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The Rich Potential of Second-Generation Biofuels

Second generation biofuels technologies are well into the demonstration and pilot-plant stage. What can these new biofuels technologies contribute to a low-carbon future without depleting food production or creating sustainability issues? Some important new insight is provided by Anselm Eisentraut, lead author and co-ordinator of the newly published IEA report *Sustainable Production of Second-Generation Biofuels - Potential and Perspectives in Major Economies and Developing Countries*.

Anselm Eisentraut of the
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OPEN Bulletin. *Your study focuses on second-generation biofuels. What are the major differences between these and the first-generation biofuels currently produced?*

Anselm Eisentraut. First-generation biofuels are produced on a commercial scale today and the technologies are well known. Bioethanol is produced from sugar or starch crops like sugarcane, corn and wheat. The sugar components of these feedstocks are fermented to alcohol which is then distilled to bioethanol. First-generation biodiesel is typically produced from palm oil, soybeans, rapeseed or animal fats. The oil is extracted from the feedstocks and turned into biodiesel using transesterfication.

Second-generation biofuels, on the other hand, are still in the RD&D stage. While the technology has been proven in pilot and demonstration-scale projects, with several plants operating both inside the OECD area and in some emerging countries, commercial-scale production is yet some years away. Unlike current biofuels, second-generation biofuels can be produced from all types of biomass like wood, straw or sawdust. Producing them does not, therefore, call for edible agricultural commodities.

Two main conversion pathways are currently under development. One is the bio-chemical route, in which enzymes or micro-organisms convert the cellulose and hemicellulose in the biomass to sugars, which are then fermented to ethanol. The second route is thermo-chemical conversion, where a synthesis gas is produced by pyrolising/gasifying biomass, which can then be transformed to a range of low-carbon biofuels such as BTL-diesel or aviation

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fuel. This route can also produce bio-Synthetic Natural Gas (bio-SNG), which can be used in gas-fuelled vehicles.

OPEN Bulletin. *What lessons have we learned from development of first-generation biofuels technologies?*

Anselm Eisentraut. The sustainability of first-generation biofuels, with the exeption of sugarcane-ethanol, has been increasingly questioned in terms of economic impacts, as well as social and environmental impacts. Many first-generation biofuels have been blamed for competing with food production. While these impacts are complex and more research on them is still required, we understand that, in particular, competition for agricultural commodities and land are critical issues.

In addition to this, most first-generation biofuels have also been criticised for being relatively inefficient in terms of greenhouse gas (GHG) reductions. The GHG reduction potential is limited by the large input of fertilisers and energy needed to produce current biofuels. Moreover, recent studies suggest that cultivation of biofuel feedstocks can cause the release of considerable amounts of GHG if it involves conversion of land with high carbon stock such as tropical peat forests or native grasslands. This land use change can be direct, for example if biofuel feedstocks replace native forest, or indirect if biofuel feedstock cultivation replaces other crops which are then grown on land with high carbon stocks. This so-called indirect land use change (ILUC) can also have a severe impact on biodiversity if valuable ecosystems are destroyed in order to grow the replacement crops.

The above-mentioned problems show that biofuels need to become more efficient in terms of their GHG emissions reduction potential. This is indispensable if we want to achieve significant cuts in global CO_2 emissions and thus prevent a critical rise in global temperature in the long term. Current lifecycle analysis suggests that second-generation biofuels could offer significantly higher GHG emissions reductions than most current biofuels. In particular, the use of by-products and residues from agriculture and forestry operations would be a suitable alternative to conventional grain feedstocks since they do not require cultivation of additional land.

OPEN Bulletin. *Once second-generation biofuels are actually produced on a significant scale, how would this affect the total contribution of biofuels to global energy demand?*

Anselm Eisentraut. IEA scenarios project a significant increase in production of second-generation biofuels in the long term, on condition that global policy action is taken in order to limit atmospheric CO_2 concentration to 450ppm. As we have seen, it is increasingly understood that the long-term potential is limited for most first-generation biofuels except sugarcane biofuels; more sustainable technologies are needed. This is also reflected in IEA scenarios, which show the share of second-generation biofuels increasing rapidly from 2015 onwards.

The 450 Scenario of IEA *World Energy Outlook* (WEO) 2009 projects that second-generation biofuels would provide 166 Mtoe in 2030. This is more than half of total biofuel demand (278 Mtoe) at that time. In the IEA *Energy Technology Perspectives* (ETP) 2008

Blue Map Scenario, which extends projections to 2050, second-generation biofuels account for almost 90% of total biofuel demand (700 Mtoe) by mid-century.

