ZEF Bonn
Zentrum für Entwicklungsforschung
Center for Development Research
Universität Bonn

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Number
122

Bioenergy and Rural Development in Developing Countries: A Review of Existing Studies

ZEF – Discussion Papers on Development Policy
Bonn, June 2008

Nicolas Gerber: Bioenergy and Rural Development in Developing Countries: a review of existing studies, ZEF – Discussion Papers On Development Policy No. 122, Center for Development Research, Bonn, June 2008, pp. 58.

ISSN:

Published by:
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List of Abbreviations

DC	developing country
ESMAP	energy sector management assistance program
ERR	economic rate of return
IC	industrialized country
IPP	independent power producer
MCA	multi-criteria analysis
PPA	power purchase agreement
PSD	private sector development
RE	rural electrification
RET	renewable energy technology
SRF	short rotation forestry
SVO	straight vegetable oil

Acknowledgements

I would like to thank Professor Hiemenz for his support, and all my colleagues at ZEF who reviewed various versions of the paper and helped me amass a very substantial amount of relevant and current literature in a field that continues to evolve on a daily basis. The usual disclaimer applies.

Abstract

Four broad types of studies on rural development and bioenergy technologies are identified. Within these four types, this discussion paper presents a number of existing studies which are most relevant in the context of developing a research focus on the role, feasibility and issues associated with bioenergy, and in particular biofuels, as engine for rural development in developing countries. The results and recommendations of the referenced studies, reflecting the global trends of the current literature, highlight the importance of bioenergy technologies in the development process of poor rural communities. The surge of biofuels and in particular of their feedstocks on the international agricultural markets has recently commended a lot of attention. However, whilst biofuels hold a huge economic potential as internationally traded commodities, the various issues and challenges facing biofuel production systems could indicate that in the context of developing economies, they are better suited for the domestic energy markets. In any case, the analysis necessary to formulate policy recommendations on how, where and when to implement which bioenergy technology calls for a differentiated – per region and/or technology – and integrated – within and alongside other rural production systems – approach. In this context, this review of existing studies exposes some unanswered questions and research gaps.

Kurzfassung

In der ökonomischen Literatur finden sich vier Kategorien von Studien zu ländlicher Entwicklung und Bioenergie-Technologien. In diesem Diskussionsbeitrag werden einige Studien aus diesen vier Kategorien vorgestellt, die für die Entwicklung von Forschungsvorhaben über Rolle, Einsatzmöglichkeiten und Bedeutung von Bioenergie, und im Besonderen von Biokraftstoffen, als Motor für die ländliche Entwicklung in Entwicklungsländern besonders relevant sind. Die Ergebnisse und Empfehlungen der vorgestellten Studien, die als repräsentativ für die aktuelle Literatur angesehen werden können, heben die Bedeutung von Bioenergie-Technologien im Entwicklungsprozess armer ländlicher Gemeinden hervor. Das Aufkommen von Biokraftstoffen und besonders der damit verbundene zunehmende Bedarf an Rohstoffen auf dem internationalen Agrarmarkt haben in der letzten Zeit viel Aufmerksamkeit erzeugt. Allerdings – während Biokraftstoffe als international gehandelte Güter ein enormes ökonomisches Potential bieten – weisen die zahlreichen Herausforderungen, denen sich die Produktion von Bioenergie in Entwicklungsländern sieht darauf hin, dass diese dort eher für den heimischen Energiemarkt geeignet wäre. Eine notwendige Analyse, aus der schließlich Handlungsempfehlungen abgeleitet werden können – für das Wie, Wo und Wann des Einsatzes von Bioenergie-Technologien – erfordert in jedem Fall eine differenzierte Herangehensweise. Jede Region und jede Technologie sollte für sich und im Zusammenhang mit anderen ländlichen Produktionssystemen untersucht werden. In diesem Sinne zeigt die vorliegende Übersicht bereits existierender Studien einige unbeantwortete Fragen und Forschungslücken auf.

1 Introduction

The goals of the literature review are first, to identify the different types of studies to date with specific focus on biofuels/bioenergy and rural development in DCs; second, to group the selected studies according to their type; and third, to compile the lessons learnt from the different (types of) studies. The review will hopefully serve researches in identifying specific gaps in this literature which might generate opportunities for future development research.

It is important to note that this review does not intend to be fully exhaustive, as the task is almost impossible due to the constantly increasing amount of information in this field (some of which is difficult to judge in terms of quality). The articles and projects reviewed here are those which I think are most important and representative of the different trends in the field, as well as those most likely to serve as a base for the development of a bioenergy project in a development institute such as ZEF. They include as many articles as possible from refereed journals and reports from known important sources (such as WB, OECD, UNDP, and BMZ/GTZ/BMBF), whilst a few projects and opinion peaces are also presented.

Four broad types of studies have been identified:

1. *(Bio)energy and rural development in DCs: projects and global policy presentations and reviews*

Such studies describe projects in particular, or generally rural electrification (RE) projects, their successes and failures, the lessons learnt.

2. *Specific types of bioenergy technologies: potential (energy output, economic viability, climate control, rural development), impacts (same, as well as food versus fuel considerations) and promotion*

These studies remain mostly policy pieces, descriptive in nature, with conceptual analysis based on descriptive information, and global in their approach of specific bioenergy sources level.

3. *Specific bioenergy (final product) and bioenergy sources and technologies: modeling/measuring of socio-economic and environmental impacts, sustainability analysis*

The studies present specific methodologies to examine the local, regional or global socio-economic impacts of bioenergy production.

4. *Specific bioenergy sources: "how to" technical articles and projects*

This group of studies shows the current state of "technological' research for various bioenergy sources, especially biofuels, through recent presentations of mostly not-yet-published projects.

