Unclassified **DSTI/STP/BNCT(2015)15**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

English - Or. English

DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INNOVATION
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY

DSTI/STP/BNCT(2015)15
Unclassified

Working Party on Biotechnology, Nanotechnology and Converging Technologies

GLOBAL BIOECONOMY SUMMIT - OECD JOINT WORKSHOP:
RECONCILING FOOD AND INDUSTRIAL NEEDS

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TABLE OF CONTENTS

GLOBAL BIOECONOMY SUMMIT-OECD JOINT WORKSHOP: RECONCILING FOOD AND INDUSTRIAL NEEDS

Introduction

1. Key objectives for a bioeconomy are now embedded in the strategic activities of more than 30 countries, with an increasing number developing a national bioeconomy strategy. In a bioeconomy, fossil-based commodities start to be replaced by bio-based in preparation for the post-fossil resource world which is several decades away. This is meant to address some of the so-called 'grand challenges' being faced by society, but especially energy security (by reducing dependence on imported fossil fuels) and climate change (by reducing greenhouse gas emissions).

2. Major sources of carbon are still required, however. The internal combustion engine is ultimately replaceable, but society will forever need chemicals to maintain the current lifestyle of developed countries, and to bring this more comfortable lifestyle to other countries. The foreseeable sources of carbon are renewable biomass carbon and waste industrial gases. As the latter is the target of climate change mitigation and waste reduction policies, it also will dwindle with time. Therefore, renewable biomass carbon is envisaged to become the source of carbon for chemicals, plastics, textiles and aviation fuels of the future.

3. This immediately creates a dilemma as the food and industrial uses of biomass clearly come into competition. It is true that there are fewer people hungry now than ever before, but food security is still an evanescent dream in many countries. Moreover, this conflicting use of biomass has geographical and geopolitical implications. Many of the OECD countries can be expected to be importers of biomass (some already are) due to a shortage of land and high population densities. Many non-OECD, developing economies, on the other hand, are rich in biomass e.g. Brazil, China, India, Indonesia Malaysia, Russia. It may be tempting for the latter to become merely exporters of natural resources, as has often been the case.

4. Two problems with this latter strategy for developing nations would be:

1. Simply exporting natural resources may inhibit technological development in those countries. There is far greater value-added for a nation to develop the technologies of a bioeconomy e.g. industrial biotechnology, green chemistry and modern agricultural practices;

2. In the absence of strong governance, it is possible for biomass to be over-exploited as a resource, resulting in market and societal failures such as deforestation and soil destruction. Many potential social risks can be imagined e.g. warlordism, displacement of landowners, threats to traditional lifestyles and job losses and job gains within the same society (Obidzinski et al., 2012).

5. For a global bioeconomy to be sustainable in the long-term, it is necessary for all stakeholders to work together to prevent the potential negatives in a bioeconomy while promoting the positives.

