*Can we mitigate **climate change** by replacing fossil fuels with **bioenergy**?*

Level: Master or Bachelor
Start: at any time
Project duration: 8 to 10 weeks for a bachelor project, 20 to 30 weeks for a master project
Project form: literature data collection, data analysis, calculations on greenhouse gas balances and radiative forcing
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Description of the project: Over the course of 21st century, large-scale changes in the global energy supply are required to drastically reduce greenhouse gases (GHG) emissions and limit climate change. Energy from biomass (bioenergy) is one of the renewable energy technologies that is increasingly used, intended to produce energy with lower GHG emissions. There are, however, several concerns surrounding bioenergy. First of all, the large amount of land required to grow biomass may lead to competition with food production (e.g., when agricultural land is used) or may strongly affect biodiversity (e.g., when natural areas are used). Moreover, the climate benefits of bioenergy are not clear-cut, which is what this project is about.

So, how can bioenergy lead to lower emissions in the first place? The principle of bioenergy is that biomass takes up CO_2 during growth. When energy from biomass is released (e.g., through combustion) the CO_2 is released to the atmosphere, but new biomass growth takes up CO_2 again. This cyclical process could lead to energy with very low associated GHG emissions.

So, what is not clear-cut then? There are four main reasons that GHG emissions from bioenergy may not always be low:

1) Conversion from a previous land-use to bioenergy productio may lead to GHG emissions (e.g., burning tropical rainforest to then grow sugarcane for bioenergy does not lead to low GHG emissions at all!)
2) GHGs like methane (from rotting biomass) or nitrous oxide (from fertiliser use) may be emitted during land conversion and during biomass growth
3) GHGs are emitted during the processing, transport and use of biomass for energy
4) While CO_2 is taken up by newly growing biomass, this may take a long time depending on rotation times

Because of these reasons it becomes quite hard to determine the GHG emissions associated with bioenergy. However, we aim to do just that. Moreover, we want to determine what combination of biomass type or "feedstock" (wood, grass, crops), cultivation location, final energy carrier (e.g., liquid fuels, electricity, heat), etc. has the lowest climate change impact per amount of energy produced. To calculate this climate impact, we consider the size and timing of the GHG emissions and determine the resulting radiative forcing (i.e., the resulting climate change effect). Often there are initial extra emissions of GHGs through land-use change, that are later compensated by using the cultivated biomass to replace fossil fuels. One of the metrics we therefore often use, is the "climate payback time" of different forms of bioenergy: the amount of time it takes before the initial GHG emissions are fully compensated, compared to a fossil reference system (see figure 1).

So, what could you do? We are always looking for ambitious students that want to do a challenging and highly relevant internship in the field of bioenergy at the Department of Environmental Science. Starting with the framework described above, we want to compare different forms of bioenergy. This can be very wide-ranging. You could for instance study a particular type of feedstock (e.g., sugar beet in the Netherlands) or final energy carrier (e.g., bio-diesel from different feedstocks). You can also challenge the framework and further improve the calculations. We are open to suggestions. You will collect your own data from the literature and use data from our existing dataset, analyse this data and calculate climate impact metrics, like climate payback times, to ultimately determine whether your type bioenergy could mitigate climate change or not.

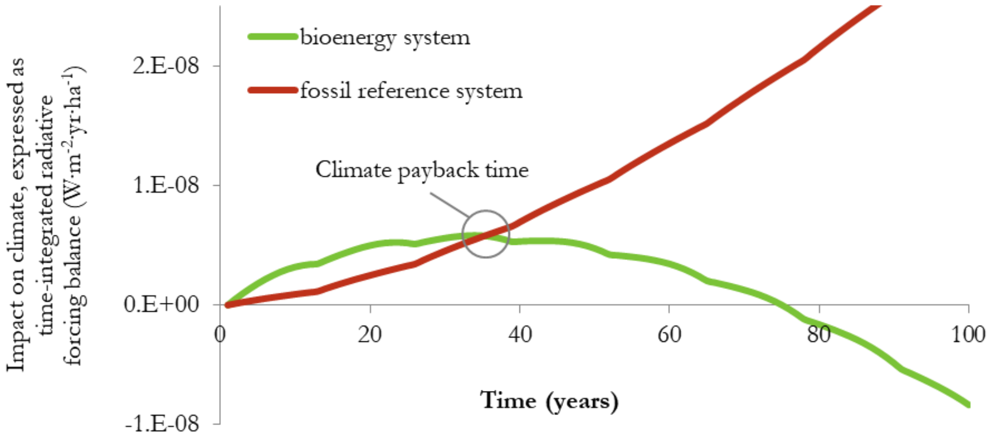

Fig. 1 Comparison of the climate impact of a bioenergy system compared to a fossil reference system. The climate payback time of a bioenergy system is reached when its impact becomes lower than that of the fossil reference.