In the context of rural development, why focusing on "modern" biomass energy (or bioenergy)?[1] Modern bioenergy - together with other new RETs such as solar, wind, ocean power and hydropower - is in line with the concept of sustainable development promoted in the work of our institute. There are also further factors to motivate this focus. Some of these factors are no doubt part of the reasons why the role of the agricultural sector has recently regained a lot of interest within the development debate:

- Biomass is a very versatile source of energy, which can be used/transformed as/into solid, liquid, and gaseous products, whose applications range from heating and cooking, to transportation fuels, as well as electricity production. It can thus answer a wide range of needs facing rural communities.
- Produced at farm level, biomass is an ideal candidate for decentralized energy production. Decentralization is a critical characteristic of rural energy systems.
- Biomass material is well known by all the potential stakeholders of a rural energy system in any DC, even at village level, and thus bioenergy in many ways can be well fitted within/alongside traditional biomass uses. It is also available in large amounts in tropical and many subtropical regions.
- Bioenergy can be used as an input into rural activities (productive and non-productive), whilst certain types of biomass produced at farm level can also be marketed alongside other agricultural products and farms outputs. In this sense, it is interesting to look into the impacts of bioenergy production and diffusion on rural development, as well as into the impacts of rural development on the diffusion, use and production of biomass energy.
- Solar and wind power in the rural context have largely failed to spur "own-growth" through rural industry development, because they are too complex, require specific technical know-how, industry-friendly structures, etc. (Martinot et al. 2002). Thus they often end-up depending on donor or public support. The idea here is to look at integrated energy and agricultural production systems, which might spur extra production activities thanks to newly available energy, but with the development push coming from community-produced and financed energy.
- Optimized biomass use for energy production is within the core competencies of our institute, with links to agricultural economics and sciences, water and land use and management. "Modern" bioenergy adoption and use are also linked to social and societal factors, another strong focus within ZEF. Thus the gaps identified at the end of this review should serve ZEF in the future as potential focus points for research projects and collaborations.

[1] Modern bioenergy is defined in Goldemberg and Coelho (2004) as bioenergy relying on sustainably used biomass (as opposed to traditional biomass use depleting forest resources for instance).

- And finally, with regard to the specific problem of rural electrification, modern bioenergy is less represented in donors' and other cooperation projects than other new RETs. But rural electrification programs to date seem to miss the targeted poorest segments of the community (World Bank IEG, 2008); developing bioenergy may help correcting this bias by including these particular segments within the production process (as opposed to rural communities as users of "imported" RETs such as PV panels or wind turbines). Indeed, the World Bank mentioned in its report on renewable energies (WB, 2006) that biomass energy projects should be integrated more in the Bank's RETs portfolio. This was seen as an important factor for the Bank's RET projects to achieve more in terms of its three objectives of poverty reduction, environmental sustainability and promotion of PSD.

2 Energy & rural development in DCs

The importance of energy supply in the development process is well known (e.g. UNDP 2004). In particular, rural electrification (RE) has long been coined as a necessary ingredient for economic growth and improved life quality in the rural communities of the developing countries (DCs). This view is backed up by earlier evidence of the success of RE in industrialized countries (ICs). Yet, it was always clear that the RE process in DCs would encounter problems of different scope and scale than that of ICs (Munasinghe 1988). Most of the problems identified early on have in many cases remained hurdles to date. One can broadly mention: the scarcity of capital, high costs, low quality and reliability of supply, the failure of RE to generate productivity gains and the distributional effects of RE missing the target with the poorest segment of rural populations (Munasinghe 1988, Barnes et al. 1996 and World Bank – IEG 2008).

Several of the issues mentioned above are connected. Traditional RE through grid connection presents particularly high costs in isolated rural communities. In such cases off-grid connections may be least cost options. However, their cost remains higher than the average cost of grid-connection projects in other communities and hence their implementation is justified by criteria that include social variables rather than by straight least cost approaches. The communities falling in this category, which are usually among the poorest, typically have very little capital available for energy production. This is strongly connected to the lack of productive uses for electricity within the community. This further impedes on the financial viability and cost recovery potential of grid and off-grid RE (World Bank – IEG 2008). For similar reasons, off-grid connections programs supported by the World Bank are reported to miss the poorest segments in similar ways than grid connection programs. This may be due to the fact that off-grid programs usually follow a business model, i.e. financial viability then supersedes social concerns. Still a reflection of the cost recovery and financing dilemma posed by the poorest, in both grid and off-grid connection, most programs are targeting extensive growth in RE – i.e. extending coverage to un-serviced communities –, rather than intensive growth – connecting/servicing new consumers in already electrified villages (World Bank – IEG 2008).

In some (areas of) DCs, notably South America and South East Asia, grid-connection for RE has reached its limits and the most cost effective solutions left are off-grid renewable energy technologies (RETs). The problem is different in many parts of Africa. The needs still very much point towards large investments for the generation, transmission and distribution of electricity (World Bank – IEG 2008). Such investments will take time, especially for the resulting solutions to reach rural communities. Hence, there is scope for developing and implementing *cost effective* off-grid solutions in many cases to fill this gap.[2] The global lesson is that such RET solutions should be tied to productive uses as much as possible in order to be financially viable and achieve a high developmental impact. So far the analysis of the economic benefits of RE on home businesses in particular, and more generally on other rural businesses, is lacking. The same is true for the "global" benefits of RE through RETs, especially in terms of the comparability of the various studies.

Off-grid electrification of rural areas has so far relied on donor programs for the most part. The World Bank has mostly adopted a private business model in this field, sticking closely to the financial viability criteria. This has distributional impacts but avoids energy market distortions. Other governmental and donor programs have not always been so rigorous. Many donor projects have proved to be unsustainable without external financing, thus limiting the prospects of long term developmental impact (Martinot et al. 2002 and Barnes 1996). Yet small-scale decentralized energy options, mostly relying on RETs, remain an important element to alleviate rural poverty (UNDP 2004). The World Energy Assessment (UNDP 2004) identifies the avenues and conditions for sustainable energy policies to promote development, with the access of the rural poor pin-pointed as one of the major challenges.

Martinot et al. (2002) reviewed a large number of renewable energy markets in different DCs. RETs can be classified according to their end-use applications. Bioenergy has to date played a role in most categories, albeit marginal in some cases. Following and adding to Martinot et al. (2002), the categories and bioenergy applications can be described as follows:

1. *Rural services to households and communities, such as lighting, radio, TV and telephony.*

In this class of applications, bioenergy is not a main player. Biogas digesters used to produce electricity and heat, household or community operated, are mentioned with mixed results, mainly in China, India and Nepal. Main problems are maintenance and adequate operation. In China, a network of rural biogas service centers has managed to improve on such problems. In Nepal, the subsidy structure, going to the end-user rather than the providers, has shown better rates of sustained operation.

