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Abstract
The European Union's EU-Africa Energy Partnership, with respect to its emphasis on transport fuels, aims to ensure that Member States can fulfil agreed upon commitments to sustainable energy via the importation of biomass grown in sub-Saharan Africa. This policy aims to reduce the dependence of developing sub-Saharan nations on fossil fuels, while ensuring the global proliferation of alternative transport energy generation as a means to combat climate change. Though the policy seems equitable in theory, and indeed mutually beneficial, several important issues arise. The paper examines the EU-Africa Energy Policy in the context of biofuels in particular, with a view to identifying potential flaws and imbalances and making policy recommendations. Aside from establishing critical uncertainties, the study adduces environmental science, historical comparanda and economic theory to assess the various threats associated with aspects of the policy, especially in light of previous policies that have stifled the development of sub-Saharan economies. In addition, the paper has substantial relevance to developing and newly industrialized nations in Asia and South America also seeking to invest in biomass cultivation and production.

Keywords: Biofuels; EU; Africa

1. Introduction

Biofuels have emerged in a world increasingly concerned by the converging global problems of climate change, rising energy demands, soil degradation, expensive fossil fuels, loss of biodiversity, and water scarcity. The European Union (EU) has been at the forefront of policy development and implementation aiming to reduce reliance on fossil-fuels for transportation, particularly for its Member States. Furthermore, the EU has set ambitious targets for the use of biofuels such as bioethanol, intended as a replacement for petrol (i.e., gasoline) and biodiesel, intended as a replacement for conventional diesel. These two fuels represent the most viable transport biofuels at present (Bomb et al., 2007), though biogas procured from the digestion of organic residues and energy crops has adherents (Börjesson and Mattiasson, 2006). The achievement of ambitious biofuel adoption targets within the EU is problematic, mainly because of the lack of physical space needed within the EU for adequate biomass production, in addition to other aspects of systems capacity. As a consequence, the EU has sought to supplement European biomass production with agricultural feedstocks sourced from sub-Saharan Africa. In this regard, the EU aims to establish biofuel production and usage within the recently signed EU-Africa Energy Partnership, which deals with energy issues at a broader level. An EU commitment to biofuels will provide sub-Saharan African economies with a lucrative cash-crop, help to free the region from a reliance on carbon-intensive energy production, create employment opportunities, and increase rural incomes, as well as increase GDP.

This paper acknowledges the criticality of the developed world contributing to the development of sub-Saharan economies and a more sustainable transport landscape at a global level. Yet it is uncertain, despite these intentions, whether the Energy Partnership as presently formulated will be truly mutually beneficial for sustainable transport fuel production and use in the long term, especially for sub-Saharan African nations currently investing heavily in the biofuel industry, or those intending to do so. Hence, this paper provides i) a brief overview of the development of EU biofuel policy and the broader contextual landscape, and ii) discusses factors that could limit the Energy Partnership's success, especially with regard to renewable transport fuels. In addressing the above issues, the paper identifies and analyses critical uncertainties that have the potential to militate against the success of the transport fuel provisions of the Energy Partnership, with a view to providing an adequate decision-making foresight for the parties concerned. Some broad recommendations are also provided.

2. EU biofuel policy

2.1. Background and Policy Drivers

The EU envisages biofuels as an important player in future energy mixes, especially in vehicular transport. The European Commission (2006a, p. 4) states that "Sustainable, competitive and secure energy is one of the pillars of ... [the EU's] daily life". EU biofuel policy, when viewed retrospectively, has emerged as an offshoot of the EU's highly controversial agricultural policy (Charles et al., 2007). As climate change concerns began to take on mainstream importance, the EU found itself in a position to steer energy policy in a direction that maximizes the interests of existing parties involved in biofuel production, such as the agricultural sector and the biofuel production industry *per se* (both of which benefit from the Common Agricultural Policy), together with those concerned with energy security and environmental sustainability. Therefore, the push for biofuel production is hardly surprising since it allows the EU to attempt to reach common ground on its internal interests and its aspired-to external role.

Any analysis of policy drivers relating to energy in the EU should be informed by an understanding of the EU's energy vulnerability. Indeed, Europe, the world's largest importer of oil and gas, buys 82 percent of its oil and 57 percent of its gas (EC, 2007a). Furthermore, 50% of the EU's total energy requirements are met by nations external to the EU, while, in the next 20 to 30 years, dependency levels are expected to rise to roughly 70% (EC, 2006a). Table 1 below highlights the fuel import dependency of the major EU-27 Member States across the main fuel types.

In part, the EU is determined to address the problem by securing a variety of sustainable energy supplies outside of biofuels, such as nuclear, wind, sea and geothermal energy, hence the development of the European Strategic Energy Technology Plan to develop technologies in energy conservation, low-energy buildings, clean coal and carbon capture (EC, 2006a). EU-financed solar power production in the Sahara desert and in Spain may, for example, augment its energy requirements (Alnaser et al., 2007), but will not wean it off its external petroleum dependency. This will remain problematic as long as the current transport energy paradigm remains. Although overall energy import dependency is high and continues to increase, as indicated in Table 1 below, the situation varies significantly from country to country within the EU. Despite improving rates of energy intensity (presently 1.8-2% p.a.), EU's indigenous energy production is depleting (EC, 2008b). Indeed, while the world's oil resources/reserves are still relatively abundant, they are becoming "concentrated in the hands of a small number of countries" (EC, 2008b, p. 19).

[insert Table 1 about here]

The broader EU energy landscape is further summarized in the following tables. In particular, Table 2 shows that oil remains the most intensively used product in the EU's fuel mix (36.9%), while renewables (including biomass-derived transport fuels such as bioethanol and biodiesel) account for just 6.6% of total energy consumption, despite concerted efforts on the EU's part to increase the use of renewable transport fuels in particular. As seen in the same table, of the five main types of renewable energy, biomass contributes 68% of total energy use.

