the transition of the electricity and district heating systems.
- ⇒ **Pathways to climate-neutral shipping: A Danish case study**
Published: "Energy"
- *Till ben Brahim, Frauke Wiese, Marie Münster*
<https://doi.org/10.1016/j.energy.2019.116009>
Focus: In this paper, we describe pathways for the Danish maritime cargo sector to CO₂equivalent neutrality in 2050 in compliance with the Paris Agreement.
- ⇒ **Modelling of renewable-gas and -fuels in integrated energy systems**
Submitted to Applied Energy
- *Rasmus Bramstoft, Amalia Pizarro Alonso, Ida Græsted Jensen, Hans Ravn, Marie Münster.*
Focus: The aim of this paper is to model RE-gas which can be 1) used for electricity and heat generation, 2) be injected in the natural gas grid, and 3) used as feedstock for RE-fuels (such as methanol and FT-biodiesel).
- ⇒ **Balmorel open source energy system model**
Published: "Energy Strategy Reviews"

- *Frauke Wiese, Rasmus Bramstoft, Hardi Koduvere, Amalia Pizarro Alonso, Olexandr Balyk, Jon Gustav Kirkerud, Åsa Grytli Tveten, Torjus Bolkesjø, Marie Münster, Hans Ravn.*

Energy Strategy Reviews 20 (2018) 26-34

<https://doi.org/10.1016/j.esr.2018.01.003>

Focus: The aim of this paper is to describe the modelling approach, applications, strengths, limitations, and potential future development of the Balmorel modelling tool.

⇒ **STREAM – an energy scenario modelling tool**

Published: "*Energy Strategy Reviews*"

- *Rasmus Bramstoft, Amalia Pizarro Alonso, Kenneth Karlsson, Anders Kofoed-Wiuff, Marie Münster.*

Energy Strategy Reviews 21 (2018) 62-70

<https://doi.org/10.1016/j.esr.2018.04.001>

Focus: The aim of this paper is to describe the modelling approach, applications, strengths, limitations, and potential future development of the STREAM modelling tool.

⇒ **Decarbonizing Sweden's energy and transportation system by 2050**

Published: "*International Journal of Sustainable Energy Planning and Management*"

- *Rasmus Bramstoft, Klaus Skytte.*

International Journal of Sustainable Energy Planning and Management Vol. 14, 2017 03-20

doi: [dx.doi.org/10.5278/ijsep.2017.14.2](https://doi.org/10.5278/ijsep.2017.14.2)

Focus: This paper develops 100% renewable scenarios for Sweden's transportation sector by 2050. The energy system model STREAM is utilized to compute the socioeconomic system cost and simulate an integrated transportation, electricity, gas, fuel refinery, and heat system.

This study is prepared as part of the FutureGas, Flex4RES, and TOPNEST research projects.

⇒ **Conceptual model of the industry sector in an energy system model: A case study for Denmark**

Published in *Journal of Cleaner Production*

- *Frauke Wiese, Mattia Baldini.*

Vol. 203, 2018, p. 427-443

Focus: The aim of the paper is to describe an extension of the energy system model Balmorel, to consider the fuel, electricity, space and process heat demand of the industrial sector and its impact on the energy system.

⇒ **The impact of introducing rolling time horizons in comprehensive energy systems models**

Will be submitted to *Nature Energy*

- *Rasmus Bramstoft, Frauke Wiese, Juan Gea Bermudez, Ida Græsted Jensen, Marie Münster, Hans Ravn*

Focus: The aim of the paper is investigate the impact of using different foresight models, i.e. myopic, limited-, and perfect foresight, when performing long-term scenario analyses.

⇒ **Analysis on Electrofuels in Future Energy Systems: A 2050 Case Study**

Submitted to *Energy*

- *Mason Scott Lester, Rasmus Bramstoft, Marie Münster*

Focus: This paper assess the role of electrofuels in a future Danish 2050 scenario.

