Stockholm Exergi
BECCS

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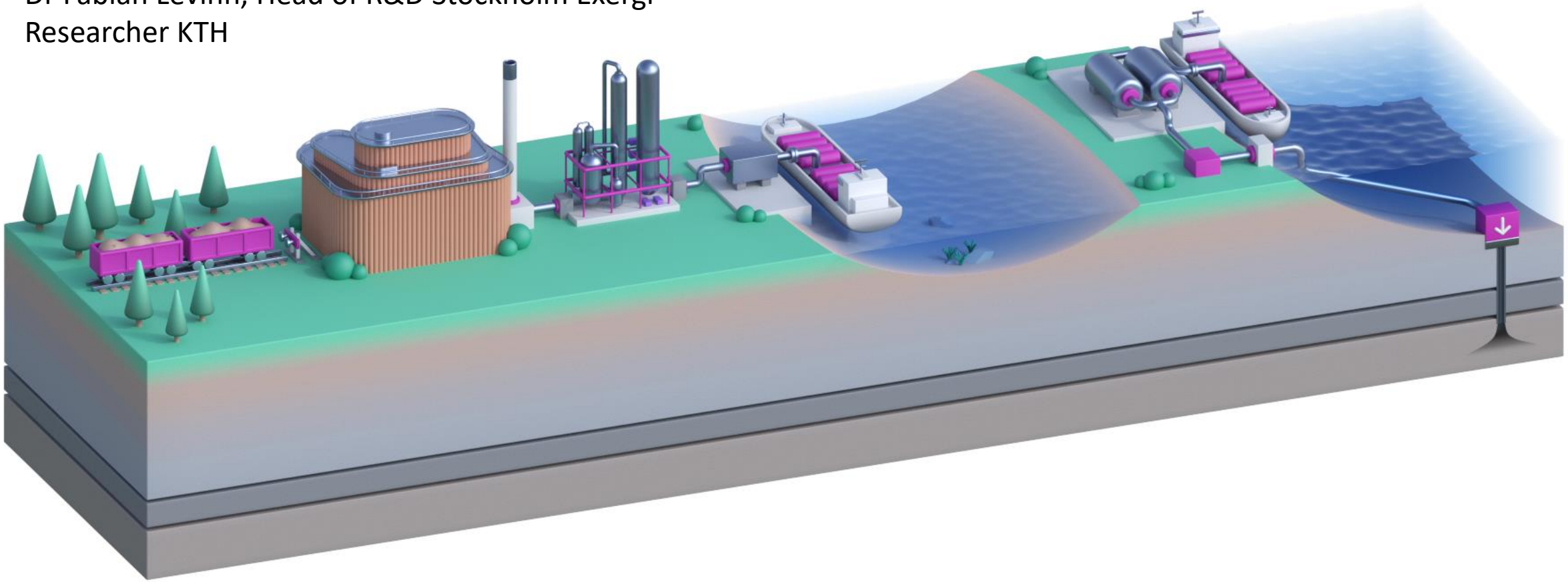