2. *Rural productive uses, power services to small/home businesses or to farm production.*

There are only a few examples of mini-grids powered by hybrid bioenergy - mini-hydro - PV systems sustaining small rural industries, for instance for drying or refrigerating food products, operating power tools for woodwork, etc.

3. *Grid-connected power supply, either linked to the national grid or to a local "mini"-grid.*

Biomass energy plays an important role in this sector. Many grids are fed partly with power from combustion plants, bio-digesters or gasifiers. Biomass comes from agricultural and forest residues as well as dedicated plantations. Examples include Brazil and the Philippines, where bagasse is used to generate power which is sold into the grid.

[2] Cost-effectiveness frontier analysis for various off-grid technologies (e.g. PV), in terms of distance to nearest grid, are mentioned in the WB-IEG 2008 report. Such studies have yet to be conducted with respect to bioenergy.

4. *Residential or commercial cooking and hot water.*

Energy to cook and heat water in rural areas is provided mostly through biomass combustion. This is potentially the most important use for bioenergy, at least by the number of people concerned. The main issues are the health impacts of the combustion process and the sustainability of the biomass supply used for cooking. Biogas is also an important source of energy for cooking. Successful in some areas, not so successful in others as mentioned above. Efficiency of cooking (combustion) stoves has been the target of many donor programs, as a mean to limit the emissions of unhealthy smoke and to promote more sustainable biomass use. Such programs have largely been successful, though in many cases depend fully on donor finances. Some countries have managed to spur local stove manufactures which operate without subsidies (e.g. China and Kenya).

5. *Transport fuels.*

Liquid biofuels for transport are used in many DCs, mostly in the form of blends with traditional fossil fuels. Brazil is a main player in this market, both in terms of production and consumption. In DCs, ethanol is the main biofuel whilst biodiesel plays almost no role (few specific exceptions). There are many issues associated with liquid biofuels (hereafter biofuels). Except for the Brazilian flexi-fuel cars, ethanol can only be used with traditional engines up to about 10% blends. Biodiesel also needs to be blended to avoid damage. On the production side, issues include production efficiency (in the growth of the feedstocks and in the processing), cost competition from gasoline, competition with food production, and appropriation of edible oils for the production of biodiesel for and in IC. Globally, biofuels trade issues for DCs are the tariff regimes imposed on their exports and the lack of unified international biofuel standards. Biodiesel plays a very little role on DC markets as compared to ethanol. Nonetheless, many projects are currently underway to increase vegetable oil production in many DCs with a view to market it for biodiesel production. Brazil has tremendously increased its soy production in this perspective. Malaysia and Indonesia have increased their palm oil production. Other countries are trying to bypass edible oils and focus on the large scale production of non-edible oil trees such as Jatropha and Pongamia. These are still in experimental phases, with issues still very centered on the seed selection process for maximal yields and most efficient oil extraction techniques. Straight vegetable oils (SVO) and biodiesel both have a potentially important role to play in DCs not only as transport fuels, but also as heat and electricity power sources. Such uses, with particular focus on agricultural productive uses, are considered as potentially more important than biofuels for transport (GTZ 2005a). At this stage though, very few examples of such uses exist. They include projects implemented in Mali (since December 1994, Projet Pourghère, Direction Nationale de l'Hydraulique et de l'Energie, République du Mali, and GTZ). The Solarserver : Forum for Solar Energy reports projects in Indonesia, Tanzania and Ghana where hybrid solar and Jatropha-SVO generators produce electricity sold to the grid, used by entire villages (360+ households) to activate water pumps. Other applications use the hybrid combination for community uses, with solar providing continuous power and the generators supplying the added load at peak time.

Martinot et al. (2002) offer a number of lessons learnt from existing RET markets in DCs. They are presented below, slightly adapted to our focus on bioenergy technologies.

1. *Impact on rural development:*

Both Martinot et al. (2002) and the World Bank – IEG (2008) report on the lack of "scientific" evidence that RETs have a clear impact on rural development on a large scale. RE programs have achieved more substantial changes in terms of life improvement, though such access also failed to spur large scale economic development if RE program were not clearly supported by adequate economic and technical framework conditions (more impact achieved when some economic activity is already present, in order to transform energy into productive uses). Bioenergy is not any different in that respect.

2. *Affordability and consumer financing schemes:*

Affordability analysis of RET applications, including biodigesters and efficient cooking stoves, often overestimate the willingness to pay of the rural communities. Thus they offer RET applications which are too large and too expensive. In the case of a biodigester, a smaller system might fail to fulfill the household energy needs or function efficiently, affecting the satisfaction of the user and future prospects of the technology in the area.

Microcredit organizations can help solving the affordability problem. However, the traditional format of microcredits is generally not well suited to finance RETs, including biodigesters, efficient cooking stoves, gasifiers, or SVO-operated generators. The main issues are the size of the credit required, the often missing link between the RETs and a clear income generating activity, the short length of the microcredit, or the impossibility of group-lending.

RETs such as solar home systems or wind turbines are now more often proposed under rental contracts. Such contracts are however, to my knowledge, not documented as yet for bioenergy applications, for instance small-scale gasifiers or SVO generators. Rental contracts, like microcredits, also need to reflect the low financing capacity of rural households and aim for a long term cost recovery. Credit risk then plays a role in this model too, and thus the poorest households remain likely to benefit from RETs only through targeted policies (donor programs or government subsidies).

3. *Subsidies and market distortions:*

All RETs need to compete with already established energy technologies. These are often directly or indirectly subsidized, especially in the case of rural communities. Without government support, RETs are thus unlikely to be competitive and to play a role in rural development. This applies to all RETs and in particular to the biomass-dependent ones (which have received comparatively less donor/government support than other RETs). Martinot et al. (2002) mention the example of the biogas-powered water pumps in India trying to compete with subsidized rural electricity, subsidized diesel fuel, and free electricity for water pumps (all governmental programs). A market for biogas pumps has thus no chance of developing without help.