[insert Table 2 about here]

The share of renewable energy produced by the (then) EU-25 countries has grown by 3.2% per annum from 1990 to 2000 and is projected to increase 1.1 to 1.3% p.a. until 2030 (see Table 3). At the same time, the share of oil produced declined -2.2% p.a. in the period 1990-2000, and is expected to decline between 1.6 and 2.5% up to 2030, with critical implications for the transport sector.

[insert Table 3 about here]

As shown in Table 4 below, transport accounts for nearly one-third of final energy consumption in the EU-27, with road transport consuming the lion's share (82.1%). In addition, only 1.1% of the fuel needs required for transportation purposes are covered by biofuels. This is of particular concern given that transport was the fastest growing EU energy demand sector in the 1990s. Overall, transport demand, however, is projected to grow by 0.5 to 1.0% by 2030, much slower than in the past (see Table 5 below), owing to fuel efficiency improvements following voluntary environmental protection agreements within the automotive industry (EC, 2003). In 2005, EU27 biofuel production, strongly led by Germany with close to half (48.4%) of the total volume, amounted to 4517 ktoe (EC, 2008a). This, however, covers only 1.2% of the transport sector's fuel needs.

[insert Table 4 about here]

[insert Table 5 about here]

Since reliable access to energy is essential to economic development, there is a need to ensure secure access to energy sources into the future. Many of the regions from which EU Member States procure their energy are troubled by insecurity or reliability of supply (European Commision, 2006a); for example, the Middle East, and Russia respectively (Ryan et al., 2006). This could result in extreme price volatility, which is of great concern given that the EU will still depend on imports for up to 90% of its petroleum requirements by 2030 (Steenberghen and Lopez, 2008). Furthermore, there are also concerns about the price volatility of the biofuel feedstocks traditionally sourced from Member States, especially in the face of potential pressure from a buoyant food production industry.

Another significant driver, aside from expected social benefits relating to agricultural and industrial employment (Balat, 2007; Bozbas, 2008; Whitely et al., 2004), is the comparatively low cost of switching to biofuels, especially given their ability to use existing or slightly adapted infrastructure (Mathews, 2007). This has important implications for road transport, or indeed any transport mode employing the internal combustion engine. Thus bioethanol can be blended with petrol in low percentages (Pelkmans et al., 2007), while biodiesel can be regarded as a near-direct substitute for conventional diesel (Mathews, 2007). The use of biofuels therefore entails minimal cost to car manufacturers, fuel suppliers, and vehicle owners (Kondili and Kaldellis, 2007).

Biofuels are also argued to enable EU Member States to meet their Kyoto obligations by reducing emissions (Lovett, 2007), although contrary assertions have been made (Balat, 2007). It is plausible that the use of biofuels vis-à-vis conventional fuels reduces CO_2 at the tail-pipe, yet concerns remain about the amount of energy that goes into producing and distributing the supposedly ‘cleaner’ fuels in the first place (Charles et al., 2007). In addition, an increase in biodiesel consumption could potentially increase N_20 emissions (Balat, 2007), which has 310 times the GHG potential of CO_2, even though emitted in much smaller amounts (Frondel and Peters, 2007).

To conclude, EU biofuel policy is intended to place Member States in a less vulnerable position with respect to transport energy security by means of diversifying supply (Pelkmans et al., 2007), even though stockpiling biofuels is not likely to be feasible on account of their comparatively short shelf-life vis-à-vis conventional petroleum products (Bozbas, 2008).

2.2. Biofuel targets

As a response to the drivers discussed above and as a means to promote the production and use of biofuels, the EU has set targets for biofuel usage within the Member States (Di Lucia and Nilsson, 2007). Policy instruments designed to stimulate biofuel use were introduced in 1992. These aimed at reducing the cost of biofuels vis-à-vis conventional fuels, including the extra cost of production and the economic and industrial risks associated with variables (such as oil and the value of by-products) and new processes, in addition to commercial considerations such as the distribution, promotion and launch of new products (Cadenas and Cabezudo, 1998).

In late 2000, the European Commission's COM(2000) 769 (EC, 2001) set a political target of substituting 20 per cent of conventional fuels with alternative sources by 2020. In addition, COM(2004) 366 articulated that short-term goal is to increase the share of green energy in total demand for primary energy from 6% to 12% by 2010 (EC, 2004). With respect to transport fuel needs, in January 2008, the European Commission put forward a proposal aimed at boosting the share of biofuels to 10% by 2020 amid growing concerns over rising oil prices, energy security and climate change. At least 40% of this would be met by “non-food and feed-competing” second-generation biofuels, or by cars running on green electricity and hydrogen (EurActiv, 2008a). In this case, green energy can be assumed as deriving from non-food crops. Since then, the EU has stepped back from this plan and struck a deal to satisfy 10% of its transport fuel needs from a range of renewables (EurActiv, 2008b).

Biofuels are the only source of renewable energy that, in the short term, could potentially take the place of petroleum in the road transport sector (EC, 2005b). A significant proportion of 20% renewables by 2020 target was intended to comprise biofuels (EC, 2001, p. 45). More recently, the EU’s Directive 2003/30/EEC (European Parliament and Council, 2003) requires Member States to see to it that biofuels account for a minimum proportion of fuel sold on their territory (for details, see Faaij, 2006). This Directive aims to ensure that 5.75% of fossil fuels used for transport are replaced with biofuels by 31 December 2010. It remains unclear, however, whether the established targets can be realized, especially since the Biofuels Directive outlines *indicative* targets, not mandatory ones. Studies carried out by the Biomass Action Plan (BAP) have found that indicative targets will not be achieved (EC, 2005a, with Di Lucia and Nilsson, 2007). In particular, the Member States’ capacity to provide the requisite amount of biomass is doubtful, although Bulgaria and Romania’s relatively recent accession will improve the availability of agricultural lands (EC, 2005a).

