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Terminology and Definitions for Biomass Production, Harvesting and Collection, Storage, Processing, Conversion and Utilization

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1 Purpose and scope

1.1 The purpose of this Standard is to provide uniform terminology and definitions in the general area of biomass production and utilization.

1.2 This includes all the terminologies that are used in biomass feedstock production, harvesting, collecting, handling, storage, pre-processing and conversion, bioenergy, biofuels, biopower and biobased products.

2 Introduction

The role of biomass in society has increased dramatically recently due to the high cost of fossil-based fuel, the burden of removal of excessive biomass in resource management, concerns over climate change, and the desire of governments of various countries to reduce their dependence on imported fossil-based fuel. Despite the effort that is being put into biomass production and utilization, the definitions and terminologies that are used sometimes differ. This has often caused confusion in the biomass production and utilization industry.

3 Definitions

The following is a list of the definitions for the terms related to this standard.

3.1 Agricultural residue: Agricultural crop residues are the plant parts, primarily stalks and leaves, not removed from the fields with the primary food or fiber product. Examples include corn stover (stalks, leaves, husks, and cobs); wheat straw, and rice straw.

3.2 Ash: The inorganic, non-combustible residue left after complete combustion of a material at minimum temperature of 575^{o} C.

3.3 Ash fusion test: A procedure used to determine the softening and melting behavior of ash. Ash of a material is formed into a cone and heated under prescribed conditions in a testing laboratory (ASTM D 1857). The temperature points that are observed are initial deformation temperature, softening temperature, hemispherical temperature and fluid temperature. The higher the fusion temperatures of the ash of a material are, the lower the tendencey of that material to slag in a combustion chamber.

3.4 Biobased product (biobased industrial product, bioproduct): Fuels, food, feed, chemicals, or industrial materials (e.g. pharmaceuticals, building materials, inks, coatings, paper etc.) commercially produced in whole or in-part from biomass materials.

3.5 Bio-char: See the definition of char.

3.6 Biodiesel: Mono-alkyl esters of fatty acids derived from vegetable oils or animal fats when chemically or biochemically reacted with an alcohol.

3.7 Bioenergy: Energy derived from biomass. This includes biopower (see definition below), energy from biobased transportation fuels, and energy from biomass that is used for process or space heating.

3.8 Bioethanol: Ethanol produced from biomass.

3.9 Biofuel: A fuel derived from biomass.

3.10 Biogas: A mixture primarily consisting of methane and carbon dioxide produced by the bacterial decomposition of biomass. It is used as a fuel, industrial intermediate or feedstock.

3.11 Bioheat: Heat energy generated from biomass sources.

3.12 Biomass: Organic materials that are plant or animal based, including but not limited to dedicated energy crops, agricultural crops and trees, food, feed and fiber crop residues, aquatic plants, forestry and wood residues, agricultural wastes, biobased segments of industrial and municipal wastes, processing by-products and other non-fossil organic materials. Three main categories of biomass are primary, secondary and tertiary biomass (see definitions below).

3.13 Biomass Conversion: Transformation of biomass into bioenergy or biobased products.

3.14 Bio-oil: A product of pyrolysis or liquefaction of biomass. It is a dark brown, partially water miscible liquid which contains oxygenated organic compounds.

3.15 Biopower: Electricity from biomass or intermediate bioproducts.

3.16 Bioproduct: See Biobased Product

3.17 Biorefinery: A facility that uses mechanical, thermal, chemical, and/or biochemical processes to convert biomass into several value-added biobased products or key intermediates for the production of chemicals and other materials.

3.18 Biosolids: Nutrient-rich organic material resulting from the treatment of wastewater and from anaerobic digestion of animal manures (see section 3.61 for additional information on animal manures).

3.19 Black liquor: Solution of lignin-residue and the pulping chemicals used to extract lignin during the manufacture of paper.

