challenges

Opinion

Alternative Energies and Fossil Fuels in the Bioeconomy Era: What is Needed in the Next Five Years for Real Change

Palmiro Poltronieri

National Research Council of Italy, AgroFood Department, Institute of Sciences of Food Productions, Lecce 73100, Italy; palmiro.poltronieri@ispa.cnr.it; Tel.: +39-0832-422-609

Received: 14 April 2016; Accepted: 15 April 2016; Published: 18 April 2016

Sustainable biomass feedstock is the key to sustainable biofuels. The impact of bioenergy on social and environmental issues may be positive or negative depending on local conditions and the design and implementation of specific projects. This means that a certain feedstock may be sustainable, or unsustainable, depending on how and where the feedstock is produced.

Plant production must be optimized with respect to energy inputs and the highly efficient conversion of biomass. Conversion processes such as fermentation must be optimized for the optimal conversion of feedstock into useful products, which must then be optimized for different end uses as mixtures for motor fuel, additives, or chemical feedstock. In turn, internal combustion engines need to be re-designed to run on different formulations with unprecedented fuel efficiency. All of these activities must be held together within an over-riding framework of sustainability and economic competitiveness. Of particular interest are the systems-based analyses of sustainability at global and local levels. The present studies address centrally important issues such as the availability of land, access to production inputs such as water and sunlight, and global trade. There is sufficient land available for cultivating bioenergy crops, and the potential of lignocellulose production and conversion can meet a substantial proportion of transport fuels. The present efforts focus on two types of potential bioenergy feedstock: the so-called "first-generation" feedstock, *i.e.*, oils, starch, and sugars, and the "second-generation" feedstock, lignocellulose. It is clear that first-generation feedstock needs to be developed to meet current objectives in Europe. ABAgri, in Leeds, has focused efforts on co-production as an essential component of ethanol production from wheat grains. Starch is fermented to ethanol, fibrous material is processed to ruminant feed, and the protein-rich fraction is used for non-ruminant feed.

Sugar beets, sorghum, corn, and sugarcane are all first-generation sugar or starch bioethanol types of feedstock. Second-generation cellulosic ethanol is primarily produced from lignocellulosic biomass.

Oil-producing plants such as *Jatropha curca*, sunflowers, palms, and tobacco offer similar opportunities: Grown sustainably, seeds and fruits can provide both animal fodder and oil which may be readily made into diesel fuel.

Bioeconomy of Biofuels

The ever-increasing population of both the developing and developed nations of the world, the consequent increase in their diesel consumption, the non-renewability of diesel source (petroleum), and the adverse environmental effects of burning diesel are factors that compel authorities to find alternatives to petroleum diesel.

Global agricultural is expected to slow over the next 10 years, and cereal production is projected to be 15% higher by 2023 compared to the 2013 period, outpaced by growth in livestock and biofuels. Cereals remain still at the core of human nutrition, but there is a shift to diets higher in fats, sugar, and protein. Biofuel production and consumption is expected to grow by more than 50%, led by sugar-based ethanol and biodiesel.

Renewable energy sources include wind power, solar power (thermal, photovoltaic, and concentrated), hydroelectric power, tidal power, geothermal energy, biomass, and the renewable part of waste.

The use of renewable energy has many potential benefits, including a reduction in greenhouse gas emissions, the diversification of energy supplies, and a reduced dependency on fossil fuel markets (in particular, oil and gas). Biodiesel life cycle analysis (LCA) indicates that it affects a 78% reduction in CO_2 (greenhouse gas) emissions relative to petro diesel. The unpredictable price fluctuations of crude oil in the international market have also been a major source of concern in absolute dependence on diesel fuel.

The growth of renewable energy sources may also have the potential to stimulate employment through the creation of jobs in "green" technologies. The primary production of renewable energy within the EU-28 in 2013 was 192 million tonnes of oil equivalent, a 24.3% share of total primary energy production from all sources. Among renewable energies, the most important source in the EU-28 was biomass and renewable waste, accounting for two thirds (64.2 %) of primary renewables production in 2013. The share of renewable energy in gross final energy consumption is identified as a key indicator for measuring progress under the Europe 2020 strategy for smart, sustainable, and inclusive growth.

