ENERGY
A CHALMERS AREA OF ADVANCE

Short version profile plan for Energy in a Circular Economy 2015–2019

Vision

The profile shall contribute to energy system transitions aligned with the vision of a circular economy and to making today´s use of fossil fuels and biomass more efficient and less harmful to human health and environment.

Background and context

Visions on a circular economy have been formulated in response to concerns about resource scarcity and impacts associated with unsustainable use of renewable and non-renewable resources. A move towards a circular economy is at the heart of the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth.

Biomass is considered a corner stone in the circular economy and is increasingly used to displace non-renewable resources (especially fossil fuels) in response to policies that are designed to address concerns about climate change and energy security. Technologies used for converting biomass to fuels and other products continue to become increasingly sophisticated, and the resulting products are usually of good quality. However, there are concerns about negative impact of the production of bio-based products, such as biodiversity loss and degradation of ecosystems. It is therefore imperative that transitions to relying on biomass instead of non-renewable resources involve development of sustainable production systems of biomass, i.e. efficient and harmless technologies and landscape management systems that provide biomass along with a broad range of other essential ecosystem services.

While the use of biomass grows, large investments are still made to further expand fossil energy generation capacity, for example from oil sand and shale oil. As fossil fuels probably will be part of the energy mix for decades to come, we urgently need to find solutions that reduce fossil carbon emissions in the near term and bridge to longer term development. Carbon capture and storage (CCS) provides an effective means of closing the carbon loop and represents one option to reduce fossil carbon emissions more rapidly than what is possible unless society accepts high costs associated with early retirement of the massive investments made to enable the use of the fossil resources. CCS has not yet been applied at scale to operational commercial fossil fuel power plants, but could enter the market if incentivised by regulation or if sufficiently high carbon prices become established. As also noted in the IPCC AR5, combining bioenergy with CCS offers the prospect of energy supply with large-scale net negative emissions.

Active fields

The challenges and opportunities described above are addressed in five active research fields:

- Resources
- Industrial combustion and gasification processes
- Biochemical processes
- Carbon capture processes
- Chemical processes and process integration

Resources

This active fields focuses on the development of production systems that utilise biomass – and consequently land, water and other resources – in efficient and sustainable ways. The research contributes to develop system analysis to extend and improve sustainability assessments of biomass production chains and to assess biomass supply prospects under varying biophysical, social and economic conditions. Methods and frameworks developed can be used for supporting governance – for example legislation, sustainability standards, and certification systems – and in stakeholder dialogues on decisions between different objectives that may not be fully compatible.

Industrial combustion and gasification processes

In this active field, the work is focused on optimisation of combustion and gasification processes – including flash pyrolysis – from the perspective of efficiency, and investment and maintenance cost, as well as emission control. The results from this activity aims at making carbon saving actions in these processes commercially interesting to implement.

Biochemical processes

The research within this active field is focused on developing new and existing biochemical processes that sustainably can produce products derived from biomass. Enzymes and cell factories (bacteria, yeasts and filamentous fungi) are being developed as biocatalysts for production of biofuels, chemicals and materials in advanced biorefinery concepts. The work is based on world-leading expertise within the fields of systems biology and metabolic engineering.

Carbon capture processes

This active field is focused on development of new, efficient technologies that capture and treat carbon dioxide emissions from industrial combustion processes. Chalmers is world-leading in the development of affordable and efficient CCS technologies, especially chemical-looping combustion (CLC) and oxyfuel combustion. A main short-term objective is to develop a combined CLC/oxyfuel concept for biomass.

Chemical processes and process integration

The technologies and chemical processes developed within this active field will allow the energy-intensive industries to significantly increase the energy efficiency of their core processes as well as converting residual streams to high-value products. Process integration activities will provide guidance to energy-intensive process industries for increasing their energy efficiency, reducing their carbon footprint, and decreasing their energy-related operation costs.

Planned activities 2015–2019

Due to the complexity of industrial technologies and systems, as well as the ongoing development, the knowledge about "robust" developments, economically, in terms of greenhouse gas emissions and other environmental consequences, is still relatively poor. To understand this better, a close **cooperation between researchers** of new technologies, system aspects and environmental consequences is necessary. We therefore plan a number of **internal workshops** for identifying and initiating more cooperation, community building activities between workshops, an **external seminar** and **seed money** for the participating groups. Other community building activities are a project for to identify better cooperation with the education at Chalmers, PhD courses and activities for writing position papers.

The profile has also initiated ten research work packages, all running from 2016 to 2019. The topics are:

- **Biomass production and conversion in sustainably managed landscapes**
  Aims at developing a framework for sustainability assessment of biomass based production, including indicators biodiversity and ecosystem services, and consideration of production at different scales.
- **Combustion and gas cleaning**
  Aims at developing efficient cleaning strategies to reduce harmful emissions (CO_2, SO_x, NO_x) in existing and novel industrial combustion processes.
- **High temperature corrosion and ash research**
  Aims at solving issues related to corrosion and ash in combined heat and power plants to enable the introduction of new technologies, e.g. CCS.
- **Experiments and modelling of two-phase flow in energy conversion**
  The aim is to establish knowledge and modelling tools which can contribute to increasing the efficiency of existing and fluidised-bed plant.
- **Gasification of biomass**
  The goal is to improve the competitiveness of gasification technology by reducing investments costs and risks while increasing the energy efficiency.
- **Yeast cell factories for advanced biofuels and microbial robustness**
  Development of yeast cell factory platform strains that can be used for efficient production of fatty acid derived molecules to be used as advanced biofuels.
- **Robust enzymatic and microbial conversion and valorisation of biorefinery side streams**
  This work package aims at increased knowledge on enzyme chemistry in lignocellulose streams and concomitant structural changes and convert that knowledge towards implication in designing robust processes.
- **Carbon capture and storage (CCS)**
  Development of a low-cost, efficient method for removing CO_2 from the atmosphere, using biomass CCS in combination with CLC/oxyfuel technology.
- **Development of resource-efficient chemical processes**
  Development of technologies and processes that will allow the energy-intensive industries to significantly increase the energy efficiency of their core processes as well as converting residual streams to high-value products.
- **Process integration for strategic development of industrial energy systems**
  The aim is to develop new knowledge about strategic development options for increasing energy efficiency and reducing emissions in the energy-intensive process industry sector.