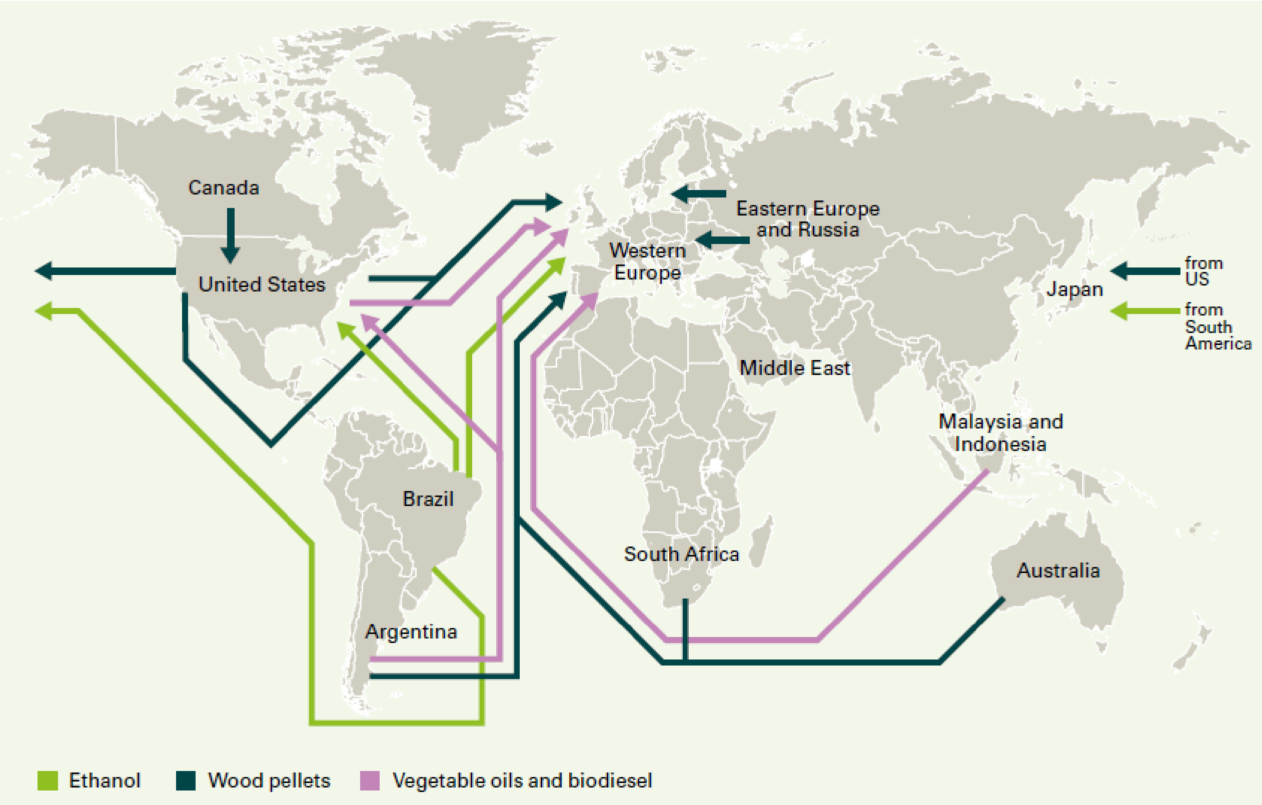
6. The purpose of this brief workshop (see Annex 1) is to bring some of the concerns of some key countries together to air some of the issues. The success of the workshop would not be in major insights into how to resolve these issues. Rather the success would be measured in whether the workshop acts as a launch pad for future dialogue between these and other countries in which the bioeconomy is taking shape as a policy cornerstone for the future.

Biomass flows

7. These concerns are based on a current reality. Figure 1 shows world biomass shipping routes for 2011.

Figure 1. World biomass shipping routes in 2011.

Not only do all the arrow-heads point to OECD nations, but there is a significant convergence on Western Europe.



Source: BP-EBI, 2014

8. This world map quite clearly shows how biomass flows: every single arrow-head points to an OECD nation or region.

9. The bioeconomy can deliver great benefits for society as a whole. Energy resources would be more distributed rather than concentrated in small, politically unstable regions of the world. However, there is a massive quandary at the beating heart of the bioeconomy concept – how to reconcile the food and feed use of biomass with the needs of industrial production. Certainly, agricultural productivity (the value-added per agricultural worker) of many Asian countries is much lower than in developed countries[1]. Farming is characterised by small farms, subsistence farming and high levels of poverty. There are great gains to be made in food supply through both changing agricultural practices and the application of modern biotechnology.

10. A large reliance on forestry for industrial biomass could also lead to environmental degradation as a result of the direct consequences of deforestation. Logging in past has led to negative societal

[1] http://wdi.worldbank.org/table/3.3

outcomes, including violent conflict. Illegal logging is already costing nations tens of billions of dollars each year, and tropical deforestation contributes 12% of total anthropogenic carbon dioxide emissions globally (Lynch et al., 2013). Therefore illegal logging works against two founding policy goals of a bioeconomy – economic growth and climate change mitigation.

11. One of the answers is to use waste materials (so-called ‘bio-wastes’) as feedstocks for bio-based manufacturing. These include agricultural and forestry residues, municipal solid waste and waste industrial gases. But this also poses large technical questions, and the answers are as yet far from clear. How much biomass can be generated this way sustainably? How do we measure the sustainability of waste bio-wastes?

The twin dilemmas of food and energy security are intimately linked

12. The snapshot of issues described above show how easily it will be for the bioeconomy to develop unevenly. The case of India is worth exploring further. Like the majority of countries, India imports crude oil at great expense. During the last decade, India’s import of crude oil more than doubled to 140 million tons from 57.8 million tons at the end of fiscal 2000. India has to import approaching 80% of its crude oil requirements (Ministry of Petroleum and Natural Gas, Government of India, 2009). During the next 25 years, demand for electricity in India is expected to increase five-fold. The biotechnology sector is seen as an important potential contributor to solving India’s growing energy problem and its need for energy security. But by 2021, the population of India is likely to surpass that of China and the two will account then for about 36% of the world population. Therefore India faces the ultimate dilemma of the bioeconomy – can it produce sufficient biomass to contribute to energy security and economic growth through bio-based production whilst still feeding the nation? Many nations with bioeconomy aspirations face the same dilemma.