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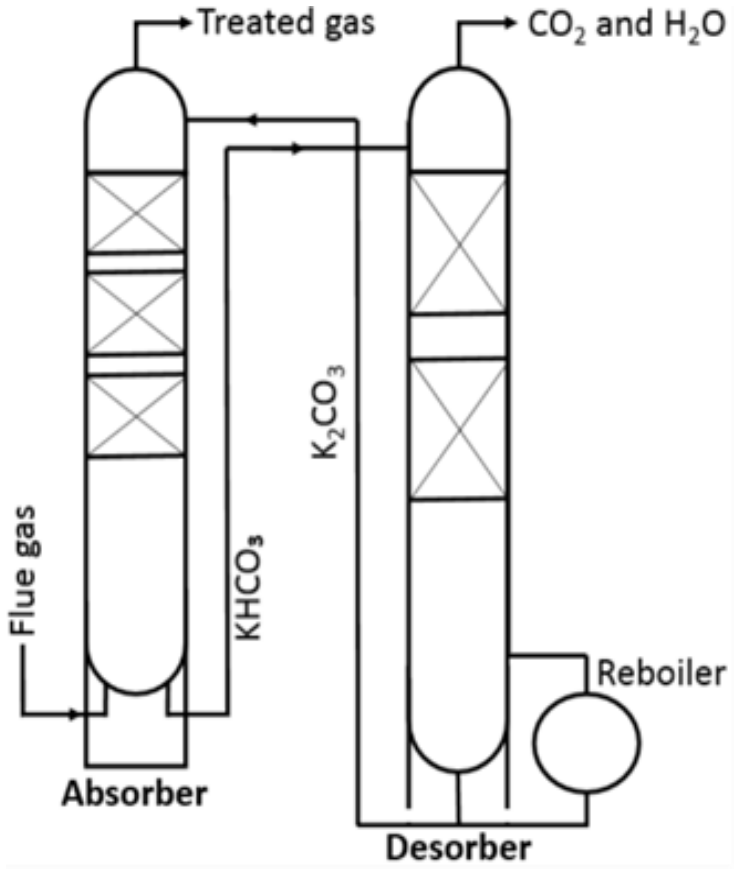
Proven technology
Cost effective

- Inhouse experience 1971-2011 (700 000h)
- More than 1000 installations since the 1950s in the chemical process industry
- Providing Bio-CHP plants with CCS is unique
- Good match with CHPs.



$$K_2CO_3 + CO_2 + H_2O \Leftrightarrow 2HCO_3^{-1} + 2K^+$$

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Bio-ccs research plant in Stockholm, commissioned Dec 2019

- Methods and optimization of physical parameters
- Composition of solvents (additives) with corresponding kinetics in the chemical reactions
- Long term test with identifying and measure side reactions, degradation products and accumulations/impurities in solvent
- Reality check of absorption rate, mass balances, pressure drops etc
- Modelings and simulations in Aspen Plus
- Stress tests of equipment
- Give better possibility for technical/economic evaluation of the cost for a BECCS plant with HPC
- 2 scientific publications planned