3.20 Bone dry material:A material having zero percent moisture content.

3.21 Byproduct: A secondary or incidental product that is derived from a manufacturing process or chemical reaction, and is not the primary product or service being produced.

3.22 Carbonization: A process similar in nature to pyrolysis, but which uses lower temperature and longer residence time in the reactor. The resulting products include approximately equal amounts of liquid, tar, and gas products.

3.23 Char: A residue resulting from pyrolysis, carbonization, and gasification of biomass.

3.24 Charcoal: Impure form of carbon, obtained as a residue when biomass is partially burned or heated with limited access to air.

3.25 Closed-loop biomass: Primary biomass grown, in a sustainable manner, for the sole purpose of optimizing its value for bioenergy and bioproduct uses. This includes annual crops such as corn and wheat, and perennial crops such as trees, shrubs, and grasses such as switchgrass.

3.26 Co-Firing: The simultaneous use of two or more different fuels in the same combustion chamber of a power plant. Generally refers to co-burning coal and biomass.

3.27 Co-Gasification: The simultaneous use of coal and treated/ untreated biomass in the gasification process to produce syngas.

3.28 Coke: The solid residue of impure carbon obtained from carbon rich feedstocks after removal of volatile material by destructive distillation.

3.29 Co-Liquefaction: The simultaneous use of coal and treated/ untreated biomass in direct liquefaction process to produce liquid fuel.

3.30 Combined bioheat and power: Bioheat and biopower simultaneous generated from biomass sources.

3.31 Combustion: Thermal conversion of a carbon rich feedstock with an oxidant (excess air) to produce primarily heat energy, carbon dioxide, water and ash.

3.32 Coproduct: A secondary product with commercial value that is intentionally produced incidental to the manufacturing process or chemical reaction, and is not the primary product or service being produced.

3.33 Crop Residue: Plant material remaining after the primary crop fraction has been harvested

3.34 Dedicated energy crops: Annual crops (such as corn) or perennial crops (such as trees and grasses) when grown specifically as feedstock for conversion to bioenergy and biobased products.

3.35 Densification: Process of increasing bulk density or energy content of biomass to improve handling, storage and transportation.

3.36 Density, bulk: Mass per unit volume occupied by a large quantity of particulate material.

3.37 Density, particle: Mass per unit volume of individual particles (volume includes volume of pores within the particle).

3.38 Density, solid: Mass per unit volume of individual particles (volume does not include volume of pores within the particle).

3.39 Devolatilization: A process (usually pyrolysis or gasification) whereby volatile materials are removed from carbon rich feedstock.

3.40 Drop-in fuel or Infrastructure compatible fuel: Synthetic gasoline or diesel or jet fuel prepared from biomass that is completely interchangeable or compatible with the conventional fuels.

3.41 Elemental analysis: The determination of carbon, hydrogen, nitrogen, oxygen, sulfur, chlorine, and ash in a sample. See ultimate analysis.

3.42 Energy crops: Crop grown and harvested to be an energy feedstock.

3.43 Feedstock: Preprocessed biomass that is ready for conversion to bioenergy and/or biobased products.

3.44 Fermentation: Process involving chemical changes in an organic substrate through the action of enzymes and microorganisms.

3.45 Fixed carbon: The remaining organic matter after the release of volatile matter and moisture from biomass. It is composed primarily of carbon with lesser amounts of H, N, and S. It is the difference between 100 and the sum of the percent moisture, ash, and volatile matter.

3.46 Fluid ash fusion temperature: Temperature at which the fused mass of ash has spread out in a nearly flat layer with a maximum height of 1.6mm (0.063 in.) – ASTM D1857. See Ash fusion test.

3.47 Fossil fuel: Fuels such as oil, natural gas and coal formed in the ground over millions of years by chemical and physical changes in plant and animal residues under high temperature and pressure.

3.48 Fractionation: Mechanical or chemical processing of biomass material into anatomical or chemical components.

3.49 Fungible fuels: Fuels such as ethanol, butanol etc. made from biomass which has chemical similarities with conventional fuels such as gasoline and can be blended and used in the existing engines.

