Case 95

Rabbits and Fuel

This article introduces innovations in biofuel that shape The Blue Economy, which is known as ZERI's philosophy in action. This article is of part of a broad effort by the author and the designer of the Blue Economy to stimulate open source entrepreneurship, competitiveness and employment. For more information about the origin of ZERI <www.zeri.org>

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The World Market for Biofuels

The world's biofuels market was valued at $82.7 billion in 2011 and is expected to double to $185.3 billion in 2021. In 2012 the world production of biofuels will reach 118 billion liters growing to 155 billion in 2015 coming from a baseline of 49 billion in 2006. By 2021 the total output is expected to have ballooned to 250 billion liters. This represents a compounded annual growth rate of 15 to 20 percent increasing market share in transport fuels from 3 to 8.5 percent representing approximately 40 percent of the global growth in output for the sector. Estimates indicate that by 2030 up to 30 percent of transport fuel blend will be biofuels. Ethanol is expected to maintain its dominance in the sector. In 2007 twenty oil producing nations supplied fuel to over 200 countries. By 2020 it is expected that 200 nations will have one or the other program to produce biofuels. It could be considered the largest conversion of a global industry in a local platform for business and development.

The first generation of biofuels competed with food like corn, soy, sugarcane, rapeseed and palm oil. The second generation of biofuel raw materials focuses on alternative agricultural and forestal feedstocks. Brazil has the largest diversity of renewable fuel sources: native *babassu* (a palm) and *cupuassu* (a cacao), soy, castor oil, oil palm, cotton, sunflower, coconut, peanuts, rapeseed, algae, cellulose and sugarcane. Several countries have embraced the *Jatropha curcas* which originated in Latin America. The largest initiatives are located in India (+ one million hectares), Mozambique (300,000 HA), Indonesia (200,000 HA), and Brazil (100,000 HA). India has set aside 60 million hectares of non-farm land and intends to replace 20 percent of biofuels with *Jatropha*. In Colombia Las Gaviotas pioneered fuel from the pine tree (turpentine) which has now caught the interest of Bhutan which by constitution has reserved 60 percent of its land as primary forest, predominantly pine trees.

By 2012, blending mandates exist in minimum 38 countries around the world, and 29 regional governments have preceded their national or federal decision makers and imposed a blend with biofuels on their local market. The US, Brazil and EU represent 85 percent of the global production in 2010. The market has no clear leaders and many are jockeying for position: Neste (Finland) in Singapore and Tyson-Conoco in the United States are building the largest facilities with 250 and 200 million gallons annual production capacity respectively indicating a growing trend towards economies of scale. On the other side of the spectrum engineers have designed competitive small scale biodiesel processors capable of producing 2,000 liters of biofuels per day from locally obtained raw materials dramatically reducing the carbon footprint caused by transportation. With 150 small facilities installed over the past two years, the company Extreme Biodiesel (California, USA) assists in the creation of local cooperatives that respond to individuals joining forces and corporate fleet accounts who like to make the shift to renewables.

The Innovation

Biofuels have a high energy yield and reduced: carbon dioxide emissions (-78%), sulfur (-100%), carbon monoxide (-48%), particulates (-47%), and hydrocarbons (-85%). It is well established that corn-based fuels cannot survive on the market without massive subsidies from the US Government. The industry is in search for improved conversion pathways amongst others through the introduction of the biorefinery concept (see Case 6). The ethanol sector is aware that for each liter of fuel, it discards 10 liters of liquid waste. As a result, a concentration of large scale facilities easily stress out the local water supply. The nine Cali-based ethanol factories (Colombia) are searching for alternative uses for their waste water. There are widespread concerns that biofuel cropland is seized or beyond control of local rural communities and that farmers are pressured to grow large areas of monocultures with little concern for energy input, local food supply, water resources and health issues.

Dr. Sean Simpson has a broad academic career in biology and biochemistry. Born in the UK now resident of New Zealand, he started his studies with a Bachelor Degree in Science from the Teesside University (UK), focusing on biotechnology. He went on to obtain a Master Degree from the University of Nottingham (UK) in plant genetic engineering, crowning his academic studies with a PhD in plant biochemistry from the University of York (UK). While he first ventured into a career in drug production working for Hoffmann La Roche in Switzerland and Sandoz in Austria, he subsequently researched cell structures at Tsukuba University in Japan before settling in New Zealand where he engaged with Genesis on how to convert hardwood into ethanol.