BECCS research facility

Test phase one met expectations

Additional test and expanded facility planned

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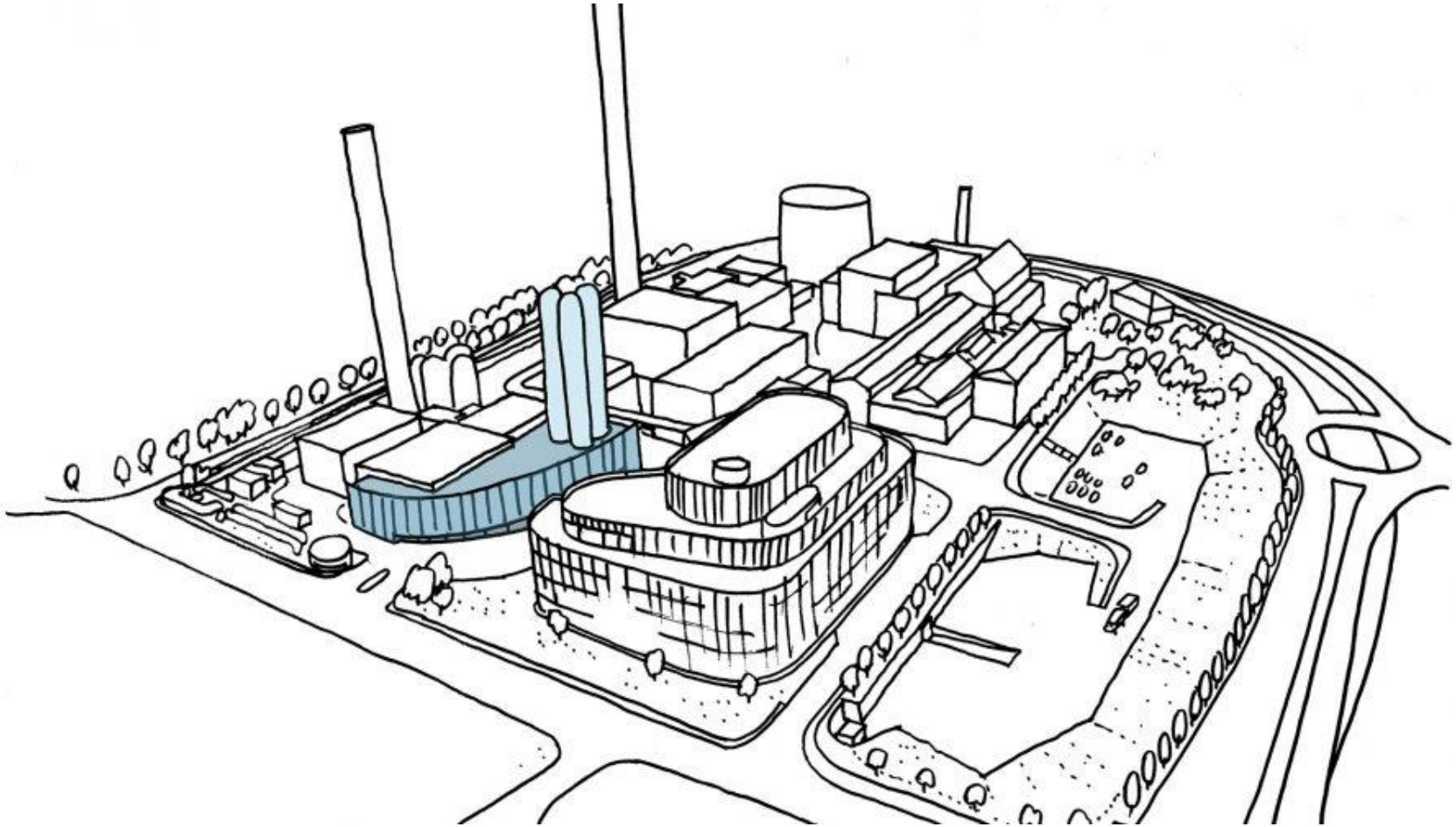
+ Great potential for heat recovery from a CCS process
+ Energy loss <2% possible
+ Avaialability of steam and electric power
+ Port (largest vessel handled 40 000 tonnes)
+ Big point source of biogenic CO2

- Crowded
- Proximity of the city

Design of full scale capture plant



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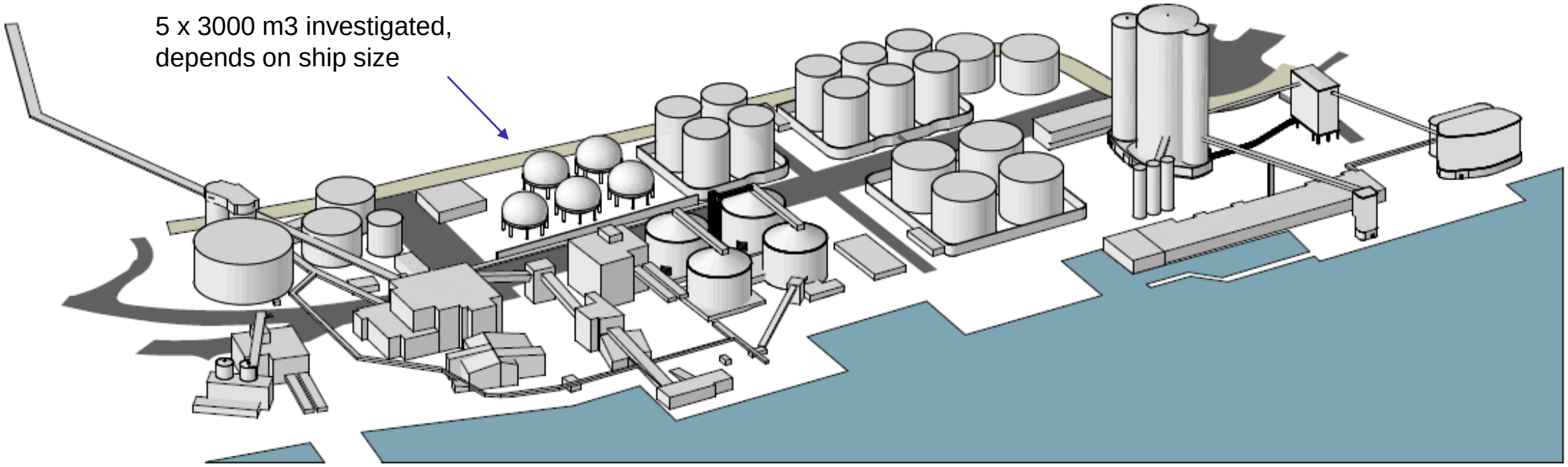
Liquefaction and storage