The even more far-reaching COM(2006) 845 proposed that the target for biofuel consumption within the EU should be raised to 20% of all transport fuels by 2020 (EC, 2007b). Likewise, the EU has proposed adjusting fuel excise duties to allow favourable tax deductions for the use of biofuels (van Thuijl et al., 2003). This involves national tax exemptions as a means to promote replacements for conventional fuels (Mallon, 2006, p. 76). Table 6 below summarizes the more salient policy developments:

[insert Table 6 about here]

EU biofuel policy has thus evolved from a means to ensure continued prosperity for the powerful agricultural sector to an instrument designed to maintain a minimum level of energy security, e.g., Directive 2003/30/EC posits that increased biofuel use will reduce reliance on external sources of energy (European Parliament and Council, 2003). A collective political will to combat climate change has also ensured that biofuels, especially those produced from more efficient second- and third-generation technologies, have assumed a key role in attempts to reduce greenhouse gas (GHG) emissions (Ryan et al., 2006).

There is a consensus among the Member States that the Biofuels Directive deserves continued supported (Di Lucia and Nilsson, 2007). Still, Denmark has argued that target-setting is inconsistent with the notion of subsidiarity, a cornerstone of the Union, and that more attention should be paid to developing second-generation biofuels, despite the initially high costs involved and the accompanying high financial risk (Londo et al., 2006).

2.3. Energy partnership and promoting demand

The issues discussed above provide a useful backdrop to the EU-Africa Energy Partnership signed in Addis Ababa in September 2008 (Europa Press Release, 2008). From the EU's perspective, the Partnership aims to provide a solution to:

- The EU's overall energy vulnerability and desire to reduce its reliance on imported fossil-fuels for transportation;

- The requirement for diversification of its energy sources;
- Securing biomass for its biofuels production;
- Increasing the use of greener energy within the Member States; and
- Meeting its ambitious short-term targets for biofuel use.

On the other hand, the Partnership is meant to provide sub-Saharan African economies with a lucrative cash-crop, a means to free the emerging sub-Saharan African region from a reliance on carbon-intensive energy production and consumption for their economic growth, and is intended to make these nations sustainable energy suppliers, with improved social conditions as a result. It also seeks to establish a greater and more coordinated dialogue or 'partnership' between the EU and Africa nations on broader energy issues. The focus, here, is on the Partnership's implications for transport fuels, especially biofuel production and use.

Policy-makers in the developed world are concerned that the growing economies of sub-Saharan Africa will intensify the proliferation of greenhouse gases (GHGs), since economic growth and energy use are highly correlated (Berndt, 1990; Jingping et al., 1996). Given that there will be little impetus for these economies to invest in cleaner technologies that could reduce national competitiveness on account of expense, the result will be higher net emissions.

Given the energy vulnerabilities outlined previously, it is not surprising that the EU should look to Africa to satisfy part of its future energy requirements. Africa has long been regarded as un-tapped energy resource for Europe (Misser, 2007; Clingendael Institute for International Relations, 2004). Over a century ago, Winston Churchill, the then UK Under-Secretary to the Colonies, highlighted Africa's vast energy potential (Churchill, 1908). A century later, it is again claimed that "Africa has vast energy resources, including oil, gas, hydro-electric and renewable energy resources which are waiting to be developed" (Africa-Europe Energy Forum, 2007). Africa is a logical export partner given its historical and colonial connections to the EU as a supplier. Indeed, Africa has always been a source of mining, agricultural and human resources for Europe; for example, nine Member States of the EU once had colonies in Africa. Africa is also geographically close. It thus makes logistical and transport sense to source energy from Africa (Dielbert, 2008).

The Partnership is also argued to allow for greater interconnectedness of energy systems, to such an extent that it could "help Europe to diversify its oil and gas supply sources" (EC, 2006, p. 15). At the same time, the EU recognizes that access to secure energy is a "key priority" for developing countries (in addition to Europe), and that "only 7% of Africa's hydropower potential is tapped" (EC, 2006, p. 17). This demonstrates that biofuels are merely one component of a broader Energy Partnership, yet, as is argued here, it is most potentially problematic with regard to transport, one of the biggest consumers of energy.

Energy security is high on the agenda, particularly with respect to transport fuels. The Energy Partnership with sub-Saharan Africa has the potential to ensure an energy source for transport that is arguably sustainable, particularly if later-generation processes are employed. Biofuels also have the potential to i) be available at a price undercutting OPEC and Russian oil, and ii) be sourced from geo-politically and climatically stable regions (especially since much of the petroleum products consumed are sourced from geo-politically and climatically volatile regions). Even if sub-Saharan Africa is not as stable as other regions, the importation of biomass or biofuels from the region has the potential to offset risk associated with petroleum sourced from the consistently volatile Middle East and increasingly unpredictable Russia.

While there has been a dearth of empirical studies and precise quantitative data concerning the penetration of biofuels in the global market, the two major industries where green market penetration has occurred on a large scale has been the automobile and energy sectors (Ludvig, 2007). *Ceteribus paribus*, penetration of biofuels such as bioethanol and biodiesel in transportation could potentially grow from around 1 percent in 2005 to 21 percent in 2030, provided that vehicles increase their fuel efficiency (Morgan Stanley, 2008). Likewise, there is a lack of comprehensive data or modelling on individual African countries to predict future land use changes in those countries (2015 and beyond). It is therefore difficult to predict, with any certainty, the effect that increased demand for biomass from sub-Saharan African countries will have on the sustainability of the countries under consideration.