⇒ **Green Ammonia-to-Power in Developing Countries: A Case Study on the Indian Electricity Sector to 2040**

Submitted to *International Journal of Hydrogen Energy*

- *Zac Cesaro*, Alberto Dalla Riva**, Rasmus Bramstoft, Richard Nayak-Luke*, Rene Banares-Alcantara**

* *University of Oxford*, ** *EA Energy Analyses*

Focus: This paper investigate the role of green ammonia to power in developing countries, with a specific focus on the Indian Electricity Sector towards 2040.

White paper

⇒ **Sector Coupling White Paper – Working Group 1**

Paper in review at Governing Board

- *Marie Münster, Daniel Møller Sneum, Rasmus Bramstoft et.al.*

Focus: The aim of the paper is to highlight potential benefits and challenges with sector coupling including power-to-heat, power-to-gas, power-to-fuels and electric vehicles.

Popular Article in Magazine

A popular is submitted to the Gas-for-Energy Magazine, after being invited based on the conference presentation at IGRC2017.

⇒ **FutureGas – The integration of gas in the future Danish energy system**

Published in "*Gas for Energy*"

- *Poul Erik Morthorst, Marie Münster, Tara Sabbagh Amirkhizi, Rasmus Bramstoft.*

Focus: The aim of this article is to present the FutureGas project. The article highlights that FutureGas will provide future pathways for the Danish energy transition towards a sustainable future, with a detailed representation of the gas system as an integrated part of the future energy system. A part of the article describes the conceptual model which is developed – and was presented at the IGRC2017 conference.

- ➔ **Æblet falder sjældent langt fra stammen - portræt af Marie Münster**
Published in "GASenergi" no. 3, oktober 2018
- **Matilda Fenger Flindt.**
Focus: Portrait article
- ➔ **Integrating Renewables in Denmark's Power Sector**
Published in "FSR Energy and Climate", Florence School of Regulation #LightsOnWomen, 4th October 2019
- **Marie Münster, Sara ben Amer, Tara Amirkhizi and Lise Skovsgaard Nielsen**
Focus: Portrait article

Conference Proceedings

Four papers are submitted as conference proceedings. Two of the conference papers was presented at the International Gas Union Research Conference – Rio 2017, Brazil (IGRC 2017). Another conference will be presented in October at the SDEWES - 12th Conference on sustainable development of energy, water and environment systems in Dubrovnik, Croatia (SDEWES 2017). The last conference paper was presented at the 26th European Biomass Conference and Exhibition, Copenhagen, Denmark (EUBCE 2018).

- ➔ **Pathways to Carbon Neutral Industrial Sectors: Integrated Modelling Approach with High Level of Detail for End-use Processes**
Presented at SDEWES 2017, October 2017.
Archival paper.
- **Frauke Wiese, Mattia Baldini.**
Focus: A detailed modelling approach for energy usage in industry is presented. The paper itself focuses on different demand profiles for electricity and heat demand of different temperature levels and different industrial groups. It is the first part of the ongoing work for detailed industrial energy modelling in Balmorel.
- ➔ **Modelling of renewable gas in the future energy system**
Presented at IGRC 2017, May 2017
- **Rasmus Bramstoft, Amalia Pizarro Alonso, Ida Græsted Jensen, Hans Ravn, Marie Münster.**
Focus: Modelling framework for RE-gas production is implemented in OptiFlow, which further is co-simulated with Balmorel to obtain socioeconomic optimal solutions for the integrated energy system. This conference paper is the first version of the paper "Modelling of renewable-gas and -fuels in integrated energy systems".
- ➔ **Conceptual model of the gas system as an integrated part of the future Danish energy system**
Presented at IGRC 2017, May 2017
- **Marie Münster, Rasmus Bramstoft, Frauke Wiese, Poul Erik Morthorst.**
Focus: Based on a literature review of energy system models, gas models, and integrated gas and electricity models, this paper develops the conceptual model of the future gas system includes, production, conditioning, transmission, storage, trade and use. The conceptual model will be implemented in Balmorel and OptiFlow.
- ➔ **Towards a sustainable future – the role of biomass in future renewable based energy systems**
Presented at EUBCE 2018, May 2018
- **Rasmus Bramstoft, Marie Münster.**
Focus: In this paper, bioenergy is modelled as an integrated part of the future energy system, through a co-simulation of the comprehensive energy system model, Balmorel, and the generalised spatiotemporal network optimisation model, OptiFlow. The results of this study show that biomass plays a key role in particular when transforming the transportation sector to a renewable-base sector. To efficiently utilise the limited biomass resource, hydrogen is used to boost the biofuel production. Moreover, the results show that biogas is produced, updated and injected into the gas grid.