He then set out to find a microbe that would be capable of using carbon from gases as an energy source and that would be able to convert this carbon energy into fuels. His research led him to a journal which highlighted certain bacteria found in the digestive track of a special breed of rabbits that could potentially convert waste to fuel. Rabbits

digest in a unique way first chewing 300 cycles and then depositing the residue after a first extraction of nutrients in the cecum which is filled with enzymes and bacteria that break down and reconditions the left-over food, ready for re-ingestion. The incredible and unique mix of micro-organisms in the cecum provided inspiration to embark on the next venture: how to produce fuel using waste.

It was clear to Dr. Simpson that the first as well as the second generation of biofuels compete with directly with food or with farm land to produce food. While the second generation is more diversified and sophisticated in its approach then the mere use of food destined for human consumption as a resource for fuel, it remains a land use that could otherwise have been put to alternative production like hemp or nettle. Dr. Simpson imagined a novel fermentation that captures CO-rich gases and converts the carbon into fuels and chemicals. He thinks in terms of biorefineries and studies the potential of converting waste streams from industries and agriculture that today are contamination in the air, soil and water, endangering climate stability. He offers a completely new vision of how carbon capture could become the basis of a renewable fuel strategy. His original calculations indicate that this technology with a possible output of more than 400 billion liters per year has the potential to make a material impact on the future supply of transport fuels, while generating new feedstocks for the chemical industry.

First Cash Flow

An analysis from the steel industry indicated that the emissions from 1.4 billion tons of steel per year could be converted through this novel compressed fermentation process into 115 billion liters of ethanol. Dr. Simpson went on to co-found LanzaTech in New Zealand thanks to the support of some local angel investors. A pilot plant was established in 2008 at the BlueScope steel mill in New Zealand which converted successfully CO and related gases to the first 55,000 gallons of ethanol. This initial experience motivated the China-based Baosteel to set up a demo-plant increasing production to 380,000 liters of ethanol annually. This plant is operational since the fall of 2011. The available data was convincing enough to scale up the operations from this small unit to a commercial facility capable of converting waste gases from the steel industry to the order of 250 million liters per annum. The angel investors are now replaced by institutional and industrial partners from Malaysia, India, China and the USA. LanzaTech has opened offices in the United States and China.

The Opportunity

Even though Europe is undoubtedly the leader in biofuels, LanzaTech has expanded its cooperation programs with India (Indian Oil, Jindal Steel and Power), Malaysia (Petronas) and Japan (Mitsui & Co). The successful operation of the demonstration plants and the subsequent funding offered LanzaTech the title of “Company of the Year Asia Pacific” and Dr. Simpson was recognized as The Young Biotechnologist of the

Year". The potential developments are not limited to exhausts from steel mills, LanzaTech is ready to expand to the waste streams from petroleum coke production and agriculture waste processing. An assessment of the 1.3 billion tons of biomass wasted in the United States alone could eclipse the use of corn as a biofuel once and for all with an estimated potential output of 720 billion liters per annum and without the need of billions of subsidies as corn-based ethanol now requires.

Dr. Simpson is not limiting his portfolio of opportunities, and it seems as if the team at LanzaTech has only just begun (Concluding words of each of Gunter's Fables). He has demonstrated the capacity use CO_2 in a continuous fermentation process from which to synthesize acetate. Then there are massive solid waste streams from forestry and agricultural residues, municipal waste (See Case 51), and even coal processing waste which could be processed like the steel industry's emissions. The way the process engineers have converted the concepts of Dr. Simpson includes the recovery of process water, while all residues are feedstock for the chemical industry, just like co-products are derived from petroleum in a refinery. A process whereby emissions and solid wastes are converted through biological fermentations inspired by natural processes into fuels and feedstock without subsidies nor competing with food is a concrete example of the Blue Economy. While the investments for a facility are beyond the means of small individual entrepreneurs, it is clear that any country with coal mining, agro-processing and steel production could adopt this technology that soon will have competing bacteria creating a platform of competition amongst the BlueFuels.

Gunter Pauli is the author of the Report to the Club of Rome:
"Blue Economy: 100 Innovations - 10 years - 100 million jobs" published in 35 languages worldwide.

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