Not all subsidies have distorting effects, and Martinot et al. (2002) strongly advocate for the use of “smart” subsidies. These are usually time-limited and self-eliminating, as they phase out as the market develops and the technology becomes competitive. They should also be based on the operational performance of the technology, i.e. the delivered energy product, rather than on capital investment. The latter is sometimes misplaced or misused, resulting in little energy final product. When complying with these two criteria, subsidies can be efficient in setting up the initial market. The Nepal biogas program is an example of successful and non-distorting subsidy program. The World Bank and the GEF seem to have adopted and applied these criteria in choosing the projects they supported recently (WB-IEG 2006, Reiche et al. 2000).

As energy markets are often distorted (sometimes destroyed) by donor and government programs, bioenergy is more likely to play a role in the remote communities where no energy markets exist, or where the support structures in place are non-distorting. Thus an *ex-ante* analysis of the (absence of) energy market is strongly advised before developing any bioenergy program.

4. *Development of rural industries who offer off-grid energy solutions:*

The difficulties associated with setting up a rural business offering RETs to the community are similar across all technologies, including biomass technologies. They include: the challenges of marketing the product, both financially and in terms of communication with potential buyers; the lack of financing opportunities and contacts with commercial banks; unrealistic expectations of potential customers that grid extension will reach them soon (i.e. reliance in government energy provision); and the lack of selling networks, outlets and personnel.

The main type of rural business to-date linked to biomass energy has been the manufacture of improved cooking stoves. The sector experienced difficulties, though to a lesser extent as they represent a smaller investment and are more easily transported and demonstrated. Biodigesters and gasifiers have typically been supplied through donor and government programs. Some of these programs entailed setting up and supporting a sales network, a service network, an information program (including demonstration), e.g. biodigesters in China. Gasifiers suffer from the same problems.

Generally speaking, (liquid) biofuels themselves do not suffer much from a lack of network, as they are an output of the rural community which is responding to a strong outside demand. Technologies using biofuels though, such as the SVO generators, are expected to face the same lack of sales network as other technologies.

5. *Private power and biofuel production and sales:*

With biomass energy, the current relevant trends in private power production include:

i. self-generation by end users,
ii. small-scale competitive generation and
iii. competitive wholesale markets (e.g. with dedicated biomass plantations, such as eucalypts in N-E Brazil, or dedicated biofuels crop farming).

All three trends are relevant when it comes to biofuel production. With respect to electrification, the first one is taking place in an off-grid setting (though there are exceptions), the last one in a grid setting, whilst small-scale competitive generation can either be linked to grid or off-grid sales.

In the case of electric power, Brazil, India and Tanzania, like over 20 other DCs, have a regulatory framework allowing independent power producers (IPPs) to sell their power to utilities under power purchase agreements (PPAs). Some countries have more advanced instruments such as “wheeling”, “banking” and direct sales to end users. This allows for a more flexible power sector. Nonetheless, in many cases there are restrictions in terms of minimum capacity, "quality" and flow, impeding on the efforts of the smaller producers to sell their power (e.g. power has to be continuous, minimum flows, etc.). It is unclear where and which regulations apply to the production of biomass for power generation (sustainability standards, moisture content, etc.).

In the case of biofuels, there generally is a striking absence of regulation, except in Brazil. The main regulation to be expected concerns the quality of the fuel. Brazil has set standards. Most DCs have not or are in the process of developing them. Setting standards is not an easy task, especially when considering export biofuels, as international standards are not unified. Similarly to biomass power generation, sustainability standards and other production regulation are currently either unclear or non-existent.

In the case of biogas, I am unaware of any regulation in a rural context as production almost entirely is the making of the end user (only a few examples of communal biogas production and use exist in Nepal).

A number of policies can help promoting grid renewable energy and non-fossil fuels. To date only a few are implemented in DCs. For electricity production, such policies include non-fossil-fuel obligations, electricity feed laws and renewable energy portfolio standards. Martinot et al. (2002) report that none of these exist in DCs. However, rural electrification targets, in the case of remote communities, can also act in favor of renewable off-grid solutions, and notably biomass power production. It is the case with Luz Para Todos in Brazil, with utilities slowly turning towards RETs for those communities where grid connection is overly costly. Brazil has also adopted a regulation which allows utilities to purchase power from renewable sources at a higher price and to spread the cost difference among all consumers. However, such a solution might not work in the context of other poorer DCs with a more uniform (in its payment capacity) customer base (e.g. Tanzania).

Other financing incentives to promote bioenergy production (as well as other RETs) include production and investment subsidies. However the latter can have a distorting effect on the actual amount of energy supplied. To secure more private financing of "bioelectricity" and biofuels small-scale and wholesale production, the policy-makers biggest challenge is to demonstrate and guarantee that such operations are economically viable, so that power and biofuel developers can repay the loans. The extra-cost-spreading policy in Brazil (above) works in that direction. Generally speaking, the policy makers should implement a framework that secures the producers access to the market and fair tariffs (e.g. secure sales contracts with utilities for bioelectricity, some protection against fossils' unfair price competition for biofuels). Protection against domestic devaluation can also be offered for attracting foreign financing options.

In the case of end-users production, examples of regulations allowing the producer to resell excess production (either bioelectricity or biofuel) can act as an incentive. The decision to produce is then not only based on the avoided cost of the alternative, but also on the potential for extra income should the production exceed the needs. This might be an important aspect in the case of risk averse rural producers.

6. *Market facilitation organizations:*

As Martinot et al. (2002) mention, MFOs are either public or private (or both) organizations supporting the growth of a particular market in different ways. Industry associations, government agencies or NGOs are traditional (part of) MFOs. The services offered by MFOs can cover facilitating project developments, training, information exchange, partner matching, assessments, consulting (management and technical), technical and maintenance staff, etc. In the field of bioenergy examples include the biogas doctors trained and biogas service centers implemented in China (though purely a government initiative). The All India Women's Conference is credited for biogas and cook stoves programs in India. MFOs typically rely on public money at the start, but often become partly self-sufficient after a while thanks to the private contracting of their services.