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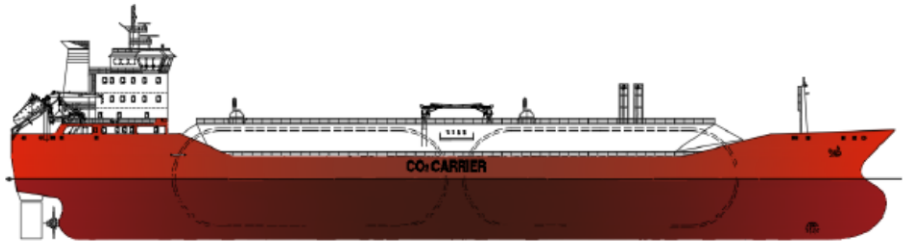
Ship size and design

- Ship size has impact on both economics and environmental performance
- Standardisation of CO2 pressure and temperature would be benifical
- 7 bar / -50 ^{o}C v.s. 15 bar / -25 ^{o}C?

RCO$_2$ 15000

Refrigerated CO$_2$ Carrier

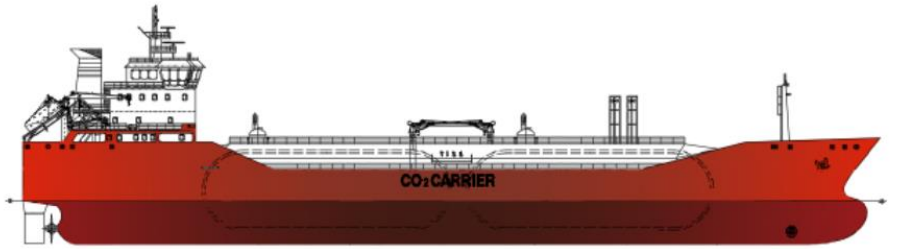
TERMINAL – Conventional propulsion, Single screw



RCO$_2$ 5200

Refrigerated CO$_2$ Carrier

TERMINAL – Conventional propulsion, Single screw



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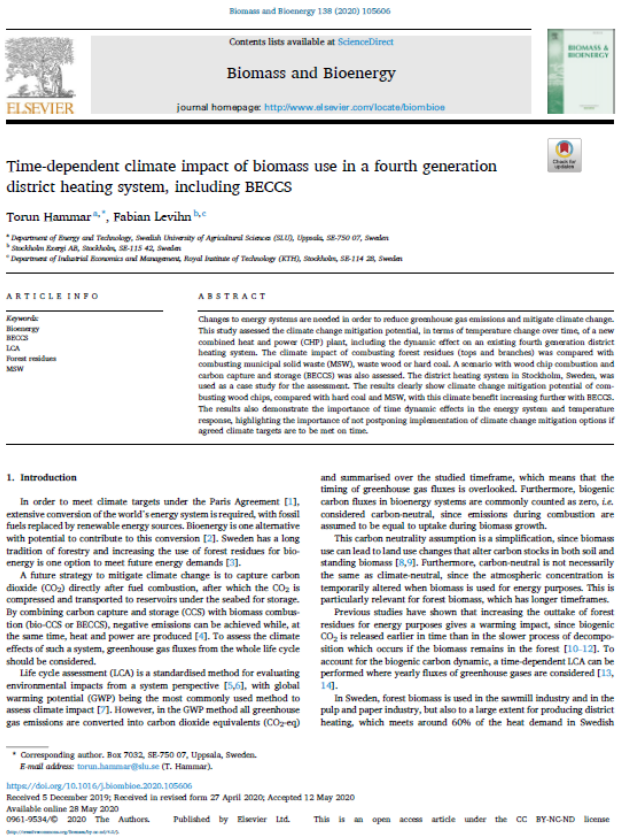
Bio CCS LCA