At the European level, there is an urge to increase the production of alternative biofuels. The current European target is for renewable fuels to comprise 10% of the energy used in transport by 2020. The biggest cause of apprehension, considering the principle of greenness, is that biofuels are made from food crops or from plants grown on land that might otherwise produce such crops, thus hurting food supplies. According to this aspect, a committee of the European Parliament posed a limit to the use of "first-generation" biofuels. The new proposed targets of the EU Commission insist that only seven-tenths of renewable energy will originate from first-generation fuels. The remaining three-tenths will be comprised of second-generation fuels, advanced fuels based on waste products, and other types of feedstock that do not affect food production. This means that, considering Europe's demand, advanced biofuels will reach 14 billion liters by 2020. Only two types of advanced fuels are capable of large-scale production today in Europe. The first one is based on turning waste cooking oil and other fats into diesel. Europe already has 2 billion liters of capacity to process these by-products. The second type of plant is based on producing ethanol from cellulose by enzymatic hydrolysis.

"Production of fully synthetic paraffinic jet fuel from wood and other biomass" (BFSJ 612763) is a project of the EU's 7th Framework Programme (2007–2013) involving Swedish Biofuels.

A full-scale commercial plant was estimated to require 200,000 ton/y of motor fuel, of which jet fuel would comprise only 100,000 ton/y. One business plan is to deploy three commercial units in the 10 years following the project, subject to market acceptance, safety, and financial risks. With a good political and economic environment, up to 600,000 t/y of advanced biofuels can be produced by 2030 using Swedish Biofuels ATJ technology: Production is economic at various production volumes, e.g., the processing of 2,500,000 m^3/y of humid, low-grade wood residues. A wide range of biomass suitable for processing is available. Biological fuel capacity: 30 t/y (3300 US Gallons/y). Jet: 14.4 t/y. Gasoline: 10.5 t/y. Diesel: 5.1 t/y.

A third type of biofuel is under development using municipal solid waste (MSW) as a source of lignocellulose.

Key market drivers for waste as feedstock are of various natures and are enumerated here: increased scarcity of urban landfill space and a societal desire for waste diversion; turning carbon waste into a useful building block for the chemical and petrochemical industry; low-cost, non-land using, unconventional feedstock for biofuels and renewable chemicals; renewable fuel mandates around the world; consumer pull for renewable and bio-based products; and focus on carbon footprints and greenhouse gas emissions reductions.

The potential for transforming garbage (with estimated values positioned around 254 million metric tonnes/year in Europe) into chemicals and fuels is in the range of 375 liters of cellulosic ethanol per metric tonne.

Biokerosene in Aviation Fuels

There are several targets to be accomplished, such as an improvement of 1.5% fuel efficiency per year from 2009 to 2020; a carbon-neutral growth by 2020; and a reduction of net emissions by 50% by 2050 compared to 2005 levels.

Air transport moves over 2.4 billion passengers annually, dumping 677 million tons of carbon dioxide into the atmosphere. While these emissions are small compared to other industry sectors, these industries have viable alternative energy sources. The power generation industry can look to wind, hydro, nuclear, and solar technologies to generate electricity.

The European Biofuels FlightPath Initiative (EBFPI) and the European Biofuels Technology Platform (EBTP)

The EU Commission has launched the EBFPI with the objective of reaching the target of using two metric tonnes of Aviation BioFuels in 2020, corresponding to about 4% of EU fuel consumption. By 2015, the EBFPI will set up financial mechanisms and secure sustainable feedstock production to feed three refineries, construct three new refineries, and launch biofuel production. By 2018, the EBFPI will start regular commercial flights using bio-jet fuel blends, construct four additional refineries, and construct two additional refineries producing algal and microbial oil-based aviation biofuels. By 2020, a full deployment of at least 2 million tons of biofuels per annum for EU aviation is envisaged.

In the US, Boeing has partnered up with other stakeholders to promote "Farm to Fly" biofuel programs that include the Midwest Aviation Sustainable Biofuels Initiative (MASBI) along with United Airlines, UOP (a Honeywell company), the Airlines for America (A4A) Inc., the Chicago Department of Aviation, the Federal Aviation Administration (FAA), and the Clean Energy Trust.

United Airlines (UA) has announced the first stable use in the tract from Los Angeles–San Francisco, by a new jet fuelled with bio-kerosene. The required amount of fuel at this stage is 180 million liters each year.

Among various initiatives, there are plants that produce fuel from flora grown in the desert using saltwater. A range of bio-kerosene show good promise to be both cleaner than standard fuels and with a greater energy density—essentially offering more power for less weight, a crucial property for aviation—soon to be certified for aviation use.

Currently, alternative fuels for transport are marketed by Neste Oil and by ENI. In 2014, Neste Oil produced approximately 1.3 million tonnes (1.6 billion liters) of renewable NEXBTL diesel from waste and residues. There is much potential for aviation since three refineries in function—one in Italy, one in Rotterdam, and one near Helsinki—currently produce around 4 billion liters of bio-kerosene. This amount for aviation corresponds to 2% of fuel use globally.