MFOs seem to be absent from the biofuel scene (especially bio-ethanol) and little information sharing takes place, though this might reflect the "developmental" stage of a number of biofuel production technologies. Partnerships between donor and cooperation agencies (such as GTZ), research institutes and local government agencies in the field of biodiesel production might be considered as MFOs, though these partnerships have not yet led to results that have been shared with the wider community (again, a reflection of the early development stage?). Advances in the field have not yet led to market creation (GTZ, 2005a and 2005b).

As Reiche et al. (2000) put it, regarding rural off-grid electrification the problems and challenges are well known. What lacks so far is a number of actually implemented programs so that lessons learnt can be shared. The World Bank report (WB - IEG 2008) abounds in this direction, mentioning the need of successful business models to be referenced and shared on a large scale to spur the industry. Whilst technology is still in a development phase for biodiesel non-food crop production and the debate on food crop biofuels mostly focuses on environmental sustainability and food competition (the crops are well developed ones), successful business models exist already, notably in Brazil. Yet the transferability of the few existing business models to other countries or similar RETs has not been proven or studied. The World Bank (WB – IEG 2006) explicitly recognizes the need to give due importance to biomass energy projects in its support to RE programs and its portfolio of new renewable energy projects.

Painuly (2001) provides a comprehensive account of all barriers to RET market penetration, as well as a framework for identifying the barriers and their potential solutions. Though not focused on DCs or bioenergy, several barriers and solutions are pertinent in the context of bioenergy for rural development in DCs. On top of the usual barriers facing new technologies competing with established old technologies, the following can be mentioned:

- All market failures, distortions, financial and institutional barriers which can be expected in the context of DCs, e.g. missing market infrastructures (increases cost of production and distribution), lack of consumer credit markets (reduces market size and thus profitability), high discount rates (i.e. high opportunity cost of project), high payback periods (decreases viability of project), lack of information and information propagation (for both producers and consumers), and many others. More specific bioenergy technology barriers include:

- Lack of standards and quality certification; this poses risks to the purchaser and can result in negative perception of the technology. This has happened in some cases for biodigesters, and is a factor affecting the commercialization of biofuels for transportation.
- Lack of consumer and social acceptance of the product/technology, which means the market might never take off. This has been the case for solar cookers, biogas in some countries (reluctance to cook with fuel coming from waste, reluctance to work with/collect waste). This may be due to preference for traditional ways, or ethical considerations in working with certain products (e.g. waste-biogas in a cast society). Generally speaking, bioenergy other than biogas should not encounter such problems, as it would use traditional sources of fuel, but simply in a different application. Though there are problems of acceptance with some Jatropha by-products, due to the poisonous content of the seedcake in particular.
- Environmental impacts might be unacceptable/costly to other sectors of the economy because of competition for resources, e.g. land and water use for biofuels and food production.
- High risk perception of a new bioenergy technology, which increases the cost of financing the project/technology, and might be due to either the unproven technology or the uncertain returns/benefits, the irreversibility of the investment (e.g. investing in a gasifier can hardly be transferred to another use). Note that circumventing this barrier was the key to the success of ethanol production in Brazil, with the possibility to switch between sugar and ethanol production freely and at no cost to the producer. Similar dual productions for other (non-food) bioenergy sources remain to be researched.

Solutions have included guaranteed markets, production and investment subsidies, government investments for the financial barriers, information campaigns and service centers for the dissemination of information and skills and removing acceptance barriers, setting up specialized government agencies to diminish the institutional and regulatory barriers. Standards and certification schemes are still lacking for most bioenergy technologies and sources, which probably affect negatively both DC consumers and producers (though the impact of certification is subject to debate and research in its own right).

As already mentioned above, GTZ is a major actor in the field of energy for rural development, mostly engaging or partnering in technical projects. As such, the projects are usually not driven by the rural development aspect, but rather by the technical aspect. Of particular interest in our context are the projects presented in the biofuels for transportation reports for Brazil, India and Tanzania (GTZ 2005a, 2005b, 2005c).[3] GTZ was also involved in a number of biogas projects, as well as biomass stoves, in both cases focusing on the technical aspects of how to build efficient systems. This is of course reflecting the fact that GTZ is engaged in cutting edge new technology development in DCs, notably for biofuels, in which cases little is known about the possibilities of these technologies in terms of operation, output and sustainability.

The World Bank has a major rural electrification programs which is reviewed at regular intervals. The last review (World Bank –IEG 2008), as well as a specific review of its assistance to renewable energy (World Bank IEG 2006), emphasize the need to draw the lessons on RETs for rural electrification programs to date in order to systemize the most efficient approaches and eliminate the inefficient ones (for instance on measuring the benefits of RE, the WB ESMAP study in the Philippines, 2003). In the course of the last decade, with the focus and assessment mostly on the financial viability of rural electrification, the World Bank itself understands these programs missed most of the poorest communities. The shift towards off-grid programs based on RETs has only partly filled this gap, as these programs mostly follow private business models and thus do not account for political and social considerations. RET programs are thought to have had significant impacts on rural development, but such impacts have rarely been measured as monitoring and evaluation are mostly absent in such programs. The main foci of RET World Bank programs have been to promote RET commercialization through public-private partnerships, setting up risk mitigation frameworks, including reducing market barriers for RE, and delivering successful business models.

On a smaller scale, the WIsions initiative of the Wuppertal Institute for Climate, Environment and Energy has conducted, partnered or consulted in a number of projects on the theme of sustainable energy and poverty reduction in DCs. They offer overviews and lessons learnt, in terms of financial and other issues, and consider the replicability of their projects (WIsions 2007). The technologies involve solar power and efficient stove systems.

[3] A fourth report focusing on China also exists.

3 Bioenergy in DCs - global situation and issues, current policies

Most of the recent literature dealing with bioenergy is implicitly or specifically targeting (liquid) biofuels. The biofuels boom is such that other bioenergy types seem to have almost disappeared from research and development agendas. Biofuels program in DCs being still in experimental stages, with the notable exception of Brazil, the literature offers general level policy analysis or model predictions of the biofuel growth impacts on agricultural markets. The issues impeding on - and the policies promoting - the dissemination of renewable energy sources, and bioenergy in particular, figure prominently. The “promises” offered by newly developed (or redeveloped) biomass-based technologies and the potential “challenges” they pose in terms of environmental, economic and social sustainability are also presented.