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Time-dependent climate impact of biomass use in a fourth generation district heating system, including BECCS

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ABSTRACT

Changes to energy systems are needed in order to reduce greenhouse gas emissions and mitigate climate change. This study assessed the climate change mitigation potential, in terms of temperature change over time, of a new combined heat and power (CHP) plant, including the dynamic effect on an existing fourth generation district heating system. The climate impact of combusting forest residues (tops and branches) was compared with combusting municipal solid waste (MSW), waste wood or hard coal. A scenario with wood chip combustion and carbon capture and storage (BECCS) was also assessed. The district heating system in Stockholm, Sweden, was used as a case study for the assessment. The results clearly show climate change mitigation potential of combusting wood chips, compared with hard coal and MSW, with this climate benefit increasing further with BECCS. The results also demonstrate the importance of time dynamic effects in the energy system and temperature response, highlighting the importance of not postponing implementation of climate change mitigation options if agreed climate targets are to be met on time.

1. Introduction

In order to meet climate targets under the Paris Agreement [1], extensive conversion of the world's energy system is required, with fossil fuels replaced by renewable energy sources. Bioenergy is one alternative with potential to contribute to this conversion [2]. Sweden has a long tradition of forestry and increasing the use of forest residues for bioenergy is one option to meet future energy demands [3].

A future strategy to mitigate climate change is to capture carbon dioxide (CO_2) directly after fuel combustion, after which the CO_2 is compressed and transported to reservoirs under the seabed for storage. By combining carbon capture and storage (CCS) with biomass combustion (bio-CCS or BECCS), negative emissions can be achieved while, at the same time, heat and power are produced [4]. To assess the climate effects of such a system, greenhouse gas fluxes from the whole life cycle should be considered.

Life cycle assessment (LCA) is a standardised method for evaluating environmental impacts from a system perspective [5,6], with global warming potential (GWP) being the most commonly used method to assess climate impact [7]. However, in the GWP method all greenhouse gas emissions are converted into carbon dioxide equivalents (CO_2-eq) and summarised over the studied timeframe, which means that the timing of greenhouse gas fluxes is overlooked. Furthermore, biogenic carbon fluxes in bioenergy systems are commonly counted as zero, *i.e.* considered carbon-neutral, since emissions during combustion are assumed to be equal to uptake during biomass growth.

This carbon neutrality assumption is a simplification, since biomass use can lead to land use changes that alter carbon stocks in both soil and standing biomass [8,9]. Furthermore, carbon-neutral is not necessarily the same as climate-neutral, since the atmospheric concentration is temporarily altered when biomass is used for energy purposes. This is particularly relevant for forest biomass, which has longer timeframes.

Previous studies have shown that increasing the outtake of forest residues for energy purposes gives a warming impact, since biogenic CO_2 is released earlier in time than in the slower process of decomposition which occurs if the biomass remains in the forest [10–12]. To account for the biogenic carbon dynamic, a time-dependent LCA can be performed where yearly fluxes of greenhouse gases are considered [13,14].