Nevertheless, it is reasonable to make an analysis based on potential biofuel demand, which is assessed to be 30% of liquid transport fuel consumption in 2006 (Morgan Stanley, 2008). Bioethanol accounted for about 90% of total biofuel production (39 billion liters) globally in 2005 (Commodity India, 2008), while total biomass, also used to provide heat and electricity, contributed around 10% to meet the 470 EJ world primary energy demand in 2007, though this was mainly in the form of traditional non-commercial biomass (Rockefeller Foundation, 2008). Liquid biofuels currently supply around 1-2% of global transport fuels (Rockefeller Foundation, 2008). The same study shows that future potential for biomass could reach 150-400 EJ/yr (up to 25% of world primary energy) by 2050 with the use of forest and urban residues, in addition to growing perennial energy crops.

3. Policy implications

The next section looks at the potential implications of the EU-Africa Energy Partnership with respect to biofuels. To aid intelligibility, this section is broken up into a number of sub-sections dealing with critical uncertainties that could impact on the success of the transport energy aspects of the Partnership, at least as currently formulated. In particular, an interdisciplinary perspective on potential implications is offered. This is important given that the Energy Partnership was formulated at a largely political level, and with seemingly limited attention paid to research suggesting that there are pitfalls associated with *ceteris paribus* formulations in a rapidly changing and increasingly complex world (see, e.g., Pietroski and Rey, 1995; Woodward, 2002). Commitment at a higher political level may not necessarily translate into successful implementation. This is more so given the variations in technical ability and capacity in the various nations.

3.1. Climate change

Global warming, if the dire predictions made by the International Panel on Climate Change (IPCC) (2007) are realized, will result in increasingly extreme weather patterns, which means that rainfall patterns and temperature will be harder to predict. Such changes could make it very difficult for biomass, especially certain types, to be grown and harvested, not only in sub-Saharan Africa but also, throughout the world, including Europe (Tuck et al., 2006).

Climate change also brings with it the possibility of other adverse meteorological phenomena such as floods and severe storms with damaging winds, which could devastate crops being grown for biomass production (Mendelsohn and Dinar, 1999).

Yields and harvesting times could also be subjected to constant change (Polsky and Easterling, 2001), a factor militating against the view that the Energy Partnership will reduce transport fuel price volatility.

Localized climate change as a result of deforestation (i.e., land clearing for arable land) is having irreparable effects on local climates throughout the world, particularly with regard to decreasing levels of rainfall (Pimental et al., 2002; Schneider et al., 2000). A greater frequency of severe fires could also have deleterious effect (Hurt et al., 2002). Indeed, these factors, it is argued, will make it nearly impossible to plan for future land usage (Firbank, 2005). Thus there is the possibility that regions currently enjoying suitable levels of precipitation for first-generation biomass cultivation may not be able to support extensive agricultural efforts in the future, something which could bring any move to rely on the production of biomass to satisfy a substantial portion of the EU's transportation energy demand to nought.

The above emerge as especially important considerations given that, as introduced previously, stockpiling biofuels is unlikely to be an option since they lack the shelf-life of conventional transport fuels such as diesel (Bozbas, 2008).

3.2. Ecological impacts

It is not certain that the cultivation of biomass in sub-Saharan Africa will be carried out in a truly sustainable fashion. Crop cultivation in the Western world has traditionally been characterized by the over-zealous use of pesticides that leach into the soil or else run off into nearby watercourses, where they wreak havoc on existing ecosystems (DeLorenzo, 2001). Pesticides have also been blamed for a reduction in biodiversity since they reduce food supplies for more developed organisms, such as birds and small mammals, which themselves form part of the food-chain for larger creatures (DeLorenzo, 2001; Relyea, 2005).

Likewise, since agribusiness profitability is generally linked to production, indiscriminate use of fertilizer has also caused problems, again as a result of run-off. For example, fertilizer run-off contributes to algal blooms in watercourses, which can deprive the water of oxygen and thereby kill oxygen-dependent organisms living in those environments (Anderson et al., 2002). The use of fertilizers in the farming of biomass is also likely to increase levels of atmospheric N_20 (GAVE, 2005), which is also harmful to the ozone layer (Frondel and Peters, 2007).

In view of the meteorological concerns relating to climate change, unsustainable farming practices could be driven by a desire to maximize the availability of feedstocks, more so given that the increased prevalence of adverse weather events could destroy, or at least severely damage, whole harvests. Thus, when local weather conditions are favourable, crop maximization by any means may result. Without checks from biomass purchasers, there would be very little incentive *not* to carry out biofuel-related agribusiness in an unsustainable fashion (on this important theme, see Mathews, 2008). For example, in 2007, a sudden and unseasonal spell of frost in Lesotho during December destroyed much of the country's maize harvest (Ziervogel and Taylor, 2008).

An additional concern relating to the local and regional environment is that poor land-use practices could adversely affect eco-based industry development (i.e., ecotourism) which could, in some cases, become an important earner of overseas currency for developing sub-Saharan nations (Akama, 1996). Conflict has already occurred in South Africa, where land reform measures, an attempt to address Apartheid-era confiscations of land from the rural poor, had led to concerns about their impact on biodiversity, one of the mainstays of African ecotourism (Kepe et al., 2005; Crane, 2006). The potential for biomass cultivation to impact heavily on biodiversity has been discussed elsewhere (Charles et al., 2007). Still, the EU evidently has a duty of care to ensure that its policies do not substantially impact on sub-Saharan ecosystems, particularly when to do so would run counter to the same body's attempts to ensure the protection of forests, and even promote afforestation, albeit with the EU (Tassone et al., 2004).

3.3. Technological change

Considerable uncertainty remains regarding the long-term suitability of biofuels, especially those produced by first-generation processes, in a future energy mix. Di Lucia and Nilsson (2007), for example, criticize EU biofuel policy on this very basis. These problems, which have been discussed extensively (see Charles et al., 2007), are beyond the scope of this paper.