This is significantly more than current levels; in total around 1.5% (8 Mtoe) of total transport fuel was provided by biofuels in 2007 and only a negligible share of this was second-generation biofuels.

OPEN Bulletin. *For a developing country with large availability of suitable land not yet devoted to feedstocks for biofuels production, what would you suggest is the best strategy for successfully integrating biofuels production into the national economy?*

Anselm Eisentraut. The country studies that we undertook in eight major economies and developing countries showed a frequent lack of infrastructure in rural areas. This not only prevents efficient use of additional land, but it also affects distribution of food from producing to consuming regions. Investing in rural infrastructure and sustainable agriculture is therefore a key priority in most emerging and developing economies. Improving rural infrastructure could at the same time be an important step towards expanded land use for biofuels production. If (second-generation) biofuels production is developed as part of an integrated land-use and rural development strategy, foreign capital could be attracted to rural areas and foster investment in roads, electricity supply and other infrastructure, bringing direct benefits to local communities.

Any assessment of additional land should in any case be undertaken carefully, in particular in non-OECD countries where land use patterns differ significantly from those in OECD countries. In order to avoid negative social impacts, the cultivation of 'additional' land for biofuels production requires strict land-use mapping to assess current use of land and its function for rural communities. Brazil for instance has recently developed a zoning tool (Agro-Ecological Zoning for Sugarcane [ZAE]), which is used to identify areas for sustainable expansion of sugarcane production, mainly on underutilised pasture and degraded agricultural land. With such a system, sustainable use of available land can be ensured. The Brazilian model could be used in other countries and, if adapted to national circumstances, permit sustainable use of unused or under-utilised land.

OPEN Bulletin. *What other alternatives do you see for the cultivation of additional land for second-generation biofuel production?*

Anselm Eisentraut. Cultivating additional land to grow energy crops involves uncertainties regarding land availability and can thus raise a number of sustainability-related concerns. The use of residues from forestry and agriculture to produce second-generation biofuels could be one alternative. Residues, which are by-products of forestry and agriculture, are sometimes considered to be waste. The totality of such residues cannot always be used for biofuel production, however, since some are often used already, for instance as cattle fodder or left on the field for nutrient cycling. In developing countries more particularly, these traditional uses can consume a large share of the residues. In several of our country studies, the local experts suggested that only around 10% of forestry and agricultural residues would actually be available if competition with traditional uses were to be avoided.

Globally, however, 10% of the residues produced in agriculture and forestry could be sufficient to meet as much as around 50% of projected biofuel demand in 2030. This is a considerable percentage, considering that no additional land would be required to produce these volumes. A big advantage over dedicated energy crops is that residues are currently already produced and are thus available as potential feedstock, in particular for the initial phase of the second-generation biofuel industry. So long as economically feasible feedstock provision can be ensured, its use for production of second-generation biofuels would bring additional income to the farmer. Another advantage is that the opportunity costs for residues in the countries studied are currently relatively low compared to costs for dedicated energy crops. It is uncertain, though, how prices will develop in the long term if demand significantly increases.

OPEN Bulletin. *What do you see as the most difficult barriers to realising the potential of second-generation biofuels by 2030 in the eight countries discussed in your study? And what are the most pressing priorities in order to overcome those barriers?*

Anselm Eisentraut. The key barriers in the different countries vary according to local geographical and economic situations. One important barrier, in particular in rural areas, is the availability of suitable infrastructure, notably streets and electricity, which would permit economically feasible supply of residues to a second-generation biofuel plant and transportation of the final fuel. Large emerging countries like China, Brazil, India and South Africa have better pre-conditions than Cameroon or Tanzania, for example, but infrastructure still needs to be improved.

The availability of skilled labour is another concern in some countries. Many of the large emerging economies like Brazil, China and India have already established a first-generation biofuel industry and can thus provide skilled labour. Less developed countries would need to invest much more in capacity building in order to provide skilled labour. The large emerging economies are also the countries where pilot plants have already been established and research collaboration with companies from OECD countries is undertaken. This ensures technology access, which will be a problem for other developing countries that are not currently involved in RD&D projects or scientific co-operation.

In order to build capacities slowly but continuously, a first step in adopting second-generation biofuels technology would be to increase use of bioenergy for other purposes like electricity generation, which are less capital intensive and technically less complex. This would provide immediate benefits to rural populations and help to build capacities in feedstock provision and handling. As with many energy technologies, enhanced co-operation on RD&D, both with OECD countries and among developing countries themselves, is a key requirement to ensure second-generation biofuel technology access and transfer. In the long term, this will be essential to build the foundations for domestic second-generation biofuel production.

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