In Sweden, forest biomass is used in the sawmill industry and in the pulp and paper industry, but also to a large extent for producing district heating, which meets around 60% of the heat demand in Swedish

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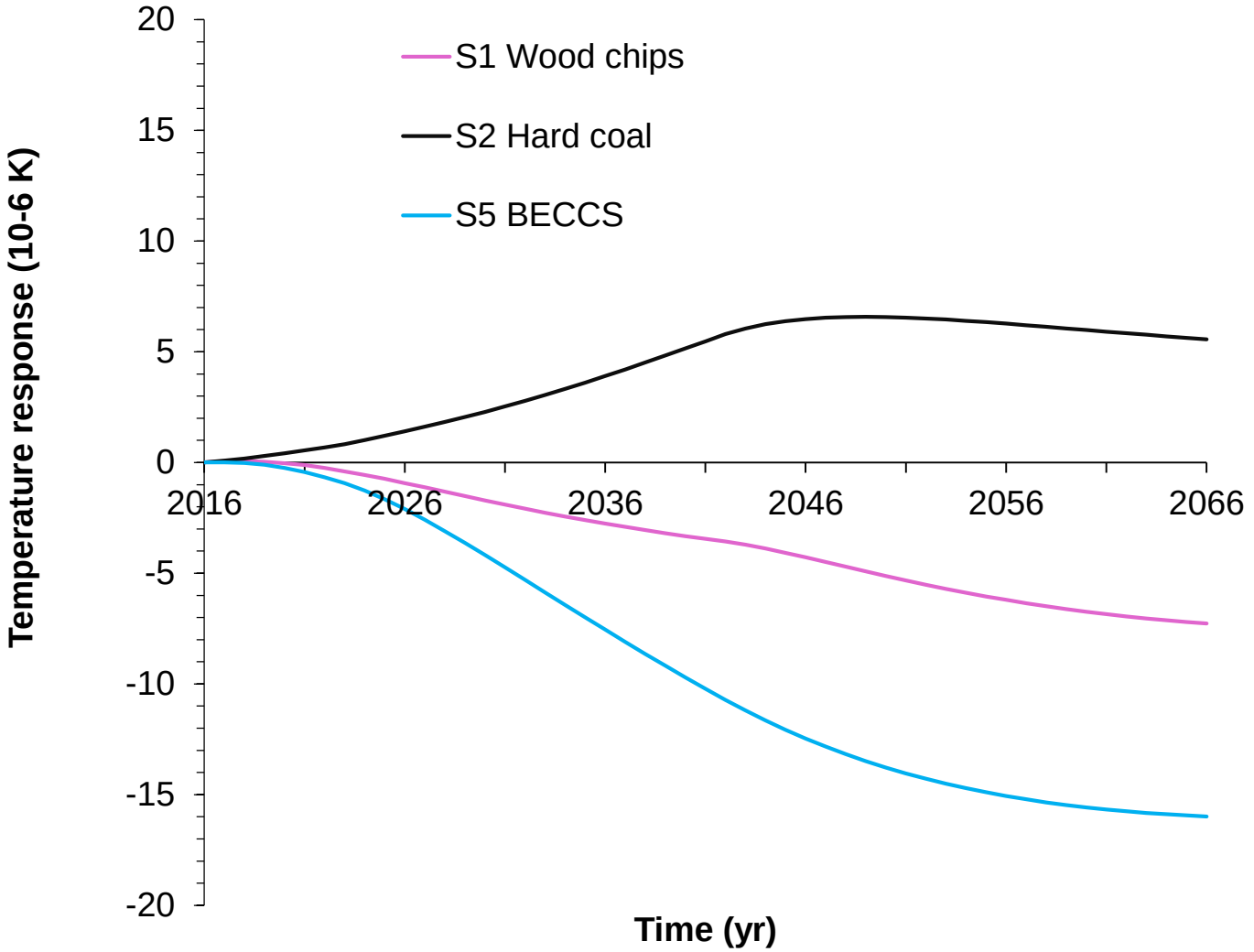

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Thanks

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