THE IRISH WOOD FUEL DATABASE

A new tool for the biomass industry and researchers on parameters affecting the use of wood as a fuel, by Enda Coates, Christopher McGurren, Brian Cronin & Tom Kent of Waterford Institute of Technology.

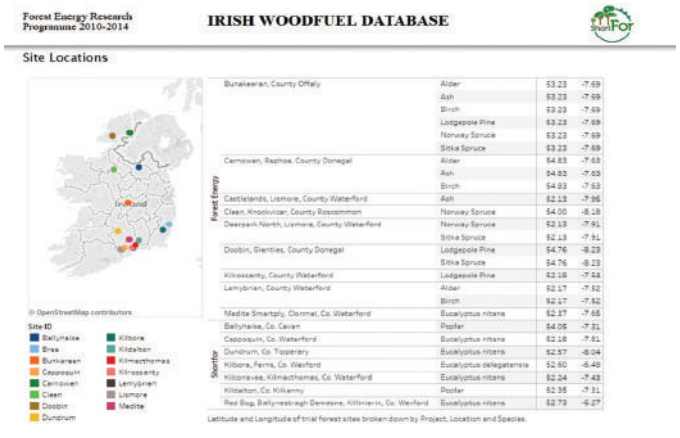
Field sampling of hybrid poplar at Kildalton Agricultural College, Co. Kilkenny. Specimen trees can be seen crosscut at every three metres where disks have been cut and taken to the lab for analysis. The branches and tops are being removed to be chipped by the chipper in the background.

INTRODUCTION

An online database has been developed by Waterford Institute of Technology which details the wood fuel characteristics of many Irish commercially-grown tree species. The purpose of the database is to provide industry and researchers with information on properties affecting the use of wood as a fuel. The database includes values for moisture content at felling, basic density, ash content, calorific value, carbon, hydrogen, nitrogen, chlorine, sulphur, oxygen, arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc.

The information that populates the database has been collected from the felling and destructive sampling of specimen trees. It is presented in an online web-based format, where users can query parameters to view specific data as graphics, download figures, and also tables of the underlying data, all of which is freely available. The species currently represented in this database are alder (*Alnus glutinosa*), ash (*Fraxinus excelsior L.*), birch (*Betula pendula & B. pubescens*), lodgepole pine (*Pinus contorta* Dougl.), Norway spruce (*Picea abies* (L.) Karst.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.), hybrid poplars (*Populus sp.*), *Eucalyptus delegatensis*, and *Eucalyptus nitens*. For each species, data is presented separately for the stem, wood, top, bark, branch, and foliage.

The database can be accessed at www.forestenergy.ie



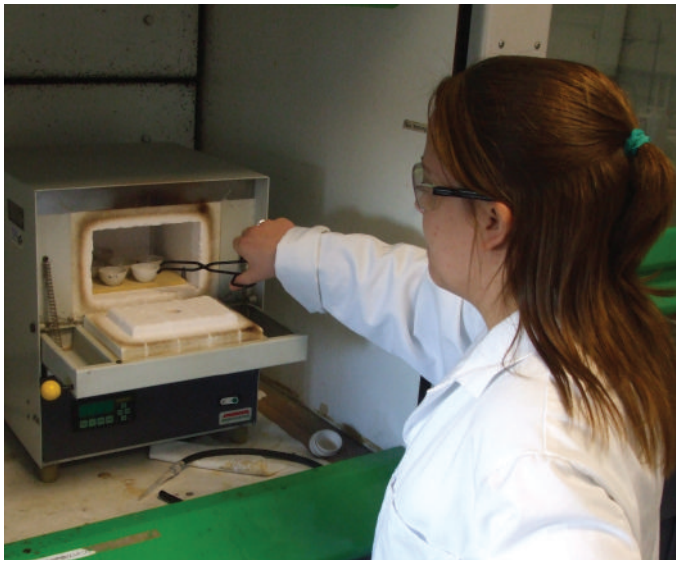
Screenshot of database landing page which shows site locations and species

WHY IS THIS DATABASE USEFUL?

It is estimated that due to EU directives, the demand for forest-derived biomass for energy in Ireland will be 3,084,000 m³ per annum by the year 2020. However, it is estimated that only 1,453,000 m³ of forest biomass will be available for the bioenergy market from currently employed supply chains. This forecast of supply only estimates stemwood, and does not take into account the biomass that may be mobilised from branches and tree tops. The Department of Agriculture has introduced to the Afforestation Grant Scheme a new category, Forestry for Fibre, which aims to grow fast growing species such as poplar, eucalyptus, and alder specifically for fibre for use in wood fuel supply chains and to feed the panel board mills. As biomass supply develops from forest residues and these new species, data on the characteristics of these wood fuels will be needed in order for biomass users to decide if a particular wood fuel is suitable in their combustion systems. In an effort to inform industry as to the makeup of these biomass feedstocks, this database has been created.