Awards

- ➔ **8th GERG Young Researchers Award**, where the prize was awarded by the European gas research group, GERG. The award was given for the innovative project in the field of renewable or other low-carbon gas. The 8th GERG Young Researchers Award event took place in association with the Eurogas Annual Conference on 27th October in Brussels.
- ➔ **EUBCE Student Award (2018)**. The EUBCE Student Award is awarded for the excellent research work in the field of biomass, and was given on the occasion of EUBCE 2018 Conference.

Other Presentations (selected)

A long list of presentations has been given at different conferences, workshops, meetings, etc. Here is some of the most important listed.

Other conference presentations:

- **A simplistic method for representing renewable gasses and fuels in an energy systems optimisation model**
Presented at: EURO 2018 conference on Operational Research – Valencia, Spain, July 2018
- Ida Græsted Jensen.
- **Role of gas in sector coupling and in renewable transport**
Presented at: 7.EUM Fachtagung –Zauberformel Sektorkopplung, der nächste Schritt zu 100% EE (7. Energy- and Environmental Management Conference – Sector-coupling, the next step to 100% renewable energy systems) – Flensburg, Germany, March 2017
- Frauke Wiese.
- **Open tools required for integrated energy modelling / Workshop on modelling tools for gas in integrated energy systems**
Presented at: European Open Energy Modelling Workshop, Frankfurt, Germany, April 2017
- Frauke Wiese.
- **Future Marine Fuels - A Danish Case-Study on Climate Compatible Energy Pathways** Poster presentation at: Energy Modelling Platform for Europe (EMP-E) – Brussels, September 2018
- Till ben Brahim
- **What is the benefit of sector coupling?**
Presented at 4th Generation District Heating, Electrification, Electrofuels and Energy Efficiency - Copenhagen, September 2019
- Marie Münster
- **PtX - Integration into the energy system**
Presented at DTU High Tech Summit - Lyngby, October 2019
- Marie Münster
- **A systems approach to sector coupling**
Presented at DTU High Tech Summit - Lyngby, October 2019
- Marie Münster
- **Future gas utilisation for transport, heating and industry - a Danish case study**
Presented at European Gas Technology Conference (EGATEC), Groningen, November 2019
- Marie Münster

Other presentations:

- **"The FutureGas project" - European Research Institute for Gas & Energy Innovation (ERIG) network workshop, Brussels, 2016**
- Marie Münster.
- **"The FutureGas project" Meeting in the energy storage and distribution group under the The Danish Partnership for Hydrogen and Fuel Cells, HMN Copenhagen, 2016**
- Marie Münster
- **"System aspects related to the future role of the gas system" GasAkademin, Sweden August 2017**
- Marie Münster.
- **"Towards a sustainable future – the role of renewable gas in future Danish energy systems" GERG – 8th Young Research Award Event, Eurogas annual conference, Brussels 2017**
- Rasmus Bramstoft.
- **"Comparison of future technologies for shipping", Fremtidens grønne transport til lands og til vands, Energiens Hus – københavn, 2017**
- Frauke Wiese.
- **"Modellerings resultater fra FutureGas" Dansk Gastekniske Dage, Billund 2018**
- Rasmus Bramstoft
- **"Gassens rolle i det fremtidige energisystem" Folkemøde, Bornholm, June 2018**
- Marie Münster
- **"Produktion af VE-gas i den grønne omstilling" Folkemøde, Bornholm, June 2018**
- Rasmus Bramstoft
- **"System aspects related to the future role of the gas system" GasAkademin, Sweden, August 2018**
- Marie Münster
- **"Grøn omstilling af transporten frem mod 2050 med fokus på VE-gassers rolle", Fremtidens intelligente energi- og forsyningssystem seminar, Intelligent Energi, TREFOR Kolding, September 2018**
- Marie Münster
- **"The FutureGas Project - The future role and production of renewable gas" Exploring Innovations and Policy Development in the Danish Biogas Sector - US delegation, Lyngby, September 2018**
- Marie Münster
- **"Biorefining in an Energy System Perspective", Tokai University and DTU energy seminar, Lyngby, November 2018**
- Marie Münster
- **Gassens rolle frem mod 2050, Danish Energy Agency Workshop, March 2019**
- Marie Münster

