Reverse supply chain of residual wood biomass

Sustainability and environmental consciousness is becoming an increasingly important issue, and questions of recycling and reuse are getting more and more attention lately. While biomass is an important renewable resource and can take many forms (ranging from agricultural residues to food waste, forestry residues and construction/wood processing residues), biomass wastes are predominantly considered for the production of bioenergy. This is also true in the European Union, where domestically produced biomass provides the main source of renewable energy. Because of this, academic studies dealing with processes in the value chain of biomass usually concentrate on its efficient use for energy. However, depending on the exact type of biomass residual, alternatives might also exist for its use that are significantly less studied. A good example for this is woody biomass (such as forestry residues, wood-processing residues or construction and municipal wastes) that can be recycled and reused, providing a more environmentally friendly alternative to bioenergy production. The applicants intend to study the possible alternative reverse logistics processes of biomass residuals, concentrating on woody residuals as a use-case. They wish to identify the crucial optimization problems connected to the collection, sorting, transportation, warehousing and processing of this biomass, and provide efficient models and algorithms for their solution. As wood residual biomass can be of many types and characteristics, various potential uses can exist for them. Different industries require specific types of wood residuals, and the optimal distribution and processing of the available biomass also has to take considerations like expected wood balance metrics into account. As it can be seen, the reverse logistics processes of residual wood biomass include challenging large-scale problems and there is a need for new solution technologies and automated problem-solving processes in this area. Besides minimizing capital and operational expenses, these solution methods should also consider multiple other objectives such as the minimization of waste and optimal distribution of biomass based on its quality.

The applicants propose to study relevant real-life problems belonging to a field that has not been studied extensively in the past. These problems are interesting from a theoretical point of view because of their complexity as well as from a practical standpoint due to the applicability of the resulting models and methods in real-life. As detailed real datasets are also scarce in this field, the real-life data collected as a result of the empirical research carried out during the project will be important.

Optimization problems in the reverse supply chain of residual wood biomass will be modelled as the output of the project and efficient solution methods will also be implemented for their solution. As these models and methods will consider the multi-objective nature of these relevant optimization questions, they will have both an environmental and economic impact. Companies can utilize them to decrease their environmental footprint (e.g. reduce the amount of resources sent for landfill or incineration, decrease the number of trucks used and distance travelled) as well as to streamline their economic efficiency (e.g. optimize transportation routes, save inventory or truck space by efficient packing schemes). The developed methods will be intensively tested in a simulation framework, which can also have potential to be expanded into a decision support system in the future. This would allow the simulation of various scenarios with different parameter set-ups and provide multiple good-quality suggestions to end-users for a given problem instance.

Real-world and simulated information connected to the availability of residual wood biomass will also be collected through empirical studies. The study of this data can reveal unique characteristics and patterns that can be generalized to other biomass supply chains as well, making it easier to produce randomised and realistic test instances for future research.