Boeing Airlines have conducted more than 1500 passenger flights using biofuel since the fuel was approved in 2011. Alternative aviation biofuel reduces carbon emissions by 50%–80% compared to petroleum jet fuel through its life cycle.

South African Airways (SAA) is partnering with Boeing aerospace company and Amsterdam-based SkyNRG to make sustainable aviation biofuel from a new type of tobacco devoid of nicotine—the Solaris variety "energy tobacco"—in a pioneering project that is advancing rural development in Southern Africa. SAA estimated a cost of the tobacco-based product matching that of jet fuel refined from fossil sources. SAA expects to use 20 million liters of jet biofuel, blended 50-50 with conventional fuel, by the end of 2017 and 500 million liters by the end of 2022. SkyNRG's mission is to create structural supply and demand for sustainable and affordable jet fuels. This mission is being executed short-term via co-funded green routes (such as AMS-JFK) and long-term via developing regional supply chains that represent an affordable alternative for fossil fuels, known as BioPorts. The company is working with fuel technology partners to create the best fit for certain regions in the world. SkyNRG is the world market leader for sustainable jet fuel, having supplied more than 20 carriers worldwide. Since 2011, the company has been expanding into the marine and heavy trucking sectors as well. These sectors, like aviation, have no other alternative but to use sustainable fuels to significantly reduce their carbon footprint.

Sunchem Holding holds the exclusive rights to the employment and development on an international scale of the industrial patent "Solaris," a nicotine-free variety of tobacco with a high yield of seeds and tobacco seed oil. Since 2009, Sunchem Holding concentrated its efforts on research on tobacco plants for biofuels. Sunchem Holding made a strategic partnership involving medium-to-large companies operating in the oil/fuel processing and distribution sectors (Seasif Holding, Alphatrading Spa—Italy, Argos oil Ltd—Holland, Diester Group—France, *etc.*, Terasol LLC and M&V Consultacoes Brazil). SkyNRG expanded production of the hybrid Solaris as an energy crop for farmers to grow instead of traditional tobacco. SAA, Boeing, and SkyNRG are developing fuel based on oil from tobacco seeds. The fields are grown by impoverished farmers who gain two cash crops a year from the tobacco and then have money for seeds and fertilizer for a third food crop. The seeds' residue becomes animal feed. From one hectare's cultivation of energy tobacco, it is possible to obtain a seed production average between 4 and 10 tonnes, with multiple harvests per year (based on varying weather conditions). Seed contains around 40% of the oil that, by cold press extraction, produces 33%–34% of the world's raw oil (3 tonnes of oil from 10 tonnes of crop/hectare, with two or more crops/year) and 65% of the world's protein cakes. An initial area of 50 hectares was planted in 2015, which will be doubled in 2016. The cost of the tobacco-based product matches that of jet fuel refined from fossil sources. Solaris-based jet fuel will meet the Roundtable and Sustainable Materials (RSB) minimum CO_2 life cycle reduction threshold of 50%, and, when produced in an optimized supply chain, savings are expected to reach 75% compared to fossil jet fuel. Solaris plants, when produced in an optimized supply chain, will set up to produce 75% savings, compared to fossil jet fuel. The development of Solaris' production in South Africa offers additional socio-economic and environmental benefits as a side effect: increased land productivity (additional biomass production and increased land use efficiency), the development of rural economies and job creation; the education and enablement of regional communities; agricultural innovation and knowledge transfer; a shift from fossil to renewable energy sources (diversification of energy sources); the substitution of less appealing industries (e.g., traditional tobacco industry); and greenhouse gas reductions.

Conclusions

Sustainable biofuel technologies have a key role to play in energy-efficient, decarbonized transport sectors around the world, in providing reduced GHG emissions and energy dependency.

Presently, Europe fuel consumption is about 50 metric tonnes/year but, with their present efforts on using alternative fuels, will produce only 2 metric tonnes/year.

We need to accelerate the deployment of innovative, sustainable biofuels technologies. Using tobacco plants, SKYNRG and Boeing have shown the feasibility of producing alternative jet fuel at a small scale, which, when implemented, may expand to a high production scale such that more energy sources are available, and the growth of a sustainable bioeconomy is exceeded. Renewable energies must be sustained for nations to have available competitive fossil fuel alternatives. If we do not invest billions in biotechnologies and agriculture, no significant result will be achieved.

Conflicts of Interest: The author declares no conflict of interest.