13. Thailand is highly dependent on crude oil imports, accounting for more than 10% of GDP (Siriwardhana et al., 2009). Korea imports 97% of its energy, which still comes from fossil fuel reserves. Many African countries are in the same position, if not worse, as their economies are developing more slowly than some of those of South East Asia.

14. Sub-Saharan Africa is the epicentre of the global challenge to overcome energy poverty. Since 2000, sub-Saharan Africa has seen rapid economic growth and energy use has risen by 45% (IEA, 2014). Sub-Saharan Africa produced 5.7 million barrels of oil per day in 2013, primarily in Nigeria and Angola. And yet, while 5.2 million barrels per day of crude oil were exported, around 1.0 million barrels per day of oil products were imported. While a large proportion of the population is employed in farming, agriculture remains largely unmodernised, with huge scope for productivity gains.

15. No country illustrates the situation better than Japan, the world’s third largest economy which is just 16% energy self-sufficient.[2] Japan is the world’s largest importer of liquefied natural gas (LNG), the second largest importer of coal and the third largest net importer of oil. Japan relied on oil imports to meet about 42% of its energy needs in 2010 and to feed its vast oil refining capacity (some 4.7 million barrels per day at 30 facilities as of 2011), and relies on LNG imports for virtually all of its natural gas demand. Japan consumed an estimated 4.5 million barrels per day of oil in 2011, whilst it produced only about only 5 000 barrels per day (OECD, 2014). Projections by the Japanese government indicate that if the current trend continues, the population of Japan will decline from about 127 million in 2014 to about 97 million in

2 www.eia.gov/countries/cab.cfm?fips=JA

2050 (National Institute of Population and Social Security Research, 2012), a phenomenon which has been termed Japan's "demographic disaster"[3].

16. Moreover, Japan has a dwindling number of farmers and they are ageing and farming very small plots, which poses problems for agricultural vitality (Karan, 2005). The average age of its farmers was 65.9 years in 2011. In 2012, the agriculture industry employed 2.51 million people, less than 20% of its peak of 14.54 million in 1960 (*The Japan Times*, 2013), and farmers' children do not want to stay in farming. This is by no means unique to Japan – for example, the rural population of China is also declining, the average age of farmers is rising, and fewer young people are choosing farming as a vocation (Yang, 2013).

How much biomass is available: the biomass potential

17. The recurring theme is "uncertainty". When the issue of sustainability is applied to biomass, there are no internationally accepted metrics or tools (Bosch et al., 2015). In such a situation, it is no surprise that biomass potential estimates are extremely variable. There have been many such, but the situation was very well illustrated by Saygin et al. (2014). From 17 separate studies they identified a discrepancy in estimates of biomass potential of 20 fold from highest to lowest (75 to as high as 1500 EJ/yr in 2050).

18. Table 1 contains data which highlight the above issues very well. It demonstrates that, if OECD countries are to be seen to be active in world food security, very soon there will be no farmland available for industrial use.

Table 1. Land potentials (farmland) for non-food use, scenario - business as usual (BAU). (Adapted from Deutsches Biomasse Forschungs Zentrum, 2011). Figures are x 1 000 hectares

	2010	2015	2020	2050	2010	2015	2020	2050
Europe	102 717	115 134	127 096	171 446	44 531	20 315	0	0
N America	65 621	59 090	53 709	33 144	27 759	10 135	0	0
C America	-3, 545	-11 765	18 639	-42 219	1 171	446	0	0
S America	35 786	29 132	24 170	18 066	21 182	9 364	0	0
America	97 865	76 458	59 240	9 992	50 113	19 945	0	0
Oceania	33 157	28 185	23 362	-6 416	14 026	4 834	0	0
Asia	-62 219	-113 430	-153 786	-292 920	18 540	6 734	0	0
Africa	-56 818	-91 310	-121 677	-322 022	6 385	3 717	0	0

19. This table shows the farmland potentials (i.e. farmland for non-food use) in the "business as usual" (BAU) scenario developed by the authors of the report. On the left part of the table is the farmland potential if the countries in these continents (134 countries in total) do not take part in food security for nations in food deficit. On the right side of the table is the remaining non-food land potential when the group of countries participate on a *pro-rata* basis in exports to cover the deficit food supply of the import countries. The following is a quotation from the report from which the Table is derived (bold text is this author's emphasis).

