Biomass Pre-treatment Technologies

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TORWASH and Torrefaction are pre-treatment technologies that can improve the supply chain of biomass by increasing the volumetric energy content of the fuel, and improving its fuel characteristics. This leads to the production of high-quality sustainable solid bioenergy carriers. In addition, TORWASH can reduce the salt content of biomass.

TORWASH

TORWASH is a technology that is under development at ECN for the conversion of herbaceous biomass into an attractive solid bioenergy carrier. The feedstock for TORWASH often combines three undesirable characteristics: 1) high moisture content, 2) containing too much salt, and 3) being difficult to comminute and bulky. Herbaceous biomass is typically not suitable for direct utilisation as fuel for combustion or gasification. These fuels display an increased moisture content that corresponds to lower net calorific values, while the increased salt concentration – in particular potassium and chloride – can cause problems such as corrosion, agglomeration, slagging and fouling upon thermal conversion. Furthermore herbaceous biomass can result in issues during size reduction due to its flexible nature. Lastly, the bulky nature and the high moisture content result in relatively expensive logistics costs. By using TORWASH, all of these undesirable characteristics are drastically improved. The product of TORWASH is a solid bioenergy carrier with characteristics equal to those of torrefied wood pellets. Within the LogistEC project Arundo Donax Giant Reed was successfully subjected to batch TORWASH experiments. The recovery rates during the pre-wash and TORWASH step are displayed in Figure 1.

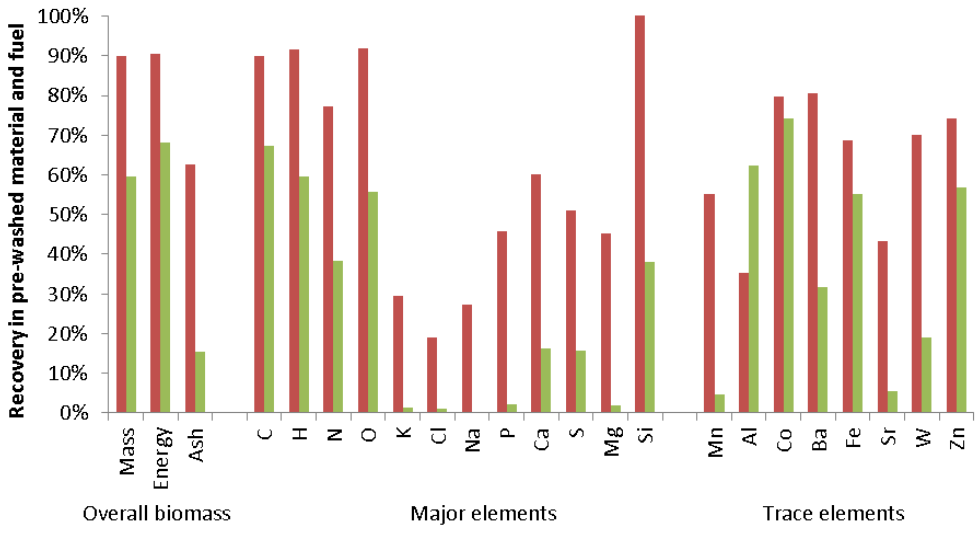

Figure 1 Mass recovery of *Arundo Donax* Giant Reed after pre-wash (red) & TORWASH (green)

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TORWASH, also known as wet torrefaction, is a hydrothermal treatment step that is performed under pressure, at temperatures between 150 and 250°C. The treatment changes the structure by making the fibres brittle, therefore the biomass becomes easy to mill. Simultaneously water that permeates the biomass dissolves most chloride and alkali salts. After the heat treatment, the biomass is mechanically dewatered, in order to remove the majority of the water and salts without the use of thermal drying. The combination of washing, thermal treatment and mechanical dewatering allows for typical salt removal rates in excess of 98%. The resulting pressure cake contains less than 35% moisture.

Figure 2 Untreated, torwashed and pelleted *Arundo Donax* Giant Reed

The combination of washing and TORWASH demonstrates a very effective means to separate combustible matter from ashes. The overall result is that 84% of the ash forming components from Arundo Donax Giant Reed are removed. The resulting ash content of 0.6 wt% is very promising and confirms that this is an attractive fuel. Based on the chemical composition the resulting solid bioenergy carrier would comply with the ENplus A1 standard, which is the most stringent standard for white wood pellets, as demonstrated in Table 1. The dissolved matter in the washing liquid and the TORWASH liquid are dissolved sugars and ash components, the sugars can be fermented to produce biogas to sustain the process, while the ash components can be precipitated.

Table 1 Chemical composition in accordance with EN plus A1 standard, example of white softwood pellets, and untreated and torwashed *Arundo Donax* Giant Reed

Parameter	Unit	ENplus A1 white wood pellets	White softwood pellets	*Arundo Donax* untreated	*Arundo Donax* torwashed
Additives	wt% ar	none	none	none	none
Moisture content	wt% ar	≤ 10.0	8.3	variable	7.0
NCV	MJ/kg db	≥ 16.5	18.6	17.9	20.6
Ash	wt% db	≤ 0.7	0.3	2.3	0.6
Chlorine	mg/kg db	≤ 200	120	2270	50
Potassium	mg/kg db	-	380	4924	116

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TORREFACTION

Torrefaction is a thermochemical process that has its roots in the roasting of coffee beans and gives coffee its characteristic flavour. For biomass, it is used as a pre-treatment process in the typical range between 250-300°C in order to upgrade the biomass and convert it into a high-value solid bioenergy carrier. The chemistry behind torrefaction involves mainly the removal of oxygen from the biomass structure after exposure to a hot, inert atmosphere. This causes the biomass to transform into a hydrophobic, homogeneous and dense solid energy carrier, which typically contains about 70% of the mass and 90% of the energy initially present in the biomass. Torrefaction side-products are vapours and gases which can be combusted to generate process heat, creating a self-sustaining overall process. The torrefied product can be further processed into densified pellets or briquettes obtaining a high-quality product adjusted to logistics and end-use requirements.

Chipped Willow and Triticale pellets were successfully torrefied at the ECN pilot torrefaction plant with a throughput of approximately 50 kg/h. It should be noted that torrefaction, unlike TORWASH, does not typically result in ash removal; the volatilisation of some organic matter normally results in a slight increase of the ash content. The torrefied Willow was successfully briquetted by CF Nielsen, although briquetting of pre-compacted materials proved to be more difficult. The pre-pelleted torrefied Triticale was successfully densified in ECN's lab-scale pellet mill, as displayed in Figure 3. This figure indicates that the volumetric energy density of bulky biomass streams can be significantly increased through torrefaction and densification.

Figure 3 Untreated *Willow* and torrefied *Willow* briquettes (left) and pre-pelleted *Triticale* and torrefied *Triticale* pellets (right)

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