3.50 Gasification: Thermochemical conversion, typically occurring at 750 to 850^{o} C (1382 to 1562^{o} F) in an oxygen-deficient environment, of carbon rich feedstocks into a gaseous fuel known as producer gas or syngas.

3.51 Green metric ton: Mass of one metric ton of freshly collected biomass.

3.52 Greenhouse gases: Gaseous constituents of the atmosphere, which trap the heat of the sun in the earth's atmosphere, producing what is commonly known as the greenhouse effect. Examples are water vapor, nitrous oxide, methane, carbon dioxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6).

3.53 Greenhouse heating: The heating effect due to trapping of the sun's radiant energy by greenhouse gases in the earth's atmosphere.

3.54 Hemispherical ash fusion temperature: The temperature at which the cone of ash has fused down to a hemispherical lump at which point the height is one half of the width of the base.

3.55 Higher Heating Value (or HHV): The full energy content of a fuel. It is the amount of heat produced when a liquied fuel or oven dried solid fuel is fully combusted, all of the products of combustion are cooled to 25^{o} C (77^{o} F) and the water vapor formed during combustion is condensed into liquid water.

3.56 Hog fuel: Chipped, shredded, or ground biomass that is processed to the specifications of a combustion power producer. May be produced from primary, secondary, or tertiary biomass.

3.57 Hydrolysis: Chemical or biochemical process of decomposition involving the splitting of chemical bonds of substances and the addition of the hydrogen cation and the hydroxyl anion of water.

3.58 Hydrothermal carbonization: Mild form of pyrolysis using an aqueous feedstock. Biomass is treated in hot compressed water yielding three product forms: solid fuel, aqueous compounds, and gases. The operational autogenic pressure is the saturated vapor pressure.

3.59 Initial deformation ash fusion temperature: The temperature at which the point of the ash cone begins to round (see Ash fusion test).

3.60 Lignocellulose: Biomass composed primarily of cellulose, hemicelluloses and lignin.

3.61 Liquefaction: Thermochemical conversion process of carbon rich feedstocks into a liquid bio-oil and coproducts. Liquefaction is usually conducted in an environment of moderate temperatures (300 to 400^{o} C or 572 to 752^{o} F) and elevated pressures.

3.62 Lower Heating Value (LHV) or Net Heating Value (NHV): Net heat released from the combustion of oven dry solid fuel after reducing the HHV by the heat of vaporization of the water generated by combustion of the hydrogen in the fuel. Each gram of hydrogen produces 9 grams of water.

3.63 Moisture content: Amount of water contained in a material expressed as either on a wet weight basis or dry weight basis. Statement of moisture content must indicate whether the moisture content value reported is wet basis (wb) or dry basis (db).

3.64 Municipal Solid Waste (MSW): A waste stream consisting of post-consumer materials.

3.65 Open-loop biomass: Biomass that can be used to produce energy and bioproducts even though it was not grown specifically for this purpose. Examples of open-loop biomass include agricultural livestock waste and residues from forest harvesting operations and crop harvesting.

3.66 Oven dry material: Bone dry material produced by drying in an oven 103-130^{o} C for 24-72 hours.

3.67 Pretreatment: Biological, chemical, physical, physico-chemical processing of biomass to reduce biomass recalcitrance to conversion.

3.68 Primary biomass: Biomass produced directly by photosynthesis and harvested or collected from the field or forest where it is grown. Examples are grains, perennial grasses and wood crops, crop residues and residues from logging and forest operations.

3.69 Producer Gas: Non-condensable product of biomass gasification

when air is used as the oxygen source, consisting of carbon monoxide, hydrogen, carbon dioxide, methane and nitrogen which can be burned for heat or power or converted to liquid fuels and chemicals.

3.70 Proximate Analysis: Determination of moisture, volatile matter, ash and the calculation of fixed carbon in a material.