Most sources are concluding largely in favor of the global potential of biofuels, both as alternative energy source and rural development vector. Nonetheless they also draw attention to the potentially negative impacts biofuel expansion may have at the environmental and developmental levels. The issues debated are usually the same, but the analysis and the conclusion depend a lot on the scale and geographical focus of the studies. Here are the main issues systematically debated which could all be included under a general umbrella of biofuel sustainability (Bringezu et al. 2007), be it at an international, national or regional level (all levels being interconnected):

- Biofuel potential for energy supply
- Biofuel potential for rural development (in DCs or ICs)
- Impact on global climate
- Food versus fuel
- Trade

Many papers look at the biofuels nexus at the global scale. In these papers, ICs such as the EU block and the USA are the main focus, as they are both major producers and the largest consumers worldwide. The perspective of the DCs is then largely one of potential exporters for the IC markets. This is true for the following papers: Bringezu et al. (2007), Doornsbosch and Steenblick (2007), Dufey (2006), Fritsche et al. (2005), Hazell and Pachauri (editors, 2006), Peskett et al. (2007) and von Braun and Pachauri (2006).

Fritsche et al. (2005) rightly point out that developing a global biofuel “policy” does not make sense as the DC producers are very heterogeneous. Thus biofuel markets, existing or prospective, call for a differentiated analysis. Even within a given country, the domestic biomass potential is a state-by-state or regional problem. Land use conflicts must be accounted for and thus differentiating between energy crops is also necessary, as they all have different uses and by-products.

The authors list three types of bioenergy/biofuel production: the industrialized commercial agriculture geared towards export markets, much in the same way as other cash crops; traditional/family agriculture for local markets, often organized in cooperatives or village associations; and organic/certified agriculture for export markets, noting that traditional agriculture often satisfies the certification requirements.

In terms of "global" developmental potential, Fritsche et al. (2005) suggest that cash crop systems, i.e. industrialized agriculture, are the favored option. This seems true for biofuel crops such as sugar cane, oil plants etc., as well as for other biomass types such as agricultural waste, woodchips, etc. (though non-crop fuels still suffer from high transportation costs and their development is likely to stagnate until BtL technology is more wide spread, decreasing the transport costs of agricultural and forestry residues). Other options also depending on the development and dissemination of BtL include miscanthus and short rotation forestry (SRF) plantations.

However, on a societal basis, in which we could include targeted **rural** development, the local use of domestic bioenergy is usually more attractive than the export option (the exception may be Brazil, where developmental impacts may largely off-set social negatives). This would promote traditional/small farming bioenergy production, with the added benefits that the decentralized production of biofuels facilitates the use of the by-products. According to Fritsche et al. (2005), this is especially true for oil plants, whereas with ethanol production (almost entirely sugar cane in DCs) the favored path is conversion in hybrid plants (sugar and ethanol, electricity co-generation through bagasse) requiring more centralized production.

Possible global areas of conflicts and major issues foreseen by the authors with respect to biofuel production in DCs include:

- conflicts arising in the case of industrialized production in similar fashions to other traditional cash crops, especially in the face of lacking transport and processing infrastructure (i.e. raw exports, with value-adding activities taking place abroad);
- environmental sustainability balance of biofuel cropping as compared to other/current land uses in DCs (this has not been assessed as yet, due to the lack of data in DCs);
- land requirements conflicting with other uses, worsened as the land used for agriculture is expected to grow especially in Africa and Latin America in the near future due to population growth and change of diet – this is particularly foreseen to happen in the case of large scale energy crop farming and weak landownership systems, leading to the displacement of small farmers (already such claims in Brazil w.r.t. large soy farms);

Fritsche et al. (2005) give a list of environmental, social and economic guardrails for avoiding many of the more specific conflicts which might arise with the growth of biofuel production ins. They include, as examples:

- preserve genetic and structural diversity
- prevent erosion and bad water management (over-use and pollution), maintain the nutrient flows
- conserve ecosystems and ensure the respect of 10% conservation land/corridors
- give priority to food production
- integrate landless farmers in the energy crop production and processing systems
- stimulate local job creation and ensure local share of resource rent, local involvement in decision-making
- ensure the supply and access to energy for the locals
- balance export rents and local loss of purchasing power, use of export rents for global development
- cautious approach to the cost of infrastructures for growing, processing and trading energy crops.

Fritsche et al. (2005) suggest that the main missing information in the debate on biofuels and generally biomass energy in DCs is concrete measurements, indicators and assessments by stakeholders to conduct the analysis of biofuel impacts in a way that is systematic, differentiated - i.e. at national and regional level - and integrated – i.e. interactions between agricultural, forestry and bioenergy systems, according to export or domestic use, on environmental, social and economic sectors. Two notably positive aspects of biomass-for-energy production, as integral part of a larger system, and which still need to be evaluated are: firstly their potential to optimize total yields and secondly the possibility to make use of a large number of (some yet to be used) species and to apply new sustainable rotation schemes.

Bringezu et al. (2007) take a European approach to a global biomass strategy, including energy production as well as other uses. They mention the important “side-effects” an increase in non-food biomass use in the EU (e.g. biofuels) would have on other regions of the world, where biomaterial cropping is most economical and where governance is often not strong enough to absorb the pressure to expand arable lands and other environmental negative externalities. The cases of Brazil and Indonesia/Malaysia are discussed. The main focus is on the clearing of tropical forests and drainage of wetlands in both cases, due to the growing land demands of sugar cane, soybean and oil palm production in Brazil and oil palms in Indonesia and Malaysia. Both in Indonesia and Brazil, the clearing of peat and rainforest for biofuel crops is strongly restricted, to no effect (illegal clearing by palm growers in Indonesia, the displacing of current small farmers and cattle growers in Brazil, who then turn to forest clearing). In the two cases, clearing and drainage have very strong impacts on global CO2 emissions and call for international compensation schemes to maintain these CO2 sinks intact. Meanwhile the increase in production is in both cases predominantly geared for ethanol and biodiesel export production. The authors question the economic rationale of exporting biofuels for a country which is a net importer of crude oil: why exporting competitive biofuels when importing oil will require even higher expenditures? Instead the biofuel producers should satisfy local demand first, before exporting. This will become even more critical as many DCs are expected to experience huge increases in local demands for, in particular, transport fuels.

