# Summary

Increased use of biomass as a $CO_2$ neutral energy resource requires bigger storage facilities for the future. A potential hazard in storing biomass for longer periods is the self-heating phenomenon and the possible resulting spontaneous-ignition which may occur. In the past multiple accidents have happened where self-heating and spontaneous-ignition resulted in: flaming fires, a loss of storage equipment and even human casualties. The main goal of this literature study is understanding the mechanisms involved in self-heating and how to prevent the self-heating and material degradation in solid bulk materials. The acquired knowledge will be used for the design of a new large scale biomass bulk terminal under currently investigation by the Transportation engineering & Logistics section from TU Delft.

Self-heating in coal is a well known phenomenon. Heat is being produced by the exothermic low temperature oxidation reactions within the coal. If the produced heat exceeds the amount of heat loss from the material, the material will warm up and self-heating is the result. At higher temperatures the direct burn-off reaction produces heat, this may cause spontaneous-ignition.

The same effect can be seen in biomass self-heating, with the important difference that the initial stage of heating is caused by enzymatic heat production. Where sugars are being burnt under aerobic conditions with the use of enzymes. On the next stage -starting at about 30°C- the activity from microbes and funguses produces the heat. Mesophilic and thermophilic organisms can be identified with regard to their temperature tolerance. Up to a temperature of 70 to 75°C the micro organisms remain active and produce heat. Above this temperature chemical oxidation takes over. This is the reaction between carbon hydrates from the dry substance and oxygen in the air. Chemical oxidation is the step between self-heating and spontaneous-ignition.

Besides spontaneous-ignition also material degradation and dry matter loss can be the result of self-heating. The heat generated during storage cannot be used effectively and is dissipated to the environment. Hence, the material subject to self-heating has a lower energy content and fuel quality after storage. Sometimes there is as much as 5% loss of dry matter per month of storage.

A material's susceptibility to undergo self-heating depends on several variables, subdivided into internal and external variables. The internal variables are: material temperature, moisture content, catalytic effects, particle size and surface area, reactivity to oxygen and micro organisms. The external variables are: storage geometry, pile porosity and compaction, ambient conditions, homogeneity of the storage and storage time. Each variable affects the self-heating process in its own way. One could say that the moisture content is the most important variable. Moisture affects the heat producing process in many ways. For woody biomasses a moisture content below 20% prevents self-heating and storage is considered safe. However, self-heating leading to spontaneous-ignition is difficult to predict because of the considerable amount of variables involved and the large effect of a small change in value of one of the variables on the self-heating process. Very specific conditions are necessary for the step from self-heating to spontaneous-ignition. These conditions have proven to be very difficult to simulate under test conditions. In large storage facilities spontaneous-ignition is known to occur incidentally. Here the specific conditions arise in local niches inside the material with just the right properties.