3.71 Pyrolysis: Thermochemical conversion process (usually conducted at 400 to 600° C or 752 to 1112° F) in the absence of oxygen. Pyrolyis of carbon rich feedstocks produces a bio-oil along with some solids (char), and some gases (methane, carbon monoxide, carbon dioxide). The proportions of the products are largely dependent on factors such as operating temperature, pressure, oxygen content and feedstock characteristics.

3.72 Quad: One quadrillion Btu (10^{15} Btu or 1.05 x 10^{15} kJ). One Quad is the energy equivalent of 172 million barrels (27.35 x 10^{6} m^{3}) of crude oil.

3.73 Reactor: Vessel or equipment used in the conversion of feedstocks. Also referred to as a bioreactor, when the conversion is being done via fermentation.

3.74 Recoverable Heat: Actual heat recovered from a conventional boiler or combustion chamber.

3.75 Renewable Energy: Energy derived from a natural, managed or cultivated resource that can be replaced as it is used. Examples are wind, solar, hydro, biomass or geothermal sources.

3.76 Residue: Material that remains after a portion of biomass is removed from field.

3.77 Secondary biomass: Residues and byproduct streams from food, feed, fiber, wood and materials processing plants (such as sawdust, black liquor and cheese whey), and manures from concentrated animal feeding operations.

3.78 Slag: Ash that is or has been in a molten (or liquid) state.

3.79 Softening ash fusion temperature: Temperature at which the cone of ash has fused down to a spherical lump in which the height is equal to the width at the base (see Ash fusion test).

3.80 Soot: The fine black particles, chiefly composed of carbon, produced by incomplete combustion of carbon rich feedstock.

3.81 Sugar platform: A conversion approach that involves the breakdown of biomass into component sugars, which are then converted into products such as ethanol and other valuable fuels and chemicals.

3.82 Syngas: A synthetic gas composed of hydrogen and carbon monoxide that is obtained by gasification of biomass when oxygen is fed to the reactor, and which can be transformed to fuels, products, power and hydrogen.

3.83 Tar: A liquid product of thermal processing of carbonaceous materials.

3.84 Tertiary biomass: Post consumer residues and wastes, such as fats, greases, oils, construction and demolition wood debris, other waste wood from urban environments, as well as packaging wastes, municipal solid wastes and landfill gases.

3.85 Thermochemical or Syngas Platform: A conversion approach that uses thermal processes, such as gasification and pyrolysis, to breakdown biomass into desired products or intermediate components which are in turn converted into desired fuels and chemicals.

3.86 Timber Residue: Wood products remaining after lumber fraction has been harvested.

3.87 Torrefaction: A pretreatment method where biomass is subjected to moderate heating (200- 300° C) in a low oxygen environment.

3.88 Transesterification: A chemical reaction of exchanging the alkoxy group of an ester by another alcohol. The products of a transesterification reaction are a new ester and a new alcohol. A catalyst is typically required for transesterification. An example is when an alcohol reacts with the triglycerides contained in vegetable oils and animal fats to produce biodiesel, with glycerin as a byproduct.

3.89 Ultimate analysis: The determination of the elemental composition of the organic portion of carbonaceous materilas, as well as the total ash and moisture. See elemental analysis.

3.90 Volatiles: Materials (such as vapors and gases) that vaporize from heated (e.g. pyrolysis) and non-heated (e.g. anaerobic digestion) biomass.

3.91 Wet storage: A method of storing high moisture biomass under anaerobic conditions.

3.92 Wet torrefaction A pretreatment process to convert biomass to energy-dense solid fuel with relatively uniform characteristics. Biomass is reacted with hot compressed water at temperature around 200- 250° C.

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5 Useful Websites

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5.2 U.S. Department of Energy. Energy Efficiency and Renewable Energy. Biomass Program. www.eere.energy.gov/biomass/

5.3 National Renewable Energy Laboratory (NREL). Biomass Research. www.nrel.gov/biomass/

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