Bringezu et al. (2007) also advocate for a regional integrated assessment of biofuels (in fact for all biomass uses) that considers global implications. They call for specific measures to prevent deforestation and preserve ecosystems, so that within these limits crop choices and cultivation can then be oriented towards sustainability criteria. Quality standards are expected to play a role, though they would inevitably fail if not part of a larger, integrated policy mix. For instance, importing countries also need to set up resource management plans considering the balance between domestic biomass production and imports.

The authors suggest a number of research questions. I mention here, and adapt, the few that are of most relevance in our context of bioenergy for rural development in DCs (staying away from the international trade aspect):

1. Which biomass potential can be supplied by sustainable cultivation for food and non-food purposes in the various regions, based on existing arable land and already managed forests?
2. What aspects should a sustainable cultivation of energy crops include besides ecological criteria?
3. What is the regional balance between non-food and food production, and how can competing land-use be mitigated?
4. How can labels and certification be developed, implemented and monitored?
5. Identify the stakeholders in the non-food production and how they can be motivated into a sustainable pact.
6. Determine and define the balance between local consumption and trade (not necessarily international) of the bioenergy products, using sustainability criteria.
7. What are the economic thresholds beyond which biofuel production is likely to accelerate the expansion of arable land, or the appropriation of land currently dedicated to food production?

Doornbosch and Steenblick (2007) adopt predominantly an OECD and international trade prism in their analysis of biofuel markets. They provide a precise account of the world technical and economic potential for biofuels, concluding that under current technologies the potential for biofuels to contribute largely to the demand for transport fuels without creating major environmental and food price problems is limited. Similarly, second generation technologies (using all types of biomass) are viewed as holding little global promises, due to the logistical and transport costs of moving large amounts of (lowly energetic) biomass, which will likely impose a floor below which production costs cannot be lowered. Even counting with second generation technologies, which still require major breakthroughs to be commercially implemented, biofuels are unlikely to achieve more than 15% of the market share for transport fuels, according to IEA previsions, based on the hypothesis biofuel prices would fall below fossil competitors, delivering little relief to the global CO_2 emissions (which will actually be compensated by the increase in DCs energy use as off 2050 or earlier).

Second, the authors turn to the analysis of current government policies influencing the production, prices, and international trade of biofuels, as well as their consequences. Though OECD focused, this analysis has repercussions for DCs. The major observation is that OECD import tariffs on ethanol lead to the inefficient outcome of preventing the importation of ethanol from tropical countries with a strong cost advantage. In parallel, current regulations and blending benchmarks do not allow differentiating between ethanol and biodiesel according to the feedstocks used, and as a result can support fuels that are more expensive and have more environmental impacts than the fossil fuels they substitute. They also show that subsidies for OECD biofuels are not at all cost effective to mitigate CO_2 emissions (about 500$ per tonne in US), and that the promotion of sustainable biofuel production, in OECD countries and DCs, by developing sustainability criteria will inevitably clash with the demand quotas set by ICs in the form of blending requirements, as well as with the import quotas set in place to protect IC producers. Thus trade liberalization is necessary to achieve environmental targets, and would ensure it is done in an economically efficient way. Yet liberalization is unlikely to occur, given the difficulty to free agricultural markets. Thus the main role of biofuels in the near and mid-term future in DCs is seen by the authors in the framework of production for domestic consumption, either as transport fuels or to generate electricity. Such position, as well as the stance of the next paper, is major justification for our “local” or regional approach to bioenergy and rural development.

The next point debated is that of certification as enforcement measure for sustainable production practices. Doornbosch and Steenblick (2007), whilst not doubting the usefulness of such tools, question their effectiveness for several reasons. First, enforcement might pose enormous challenge, especially in DCs, as has been the case for wood products schemes. Secondly, if the certification scheme and efforts are not multilateral, biofuel products will merely be displaced, leading to market segmentation rather than global sustainability. Further, without a uniform scheme certification will cause more disruptions to trade, and certification schemes can easily be used for trade restrictions. Finally, certification schemes do not easily capture knock-on effects on agricultural markets.

The authors give several directions in which policies should be debated in the near future. Listed below are the ones of particular interest in our context (i.e. focus on DCs and rural development):

- The strategic importance of first generation biofuels needs to be refined; potentially I would say that positioning biofuels on the domestic market of DCs with focus on their rural use, as sparks for rural "industry" development as energy suppliers, rather than as cash crops for export markets, falls into this category; further development for global biofuel market potentials, even for DCs with comparative advantages, might require more assessment in view of the new coming technologies
- For the development of global markets, research should focus on second generation technologies and the assumptions regarding feedstock prices, costs and availability, and redirecting domestic policies towards R&D and demonstration phases of advanced technologies rather than unilateral biofuel support.
- Governments should stop creating mandates for biofuels (such as blending targets, which are also in place in many DCs), look at ways to phase the current ones out and replace them by technology neutral policies such as carbon taxes. Though the importance of the CO2 mitigation aspect in the context of DCs is probably lesser than for OECD nations. I think it is important that DCs setting blending targets should do it "scientifically", with respect to socio-economic and environmental sustainability.
- More help dedicated to DCs identifying how to best use biofuels, and biomass energy in general, to enhance economic progress, liquid biofuels for transport not necessarily being the panacea for all.
- Unification of certification efforts. This might be playing a role, through indirect impacts, in the case of DCs domestic production and consumption as well.
- Other recommendations are geared towards the WTO and trade aspects of international biofuel markets.

Also reviewing the global biofuel scene, yet with more focus on the DC angle, is Dufey (2006). She presents the technical potential and outlook for biofuels, the role of current domestic policies in the development of biofuel markets, and an extensive discussion of the WTO rules applicable to the different biofuels and feedstocks. Of particular interest to us is her section on the biofuels and sustainable development debate. In that context she discusses the economic, environmental and social aspects of biofuels.

In the list of important economic aspects, Dufey (2006) mentions the following:

1. Energy diversification and security;
2. Improve the trade balance, which is particularly relevant for the poorest DCs;
3. Higher costs of conventional fuels, especially for particular biofuel stocks in some DCs with favorable biomass production conditions.