DATA AVAILABLE IN THE DATABASE:

The parameters that have been analysed and are presented in the database are known to be important characteristics of wood fuel.



Crucibles of test sample material being extracted from a muffle furnace at 550°C to determine their ash content.

They describe the useful energy content of the material, and also the characteristics which may limit use under certain conditions. The moisture content of biomass is an important parameter: the higher the moisture content, the lower the net calorific value. Moisture content also affects the storage durability of biomass, and its suitability for use to boiler manufacturer's specifications. Moisture content is calculated as a percentage of the total weight (wet basis). Here the moisture content is given as it was observed when the trees were freshly felled. Through management processes, such as stacking and seasoning, the moisture content can be reduced. The basic density is the dry mass (0% moisture content) per unit volume, expressed in kg/m^3. Basic density is not affected by moisture content, instead it can be thought of as the amount of wood in the fuel.

The calorific value describes the energy content of the biomass in Mega joules per kg. Calorific value may be expressed as: gross or net calorific value; on an as-received (the moisture content as observed) or dry basis; including ash or ash-free. In the database, the calorific value is expressed as gross calorific value on a dry basis, and gross calorific value on a dry ash free basis. Using these values with the chemical composition, as detailed below, the net calorific value on a dry basis can be calculated easily. By having the net calorific value on a dry basis, and basic density, the actual energy content of any quantity of fuel at any moisture content can be calculated. This is useful for practitioners who are seasoning stacks of forest biomass and want to estimate the energy per stack / per load they are delivering. WIT is also developing tools to make these conversions easily using the database values as inputs.

The ash content of biomass is the inorganic, incombustible part. It is expressed as a percentage weight of the dry matter ie. % ash content on a dry basis. A high content of ash means that less of the biomass is combustible as a fuel and there is more ash to be disposed of at the end of the combustion process. It is also important to characterise the ash melting behaviour of biomass ash as ash deposition may cause slagging and fouling of the boiler system. Slagging is the deposition of sticky, molten ash on the furnace walls and hottest parts of the boiler system which experience radiant heat transfer directly from the flames from combustion; fouling takes place in the relatively cooler parts of the system where flue gas and fly ash cool down and form deposits, often on heat exchanger tubes.

The chemical composition is used in the calculation of energy content. The chemical composition can also influence the usability of biomass as a fuel in terms of emissions and suitability for combustion under

certain conditions. Chlorine, sulphur and nitrogen contents should be quantified and any biomass with high concentrations of these elements should be highlighted and may have to be omitted from the fuel mix. Chlorine content is a concern for boiler operators, as high chlorine content can cause corrosion of the boiler. While sulphur is itself corrosive, a certain ratio of sulphur to chlorine will reduce corrosive effects. For instance, Edenderry Power in Ireland requires a ratio of sulphur to chlorine in their fuel mix. It appears that when the ratio of sulphur to chlorine is greater than 4:1, corrosion is not an issue as the sulphur reactions limit the amount of surface chlorine that can build up on boiler surfaces. While maintaining this ratio is important to reduce corrosion, a high concentration of either sulphur or chlorine could lead to emission issues. Carbon, hydrogen and nitrogen are also important elements to quantify for carbon accounting purposes, and life cycle analysis of biomass supply chains. This is where the carbon released in the harvesting, chipping and transportation of the wood fuel is evaluated to see it there is a net benefit using the wood fuel in terms of carbon offsetting from fossil fuels. The biomass boiler efficiency has a large impact on this analysis also.

DATA SOURCES

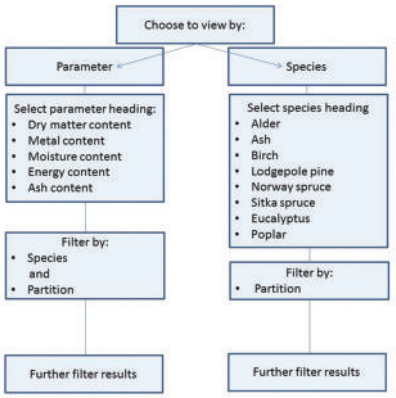
The data that populates the database has all been collected specifically for this purpose by felling specimen trees where available for each species. Eucalyptus samples were collected from counties Waterford, and Wexford. Poplar samples were collected from counties Kilkenny and Cavan. Alder, ash, lodgepole pine, and Sitka spruce samples were collected from counties Waterford, Offaly, and Donegal. Birch samples were collected from Donegal, Offaly, Tipperary and Waterford. Norway spruce samples were collected from counties Roscommon, Offaly and Waterford. Ten to fifteen specimen trees of each species in each location were felled by chainsaw. Each tree was partitioned in the field into stemwood, stem top less than 7 cm diameter, and live and dead branches. Disks were cut from the stem by chainsaw at regular intervals and the other partitions were also sampled and returned to WIT for analysis.