"The data for the "BAU" scenario indicates that ***no more farmland potentials for non-food use will be globally available from the year 2020****. However, there is still grassland for non-food use. Since no more farmland is available for non-food purposes, the big surplus states for agricultural primary products, such as Europe, North America and South America would have to export as of 2020 all agricultural primary products, which are no longer needed for their own food supply, into countries in deficit (mainly Asia and Africa)".*

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3 http://thediplomat.com/2013/02/japans-demographic-disaster/

20. If this is so, and is accepted world-wide, then using waste sources for biorefining is not a luxury, but an absolute necessity. What is more, this is a near-term situation. However, the figures may vary according to the assumptions and this table relates to one resource (farmland). The overall discussion is broader and considers more resources, e.g. forests, residual biomass, the marine environment, waste gases, etc. It is this variability in assumptions that leads to such great variety in studies and also the uncertainty of what the future holds.

What can biotechnology offer?

21. Biotechnology may hold some of the answers, both in food and industrial production. This in itself may create an unbalanced bioeconomy if the countries with greatest strength in biotechnology are also developed countries, mostly OECD countries. What is emerging, however, is that developing economies are also rapidly building capacity in biotechnology.

22. The ambitious bioeconomy strategy of Malaysia, for example, envisages a bio-production industry in the country and Malaysia has had early successes in attracting foreign investment. Malaysia is committing large resources to a bioeconomy with a focus on value-added (OECD, 2015), not simply as a biomass provider. China is quite clearly gearing up for a future bioeconomy with biotechnology as a major technology platform (Sun and Li, 2015).

23. In 2012, the Association of Biotechnology Led Enterprises (ABLE) unveiled plans to grow India’s bioeconomy to more than USD 100 billion by 2025, a level that would place it on par with India’s information technology industry today (Burrill Media, 2014). However, there is apparently a perception in India, of policymakers and the Indian people, that biotechnology is a cause of social injustice and inequality. And yet the aims of a bioeconomy are quite the opposite.

24. The potential of biotechnology is beyond detailed description here. Rather, some areas of biotechnology directly relevant to a bioeconomy and the food/industry use of biomass are referenced.

Cellulosic biorefining and ethanol

25. The primary goal of cellulosic biorefining is to specifically avoid the use of food crops in biorefining. Cellulosic or ligno-cellulosic biomass can be grouped into four main categories:

1. Agricultural residues (e.g. corn stover, wheat straw, rice hulls, sugarcane bagasse);
2. Dedicated energy crops (e.g. switchgrass, *Miscanthus*);
3. Wood residues (including sawmill and paper mill discards), and;
4. Municipal solid waste (MSW) and paper waste.

26. After some delay, the first cellulosic biorefineries are open for the production of second generation ethanol. These are considered by many to be the main model for the future of the biorefining industry. These initial plants are critically important for the industry as cellulosic biorefining has to be seen to be a success, and these are the test-bed facilities.

Metabolic engineering for bio-based manufacturing of chemicals and materials

27. The production of useful chemicals from microorganisms is centuries old. However, metabolic engineering in microorganisms is now being used to make entirely unnatural petrochemical equivalents e.g. Yim et al. (2011). Several countries have been investing heavily in bio-manufacturing using metabolic

engineering as a platform technology, now allied to software and synthetic biology. For example, the US Defense Advanced Research Projects Agency (DARPA) has a Living Foundries programme. The programme involves many companies, national laboratories, and universities working to develop new tools to enable rapid engineering of biology (National Academy of Sciences, 2015). It is tackling “impossible today” industrial projects that could become “possible” if genetic designs and operating systems never before accessible for industrial production are enabled. And its most recent large-scale initiative, the 1 000 Molecules Project, seeks nothing short of a fundamental disruption of traditional chemicals and materials industries and processes by developing 1 000 new chemical building blocks for entirely new materials in the next 3-5 years.

Genomics and food production

28. Many food sources are now under scrutiny using genomics to create crops and livestock with improved performance e.g. higher yields, increased resistance to disease. Such foods include beef, pork, lamb, and many major crops such as wheat and rice. There are other applications to food production less obvious than these e.g. DNA barcoding of wild fish stocks for improved identification and for fraud prevention. It is important to point out that these efforts need not involve genetic modification, but can be used in conjunction with traditional and modern breeding techniques to enhance the efficiency of breeding programmes.