- **FutureGas, Gabonese Ministry of Oil & Gas delegation visit, Lyngby, April 2019**
- Marie Münster
- **"Resultater af modelberegninger" i FutureGas - Danske Gastekniske Dage, Billund, Maj 2019**
- Rasmus Bramstoft
- **"FutureGas" - Danske Gastekniske Dage, Billund, Maj 2019**
- Marie Münster
- **Power-to-X i et 2030 og 2050-perspektiv, Dansk Energis analyse seminar, August 2019**
- Marie Münster
- **FutureGas, ETIP SNET workshop, Petten, September 2019**
- Rasmus Bramstoft
- **Forskningens bud på gassens rolle i den grønne omstilling - Årets Gas Konference, Copenhagen, November 2019**
- Marie Münster

Master Thesis Supervision

- **Pathways to low carbon maritime transport in Denmark**
Student: Alfie Wisdom (DTU)
Supervisors: Marie Münster, Frauke Wiese.
- **Pathways to low carbon maritime transport in Denmark**
Student: Till ben Brahim (University of Flensburg)
Supervisors: Frauke Wiese (DTU) in collaboration with Niels Træholt Franck and Thomas Young Hwan Westring Jensen (Energinet).
- **The role of electro-fuels in the future Danish energy system**
Student: Mason Scott Lester (DTU)
Supervisors: Marie Münster, Rasmus Bramstoft.
- **Modelling the gas infrastructure: A case study of Denmark in 2050**
Student: Mourad Boucenna (DTU)
Supervisors: Marie Münster, Rasmus Bramstoft.
- **Analysis of energy storage and flexibility in the Danish future energy system with the Balmorel Energy System Model**
Student: Søren Storgaard Sørensen (DTU)
Supervisors: Marie Münster, Rasmus Bramstoft.
- **Economic Feasibility of Catalytic Power-to-Gas Methanation in the Future Danish Energy System**
Student: Johannes Stuedter-Rosien (DTU)
Supervisors: Marie Münster, Poul Erik Morthorst, Torben Kvist (DGC).
- **Modelling of demand-side flexibility from electrification of the Danish industry sector in Balmorel and its implications on electrification potential evaluation**
Student: Anders Richter Lindén (DTU)
Supervisors: Marie Münster, Rasmus Bramstoft, János Hethey (EA).

Workshops

- **Transport in integrated energy system modelling**
The workshop was held at DTU in January 2017. Experts within modelling of transportation in integrated energy systems was invited. The workshop included presentations and discussions. The outcomes from the workshop is summarized in a small report.
- **CITIES/FutureGas Joint Seminar: Modeling and Optimization of Integrated Energy Systems**
The workshop was held at DTU in 15 December 2017. The purpose was to share knowledge about modelling and optimization of integrated energy systems.
- **Scenario workshop**
Two scenario workshops has been held, one in connection with the project kick-off meeting in 2016 and one in connection with the annual meeting in 2017. Subsequently, a scenario report has been developed.
- **Workshop on modelling and temporary results**
The workshop was held at DTU in May 2018. All project participants were invited. The workshop included presentations and discussions. Presentations are uploaded on Sharepoint.
- **Industry modelling workshop**
The workshop was held at DTU in November 27, 2018. All project participants were invited. The industry modelling in Balmorel was presented and discussed, and also included presentations from the project participants on industry. Presentations are on Sharepoint.
- **Workshop on time aggregation**
The workshop was held at DTU in August 2019. Balmorel users were invited. The workshop included presentations and discussions.

INFORMATION

Find all above articles, presentations and reports at FutureGas Sharepoint – WP4 Outputs