It is important to recognize that these doubts, in addition to the development of a new energy economy based largely on other energy sources (e.g., liquid hydrogen, hydrogen fuel cells or even the greater use of 'clean' nuclear energy) (Vaillancourt et al., 2008), could eventually bring about the collapse of the global biofuel industry, or at least render it largely redundant. If this occurs, there will be serious repercussions for sub-Saharan nations that have invested heavily in biomass cultivation and, in some cases, production technology. There is clearly a worldwide need for sustainable energy generation, especially with regard to power generation, but it is less clear whether biofuels will continue to be an enticing transport fuel option into the future, especially in light of alternatives such as hydrogen, or even green electricity (Charles et al., 2007).

An analysis of the lifecycle of other primary-goods-driven economies reveals that, once the utility of substitutes is proven, results can be catastrophic. For example, jute (used for making bags) was once a major export earner for Nigeria. The advent of synthetic substitute bags made from by-products of the petro-chemical industry largely made demand for jute redundant. Likewise, sodium nitrate (saltpetre) was used extensively as a fertilizer, and as an ingredient in gunpowder production in the late nineteenth century. The saltpetre trade was so profitable that Chile fought against Peru and Bolivia (1879–1883) to gain control of the richest deposits (Sater, 1986). In Chile, a third of the saltpetre profits were taken by foreigners, another by the state, which obtained rents by taxing exports, and the last third was used to re-invest in mining (De Secada, 1985). The state used its saltpetre income to build major infrastructures such as ports, roads and railroads. In the early twentieth century, European chemists managed to make sodium nitrate synthetically (Glaser-Schmidt, 1995). As a result, Chilean saltpetre rapidly declined in value. This also exemplifies the value of diversification of economies despite the abundance of crops or natural resources. Reliance on one particular export can be high risk owing to the fickle nature market demands.

By way of contrast, some nations whose wealth has rested on the exploitation of oil reserves have determined to free their economy from reliance on a single export product. Given that fossil fuel supplies will eventually run out, wealth generated from oil has been pumped into service-based industries. The rulers of the United Arab Emirates, cognizant of impending technological change or the exhaustion of oil supplies located on their territories (regardless of which comes first), have invested immense resources in education, infrastructure and the development of a service-based economy as a means to ensure continued prosperity (Khalifah, 2009). Norway has done likewise, albeit to a lesser extent, thereby aiming to prevent the onset of the so-called ‘Dutch’ disease, a term used to describe the decline in non-oil exported traded goods and services from oil-exporting nations.

Conversely, biofuels enjoy an implementation advantage that many other renewable energy sources do not. In assessing the potential uptake or otherwise of new technologies, it is important to consider the network externalities that new technologies are likely to face given the observable ‘lock-in’ effect of existing technologies (David, 1985; Katz and Shapiro, 1986). Here, it is notable that biofuels take advantage of existing infrastructural and hardware systems (Foresight Vehicle, 2004). Switching costs are thus markedly reduced, more so since substantial capital has been locked up in associated technologies. Still, these factors are only likely to be relevant if the carbon price is kept at the lower end of the spectrum. However, there is still some level of lock-in because land transport remains inherently car based.

The lesson, here, is that reliance on a single industry for a nation’s prosperity is not without risk, but nor is diversifying easy. At present, over 85% of Nigeria’s export earnings come from oil and gas, and the nation has been unable to diversify its economy despite two and a half decades of attempting to do so, despite regional integration efforts such as the Economic Community of West African States (ECOWAS), Southern African Development Council (SADC) and the East African Community (EAC) that have sought to do precisely this. Sub-Saharan African nations therefore need to ensure that biomass production is not regarded as a ‘silver bullet’ or universal panacea for their currently poor economic performance.

3.4. Economic development and opportunity costs

Investing in primary industries such as biomass production, to the detriment of other industries, will not allow sub-Saharan Africa nations to develop higher-value industries (such as manufacturing and services), which are widely recognized as important elements in a truly developed economy, in addition to adequate transport infrastructure (Njoh, 2000). The dangers associated with the 'Dutch' disease and resource dependency in general have been well documented in economic and state development literature (see, e.g., van Wijnbergen, 1984; Usui, 1997), although the difference with nations such as the Netherlands is that they enjoyed a high degree of economic (and social) development to begin with, whereas sub-Saharan African nations are not in the same position.

Although the Energy Partnership will presumably be accepted by sub-Saharan nations on the basis that it will allow them to wield an OPEC-like power, this reasoning does not necessarily hold true. In essence, sub-Saharan nations may have a comparative advantage with regard to the cultivation of various forms of biomass useful for biofuel production on the basis of a more favourable climate and lower labour costs, but they will still have to compete with Brazil, Venezuela and India, not to mention subsidized feedstock grown, for example, in the United States, and even within the ever-expanding EU. In addition, biofuels look likely to become merely one element in a future transport energy mix (Gosselink, 2002; Coyle, 2007), whereas petroleum-based fuels currently make up the vast majority of transport fuel usage throughout the globe. It is highly unlikely that biomass-producing countries will ever be able to gain enormous wealth on the strength of biomass cultivation alone.

Finally, the issue of technology transfer is an important consideration in economic development. For example, attempts to improve the agricultural productivity of developing nations have been characterized by an increasing dependency on research-intensive multinational agribusiness for source materials such as seeds, technology, support systems and know-how (Byerlee and Fisher, 2002; Kloppenburg, 2004). While agricultural output may have marginally improved, national economic development has increasingly become more dependent on the investment of foreign companies in local industrial sectors (Markusen and Venables, 1999).