DATABASE DEVELOPMENT

The Wood Fuel Test Centre at WIT has the capacity to carry out most energy parameter tests in compliance with the ISO Solid Biofuel standards, developed over the last ten years with the aim of ensuring biomass quality and sustainability. The database samples were analysed for moisture content using the oven dry method at 105 °C, according to EN 14774-3:2009, and expressed as a percentage of total weight. Ash content, expressed as percentage dry weight, was determined using a Carbolite muffle furnace at 550 °C, according to EN 14775:2009. Calorific value, expressed in Mega joules per kilogram, was determined using a Parr 5500 oxygen bomb calorimeter, according to EN 14918:2009. Carbon, hydrogen, nitrogen and sulphur were measured using an Exeter Analytical CE 440 elemental analyser. Chlorine was determined through a titrimetric method.

The metals: cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn) were analysed using a Varian 710-ES Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) equipped with a SPS3 autosampler. In order for the samples to be analysed, they were first digested using HNO_3 and 2 ml 35% H_2O_2 in a CEM Mars 5 Station.

The results of the analysis were compiled into spreadsheets to form the dataset for the database. A data visualisation software package, Tableau Public 10.1 (Tableau Software), was then used to develop an online tool in which users can interact with the data. The project team plan to expand the database further over time as additional data becomes available.



A simple representation of the two ways in which to query the database either by parameter or by species

> "As biomass supply develops from forest residues and these new species, data on the characteristics of these wood fuels will be needed in order for biomass users to decide if a particular wood fuel is suitable in their combustion systems"

USING THE DATABASE

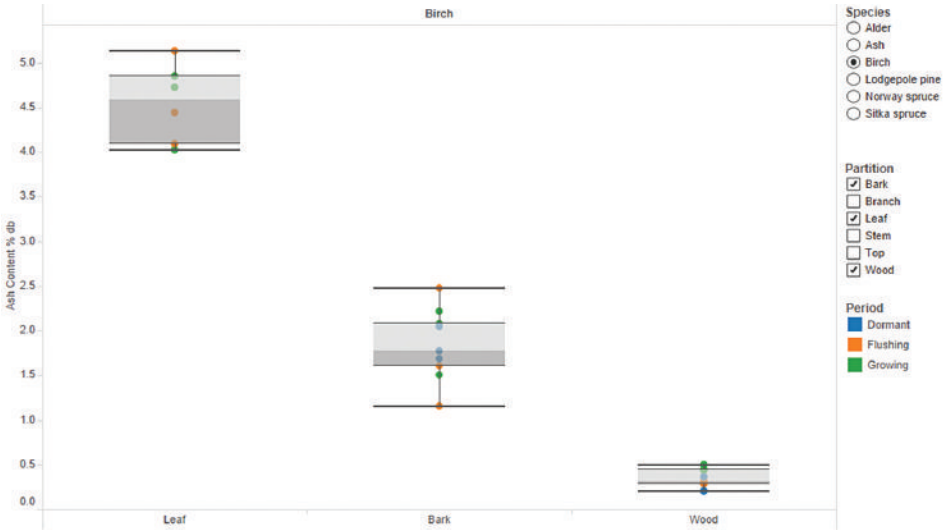
Users can access the database and query the data under two headings: Parameter or Species. Under the parameter heading, a parameter is selected and filtered by species and partition. The results for this parameter are then presented, and can be further filtered to show all or only specified results. The development team hope that industry will extract useful information on suitability of wood fuels and as a result, be in a better position to specify fuel supply to meet their particular requirement. The team expect researchers to mine the database for particular parameters to support and validate their own analyses.

For further information, a manual of how to use the database, and to access the free database (no registration or sign up required) log on to www.forestenergy.ie

This work was initiated under the Forest Energy Programme, funded by the Department of Agriculture, Food and the Marine and is continuing under the Shortfor Project, which is also funded by the Department of Agriculture, Food and the Marine.

Further information on the ShortFor Project may be found here: www.teagasc.ie/crops/ forestry/ research/ shortfor-project/

Further information on International Solid Biofuel Standards can be found here: www.solidstandards.eu



A screenshot of the database showing the ash content of Sitka spruce leaf, bark and wood in a boxplot.