29. For example, the Aviagen[4] genomics project is concerned with identifying naturally occurring markers within the genome of elite chickens and using those markers to help breed stronger and more productive birds through the current selective breeding programme, a completely natural process. Aviagen became the first company to include genomic information as a critical additional source of information in a R&D breeding programme.

30. Several such applications to genomics and other –omics technologies to animal and plant food sources are described in D’Hondt et al. (2015). This particular publication is focused on an Asian bioeconomy, and some key food sources in Asia are identified, along with genomics applications. There is a focus on dual use of two key Asian crops, and a purpose of the paper is to demonstrate that even food crops that are considered top priority can find a role in bio-based production of industrial materials such as fuels and chemicals without interfering with their primary role in food security.

Crops that make their own fertilizer

31. It is feasible within the next decade that there will be engineered crop plants that fix their own nitrogen (Keasling, 2015). Synthetic fertilizers make a direct linkage between agriculture and the fossil industry. The Haber-Bosch process for making fertilizers is very energy-intensive. It consumes 3 to 5% of the world’s natural gas production and releases large quantities of CO_2 to the atmosphere (Licht et al., 2014). When the price of Brent crude oil rose from around USD 50 per barrel to about USD 110 by January 2013, the prices for ammonia in Western Europe and the Mid-Western corn belt in the US roughly tripled over the same period.[5] Therefore here is an opportunity to significantly decouple agriculture from the fossil industry.

Concluding remarks

32. In the fossil era the world is divided geopolitically between the producers (of fossil fuels) and the consumers, especially in the cases of oil and gas. The consequences are clear to see – almost permanent

[4] http://en.aviagen.com/research-development/

[5] http://marketrealist.com/2013/02/brent-oil-moves-nitrogenous-fertilizer-prices/

price volatility, swings between economic growth and decline, including contributions to major global recessions (Hamilton, 2011), a constant search for new reserves that is going into more expensive, ecologically sensitive and dangerous places, and even armed conflict. The distributed nature of biomass could help to prevent such situations in the future.

33. Nevertheless, there are also those countries that are biomass-poor and those that are biomass-rich. In a sustainable bioeconomy, the balance of power among nations would be more even, but this requires very serious consideration of another critical balance – between food and industrial use of biomass. An international trade of biomass in which industry security is achieved in consumer nations (many OECD nations) and food insecurity is a result in exporting nations would defeat the purpose in some ways. Whist the needs of climate change mitigation may be achieved, food security and energy security may be threatened.

34. The policy regime governing this transition is enormously complex. What is quite clear is that international policy will be just as essential as domestic policy. There is much to be gained in a bioeconomy, but ultimately if it does not achieve sustainability, then a great opportunity for inclusive economic growth will have been missed.

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ANNEX 1- BIOECONOMY POLICY ANALYSIS: RECONCILING FOOD AND INDUSTRIAL NEEDS

Workshop GBS2015

Chairs (Co-Chairs): James Philp

Time: 11:30 – 13:00, 26th November 2015

Abstract:
For the bioeconomy to work it needs new supply and value chains that will be more complex and numerous than fossil fuel chains. However, the mantra of the bioeconomy has to be “food first” as there is a natural tension between using biomass for food and industrial usage. Many of the OECD nations are net consumers of biomass, and some of the key developing nations are net suppliers of biomass. However, we know that Malaysia and other emerging countries have ambitious plans to develop a ‘bioeconomy industry’ around higher value-added products.

Key topics:
The workshop will allow us to look at:

- What policies can be put in place to ensure food security first;
- How biotechnology can contribute to a bioeconomy;
- How food/feed and industrial demands on biomass may be reconciled;
- How these policy goals may achieve sustainable value chains and an equitable global bioeconomy.

The workshop will not provide the answers to these central issues, but it should be viewed as a spring-board for future dialogue between biomass-poor and biomass-rich nations.

Provisional agenda:

11:30 – 11:45 Enabling Food Security Policies in Southeast Asia: ASEAN Food Security Initiatives. Margaret Yoovatana

11:45 – 12:00 Biotechnology in India for a Global Bioeconomy. Renu Swarup

12:00 – 12:15 An Inclusive Bioeconomy: Potential Benefits for Africa. Hailemichael Teshome Demissie

12:15 – 12:30 Policy Instruments for Sustainability in Bioeconomy Value Chains. Sergio Ugarte

12:30 – 13:00 Open discussion