3.5. Ongoing commodity dependency and other challenges

Europe, in the form of former colonial powers, has a history of exploiting cash-crops grown in former African colonies. The colonial legacy looms large over African-European relations, though the EU and its institutions are much less stigmatized than the former colonial powers. Despite this, the promotion of demand for biofuels may lead to the aggravation of problems currently faced by developing nations (Charles et al., 2007). In short, if global biofuel demand increases, vast stretches of arable land could be switched from food production to the cultivation of cash-crops sold to developed countries for use in biofuel production (Anderson and Fergusson, 2006). Aside from reducing the pool of available food at a regional or national level, this would lead to an increase in the price of food that does find its way to market (Bwibo et al., 2003); of course, the paradox is that crops are over-produced in many countries. Agrarian-based economies rely heavily on food produced either within the nation itself, or in neighbouring states. A large amount is often imported, which generally leads to an increase in national debt (Bourguignon, 2004). Promoting biofuel demand could thus have undesirable socio-economic repercussions on developing nations.

There are historical grounds for these assumptions. Food shortages, poverty and high levels of indebtedness in sub-Saharan Africa are part of a larger historical phenomenon (Bowman, 1987). In the post-war colonial period, when much of Africa was still controlled by the colonial powers, the economic emphasis still centred on cash-crops exported as raw materials for European industries (Havinden, 1970; Brooks, 1975; Munroe, 1984; Schraeder, 1995). When domestic food supplies ran low, prices for food staples rose, thus causing political disturbance and famine. With independence, the same countries were forced to import foodstuffs, a practice which incurred large amounts of foreign debt. Some contend that this situation was deliberatively cultivated to keep the colonies or newly emancipated states dependent on their former colonial masters for their economic wellbeing (Lofchie, 1975; Wright and Brownfoot, 1987). The concept of tariff escalation can be used to buttress this point. The more value added to an African export to the EU, the higher the tariff. Hence, production and export of value-added goods to the EU is penalized.

This pattern of commodity dependence has changed very little. Africa thus grows and mines what it does not consume and imports what it does, which has led to debt, since the high price paid for food imports rarely matches the low price obtained for export crops. Even with increased production of demand inelastic goods, such as cocoa and cotton, African countries continue to fall deeper into debt, while the demand for high-value foreign imports leads to the greater use of land for the production of cash crops at the expense of food production (Carmody, 1998).

Although the above considerations are debatable, it is clear that the EU needs to pay attention to the possible repercussions of promoting biofuel production in sub-Saharan Africa. If the EU genuinely wishes to alleviate poverty in the region and ensure greater industrialization and the development of service-based industries, the push for ever-increasing amounts of biomass may work against adequate industrial and social development in Africa. The promotion of biofuels is politically convenient at home in the EU, since it plays on the environmental sentiments of the EU citizenry.

3.6. Adverse effects on small-scale farmers

One of the claimed benefits of the Energy Policy for sub-Sahara Africa is that it will benefit the rural poor. If biofuel production were undertaken locally, however, the efficiency and competitiveness of the biofuels industry would be largely dependent on gaining economies of scale. Expansive and expensive processing plants require massive and steady inflows of feedstock to produce sufficient volumes of fuel at competitive prices (ICRISAT, 2007). This would appear to work against small-scale farmers. These farming operations will not be economically competitive, except perhaps for running village engines, pumps and other machinery in remote areas not yet integrated with the rest of the economy. The question remains: how will EU and African policy makers ensure that the poor connected to market economies can contribute and prosper within a large-scale, industrial biofuels paradigm? The achievability of this is highly problematic given the historical and contemporary treatment of poor, small-scale farmers throughout much of Africa.

Unclear, too, is how more isolated villages and farmers traditionally dependent on self-sufficiency rather than connection to the broader economy can achieve greater energy self-sufficiency through biofuels. Such farmers have little direct access to consumers, so they tend to sell their farm output to village brokers or commission agents or neighbours at (generally) low prices. For example, apart from a few large farms owned by wealthy elites in Nigeria, farm sizes are becoming smaller as land is taken through the land use decree of 1979 for urban development, roads and industry.

At the same time, the oil, gas and mobile phone tower industry is growing rapidly owing to a favourable regulatory climate that captures scale economies (Ortiz et al., 2006). Thus, small-scale production, when contrasted against large-scale processing, is the direction that the future seems to hold for biofuels in sub-Saharan Africa. This creates a potentially asymmetric power relationship that could expose small-scale farmers to price squeezes by a limited number of large processing facilities that would control the buying of feedstock. If the connection of African farmers to markets is controlled by a few mega-industry decision-makers in competition with those farmers for the profits, the farmers are likely to lose out over time, just as they do with middlemen at the village level today.

To protect small-scale farmers from losing out to price squeezes by middlemen or large-scale processors, farmers may need to form cooperatives. However, cooperatives are inefficient if poorly managed and are also subject to political interference. The final collapse of state marketing boards in Nigeria in the 1990s is evidence of this. Finding a mutually beneficial balance between the market power of i) biofuel consumers in the EU and ii) African farmers and cooperatives requires thoughtful planning and execution by all stakeholders, including researchers, farmers, governments, and the private sector.

3.7. Summary of critical uncertainties

What follows is a summary, in tabular form, of the various critical uncertainties discussed above, together with the potential impacts if these uncertainties do indeed manifest themselves.

[insert Table 7 about here]

4. Discussion and recommendations

The purpose of this paper is to provide some analysis of possible problems associated with a biomass-cultivation-dependent sub-Saharan Africa. In particular, it is argued that parties signatory to an EU-Africa Energy Partnership need to be cognizant of the potential economic and ecological hazards associated with promoting biofuel dependency. There are lessons to be learned from the current unequal power dynamic that currently exists between Europe and Africa.

There are several important issues. First, biofuel is likely to increase in economic value with its increasing use as a transport fuel, particularly if policy instruments are continually employed to encourage its use (Charles et al., 2007). However, supply of the raw material reinforces the dependency of these nations on the lowest-value part of the supply chain. Indeed, the future value of biomass as a fuel, in light of its multiple uses depending on the type of feedstock, in addition to the emergence and promotion of new technologies, is relatively unpredictable (Ådahl et al., 2006). An economic strategy based on its future value is therefore subject to relatively high risk. Furthermore, biomass is likely to remain only one component of a more complex mix of future sources of energy.

Second, later-generation biofuel production processes must be advocated collectively by sub-Saharan African leaders if the industry is to increase its share of the renewable energy market. Second-generation biofuel technology is already available. Considerable amounts of research and development funding is being invested across the globe in the next generation of technology. The long-term sustainability of a biofuels industry in sub-Saharan Africa is therefore likely to require some level of knowledge and technology transfer. It is also likely to involve a degree of private investment in high-value activities associated with the production of biofuels. Thus the political will on both sides to promote cleaner biofuel production process over more carbon-intensive first-generation processes must be engendered. Without this, the entire future of the biofuels industry may be comprised in the face of emerging—and more efficient—energy technologies.

Third, it is clear that the EU has an important role with respect to ensuring that the Energy Partnership does not repeat the historical exploitation of Africa as a source of raw materials. Accrued rents should also include a component of assisting the development of sub-Saharan energy security and value-adding processing capabilities, thereby ensuring a viable local and regional market, in addition to a European one. Future rents might also be used to assist in the development of trade beyond agriculture-dependent industries.

From these overall considerations, some broader recommendations, or at least potential reference points for policy formulation, can be established:

For sub-Saharan nations:

- Biofuels cannot be exclusively relied upon for economic prosperity; rather, they will, at best, become part of a diverse energy mix.
- The ability to process biomass into renewable fuels is paramount since negligible value-add will be gained by merely cultivating biomass, while processing close to place of biomass origin will enhance logistical and energy efficiency.
- Later-generation biofuel production processes must be advocated collectively by African leaders if the biofuel industy is to increase its share of the renewable energy market.

- Biofuel production must be allied to policy measures designed to create national and regional markets for biofuels, albeit in a manner designed to ensure a competive industry capable of attracting private investment.

For the EU:

- The market mechanism must be used to ensure that sound (if not leading-practice) agricultural methods are employed (on this, see Mathews, 2008), i.e., biomass/biofuel should not be purchased without ascertaining the cultivation methods.
- Sub-Saharan nations must be encouraged, as a matter of priority, to develop their own energy security and processing infrastructure.
- Later-generation biofuel technology must be made available at fair prices to ensure that the Partnership is truly equitable, or else mechanisms should be put in place to ensure the purchase of class-leading equipment.
- The political will to promote cleaner later-generation biofuel production over carbon-intesive first-generation processes must be generated—if not, the entire biofuels market may be compromised in the face of other technologies.
- A conscious effort and investment by the EU's development agencies working together with the private sector and research institutions in Africa must be undertaken to solve the scale challenge since growing crops cost-efficiently on small-scale farms is highly problematic.

The material presented here does not necessarily pertain to sub-Saharan nations. Indeed, other nations in the developing world have demonstrated or expressed interest in forming part of a global biofuel economy. Many of the advantages shared by sub-

Saharan nations with respect to biomass cultivation are also thus applicable to nations on the Indian sub-continent and in South-East Asia, not to mention Latin America—a region with considerable leadership with respect to biomass cultivation *and* biofuel production. However, the transport fuels element of the Energy Partnership between the EU and Africa (and sub-Saharan nations in particular) is an important case study in a broader global emissions reduction agenda.

5. Conclusion

In sum, the long-term success of the transport fuel aspects of the Energy Partnership, and particularly its implications for the rapidly developing sub-Saharan biofuel industry, depends on the extent to which later-generation biofuel processes that involve minimal environmental impact are embraced by the market. The EU must here play a leading role in ensuring that this is the case. The policy instruments to carry out this increased use and promotion of later-generation biofuels, however, should be discussed in another forum. It seems clear that, without this development, the biofuel industry could potentially be overtaken by 'cleaner' energy sources, to the detriment of the organizations and nations that have invested heavily in biomass cultivation and production, including those in sub-Saharan Africa. Given the vast economic and political challenges already faced in the region, this should be of utmost importance to any trade block genuinely interested in improving economic and social conditions in sub-Saharan Africa. The EU therefore has an important responsibility to ensure that the sub-Saharan African biofuel industry is sustainable with respect to future technological development.

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Table 1. Fuel import dependency EU-27 in 2005 by fuel type (in %)

	All fuels	Solid fuels	Oil	Gas
EU-27 total	52.4	39.6	82.3	57.6
For example:				
Belgium	79.6	101.1	100.8	100.6
Denmark	-51.6	94.3	-104.8	-113.9
France	51.6	94.7	99.6	99.3
Germany	61.6	32.4	97.1	81.3
Italy	84.4	99.3	91.8	84.7
Netherlands	37.8	101.5	97.1	-59.3
Spain	81.2	69.7	101.2	101.4
Sweden	37.2	93.8	103.9	100.0
United Kingdom	13.8	71.9	-2.6	7.0
Other European Economic Area (EEA) and in EFTA				
Norway	-609.1	-52.8	-854.3	-1378.3

Source: EC, 2008a

Table 2. Gross inland consumption EU-27 in 2005 by fuel type

	All fuels	Solid fuels	Oil	Natural gas	Nuclear	Renewables	Other
In ktoe	1816.1	320.0	669.8	445.4	257.4	120.8*	2.8
Share	100%	17.6%	36.9%	24.5%	14.2%	6.6%	02%
						** Of which:*	
Biomass						68.0%	
Hydro						21.9%	
Wind						5.0%	
Solar						0.7%	
Geothermal						4.5%	

Source: EC, 2008a

Table 3. Primary production EU-25 by energy source from 1990 to 2030

In Mtoe	1990	2000	2010	2020	2030	*Annual % change* *90-00*	*00-10*	*10-20*	*20-30*
Solids	350.9	203.1	152.3	124.1	101.6	*-5.3*	*-2.8*	*-2.0*	*-2.0*
Oil	120.4	164.1	131.5	102.0	86.4	*3.1*	*-2.2*	*-2.5*	*-1.6*
Natural gas	139.6	196.7	196.9	147.6	117.1	*3.5*	*0.0*	*-2.8*	*-2.3*
Nuclear	197.1	237.8	245.4	213.7	185.2	*1.9*	*0.3*	*-1.4*	*-1.4*
Renewable energy sources*	70.5	97.2	132.9	151.5	169.6	*3.3*	*3.2*	*1.3*	*1.1*
Total	878.5	898.9	859.0	738.9	660.0	*0.2*	*-0.5*	*-1.5*	*-1.1*
**Of which:*									
- Hydro	23.4	29.0	29.6	31.1	31.7	*2.2*	*0.2*	*0.5*	*0.2*
- Biomass	32.1	43.1	58.7	66.1	75.1	*3.0*	*3.1*	*1.2*	*1.3*
- Waste	12.6	19.5	25.3	27.5	27.1	*4.4*	*2.6*	*0.8*	*-0.1*
- Wind	0.1	1.9	13.9	19.9	26.1	*40.0*	*21.9*	*3.6*	*2.8*
- Solar and others	0.1	0.4	1.6	2.9	5.3	*10.6*	*15.6*	*6.0*	*6.2*
- Geothermal	2.2	3.3	3.8	4.0	4.2	*4.2*	*1.2*	*0.5*	*0.7*

Source: EC, 2008a

Table 4. Final energy consumption EU-27 in 2005 by sector

	All sectors	Industry	Transport	Households
In Mtoe	1170.2	327.7	361.6*	481.0
Share	100%	28.0%	30.9%	41.1%
			* *Of which*	
Motor spirit			38.6%	
Gas, diesel, oil (incl. biodiesel)			61.4%#	
			# *Of which*	
Biodiesel			1.1%	
			* *Of which*	
Road			82.1%	
Rail			2.6%	
Air			13.8%	
Inland navigation			1.5%	

Source: EC, 2008a

Table 5. Final energy demand EU-25 by sector from 1990 to 2030

In Mtoe	1990	2000	2010	2020	2030	*Annual % change* *90-00*	*00-10*	*10-20*	*20-30*
Industry	328.4	310.2	338.1	364.8	385.5	*-0.6*	*0.9*	*0.8*	*0.6*
Residential	267.4	279.1	308.6	328.9	338.6	*0.4*	*1.0*	*0.6*	*0.3*
Tertiary	144.8	154.3	173.7	193.9	217.8	*0.6*	*1.2*	*1.1*	*1.2*
Transport	273.6	333.1	388.6	428.5	449.8	*2.0*	*1.6*	*1.0*	*0.5*
Total	1014.2	1076.6	1209.1	1316.1	1391.8	*0.6*	*1.2*	*0.9*	*0.6*

Source: EC, 2008a

Table 6. Chronology of EU biofuel policy developments

Year	*Total energy needs targets*	*Transport energy needs targets*	*Source*
2000	20% of conventional fuels substituted by alternative sources (biofuels a significant source) by 2020	N/A	COM(2000) 769 (EC, 2001)
2002	22% of electricity consumed in EU by 2010 should have been produced from renewable energy sources	5.75% of fossil fuels used for transport to be replaced with biofuels by 31 December 2010 Replace 20% of fossil fuel use in road transport by 2020	COM(2002) 321 (EC, 2002) Directive 2003/30/EC (European Parliament and Council, 2003)
2004	Increase the share of green energy in total demand for primary energy from 6% to 12% by 2010	N/A	COM(2004) 366 (EC, 2004)
2006	N/A	Proposal to raise target for EU biofuel consumption to 20% of all transport fuels by 2020	COM(2006) 845 (EC, 2007b)
2008 Jan	N/A	Proposal to boost share of biofuels in transport fuel to 10% by 2020	EurActiv, 2008a
2008 Dec	N/A	10% of EU transport fuel needs to be sourced from a range of renewable sources, including biofuels, but also hydrogen and green electricity	EurActiv, 2008b

Table 7. Summary of critical uncertainties and potential impacts

Critical uncertainty	*Potential impacts and outcomes*
1. Climate change	• Increasingly variable rainfall impacts on biomass cultivation • Severe storms or floods could damage and/or destroy crops • Deforestation for farming could alter local climate
2. Ecological impacts	• Excessive use of pesticides and herbicides leads ecological degradation • Fertilizers harmful to ozone layer • Adverse impact of higher-value ecotourism through impact on biodiversity
3. Technological change	• Biofuels (at best) will only be a part of future energy mix • 'Cleaner' transport energy might overtake biofuels completely • Misdirection of resources to potentially redundant technology
4. Economic development and opportunity costs	• Failure to develop higher-value industries (manufacturing and services) • Competition with other biomass producing nations reduces profits • Sub-Saharan biofuels industry overly reliant on foreign investment and fail to invest in value-adding
5. Ongoing commodity dependency	• Arable land increasingly devoted to biomass cultivation • Continued need to import foodstuff and desire for foreign goods increase national debt • Tariff escalation hinders value-adding activities
6. Adverse affects on small-scale farmers	• Economies of scale limit involvement of traditional farmers • Regulatory environment captures scale economies and forces out small farmers • Connection to markets controlled by middlemen and large corporations