4. A serious issue could be the foregone income revenue from decreased fossil fuels tax collected; this could become a serious problem in some DCs.
5. Agricultural production diversification and value-added, which may reduce the volatility, or at least the exposure to volatile agricultural commodity prices for DC producers, and likely start a new trend of increasing agricultural prices, as well as creating new opportunities for value adding activities in the agricultural sector. However, there are uncertainties here, notably on the impact of ICs trade policies on the possibilities for processing in DCs, as well as on the distributional impacts of generally increased agricultural prices on some segments of the DC populations.

Then the author looks into the environmental aspects:

1. The energy balance of many biofuels has been criticized, albeit mostly when produced in ICs; yet some DCs are engaging heavily in the production of sub-optimal biofuels, as is the case with soybean in Brazil. While this might correct itself as the market, of biodiesel in particular, develops further, close attention should be paid to government policies not interfering with this natural market correction by supporting the sub-optimal options through the wrong incentive schemes. This is crucial with regard to North-South biofuel markets, but is also crucial intra-country for DCs to develop an optimal domestic biofuel industry.
2. The GHG balances of the different biofuels vary a lot, also in function on how and where they are produced. Incentives for the production of GHG poor biofuels include the role of certification schemes; some are currently being researched, based on carbon intensity, a multilateral uniform scheme being necessary to enforce the sustainability of biofuel trade at global scale.
3. Biofuels will impact the air quality, in reducing in particular particulates and other pollutants emitted by fossils, and in DCs will impact air quality in households by being substituted to traditional fuels such as coal, fuelwood and paraffin, thus having positive health externalities. At the same time, this should not be compensated by bad agricultural practices, such as mass burning of sugar cane fields. Hence the global impact in uncertain.
4. Growth in biofuel production will inevitably expand the agricultural frontier and increase forest conversion, if not directly at least indirectly by displacing concurrent agricultural activities. This is hard to monitor, as is shown in Brazil, Malaysia and Indonesia, and can have sever global environmental consequences. Particular attention should be paid to productivity gains and efficiency as well as to resistant crops capable of growing on marginal land to minimize such impacts.
5. The spread of GMO to improve energy efficiency of biofuels might be a sensitive issue, especially for crops used for food and for energy. Access to such technologies to maximize yields might be a critical point in the case of small-farmers.

6. Other environmental issues cover monocropping and loss of biodiversity, biomaterial consumption, water quality and land degradation, all of which might be of some importance in the case of small farmers and rural bioenergy development.

The next set of aspects considered, are related to the social benefits of biofuel production:

1. The first set of benefits accrues to rural development in general, in particular job creation in rural areas and to higher levels of income in those areas. Such impacts are however largely crop dependent, as some are more prone to large scale production than others. There is also potential to attract CDM funding through biofuels. However, all positive livelihood impacts in rural areas are mitigated by the issue of the distributional impacts of increased food prices.
2. Understanding the social effects of market structures and distribution of income along the biofuel trade chain is of the highest importance. With traditional agricultural goods, it is often the case in DCs that the appropriation of the resource rent is concentrated in the upper part of the trade chain, away from the producers. This is of particular concern in the case of a biofuel export sector. There are factors in the essence of biofuel production that could lead to a similar situation, such as the presence of economies of scale or the world concentration in grain export markets. I can note here that many examples of foreign energy companies buying agricultural land in DCs already exist for a while, notably in Africa.
3. The food versus fuel debate is of primer importance for DCs. The concerns have already been exposed in other papers (competition for land creating supply shortage and especially higher food prices). In fact Malaysia has already stopped issuing licenses for oil palm export to new producers, until progress is made in dividing appropriately the products between the food and fuel markets. On the other hand, some people claim the competition will not take place, because there is enough land in many DCs, some energy crops can grow on marginal land and food shortages are usually not the result of a lack of supply, but mostly bad distribution and lack of purchasing power for specific groups. The two views make it very important to provide in-depth analysis of the problem at regional levels, as the various crops and agricultural systems will lead to very different outcomes.
4. Large scale plantations have traditionally been linked with land right violations, biofuels might not escape this, at least for certain types of crops.

Dufey (2006) offers conclusions and recommendations. Here are the ones that I think are useful for us (i.e. leaving aside the international trade aspect and the IC perspective). Due to the high variations of conditions in production, an analysis following a feedstock approach should be taken, as well as regional analysis. While there already is some information on the social and environmental impacts of growing certain biofuel crops (e.g. sugar cane), not much information on similar impacts of the processing sector is available. Extending the information to other types of crops is also key. Coordinating international action in certifying schemes in a way that will ensure sustainable practices, also for local markets, needs to take place. Similarly, linkages between fuel and food value chains, down to local level, are crucial. Finally, the cooperation between countries to smoothen technology differences, even in a South-South way, could increase efficiency in biofuel production in many DCs.

In an article focusing entirely on DCs, Peskett et al. (2007) look at the global impact of biofuels on agriculture and poverty reduction. Reflecting the need for differentiated analysis mentioned in the previous papers, they too point out the difficulty to generalize due to the many different feedstocks and production processes, the region-specific downstream and transport costs, the differences in land-holding patterns and the variations among the existing non-fuel crop and processing systems.

In their view, a major challenge will be to monitor the biofuels' impact on land access for the Poor. This pressure will result from the economies of scale in biofuel production, especially with sugar cane and oil palm, and particularly at the processing level. Other general trends the authors extract from the economics of biofuels include: the feedstock production represents the largest costs in the biofuel production chain, the opportunity to use biofuels as complement to other agricultural production and create linkages and multiplier effects, and the labor intensity of biofuels (feedstock) production. The main on-farm challenges in promoting biofuels, as presented by Peskett et al. (2007) are:

1. Fitting the institutional structures to the production models of biofuels, i.e. organizing small-farmers in such a way that they can best benefit from the economies of scale to be realized;
2. Assess/incorporate/monitor the environmental impacts of producing biofuels, i.e. water pollution and use, soil fertility impacts, as well as more global impacts (such as deforestation and wet land drainage);
3. Farm-level access to yield optimizing technology, i.e. choice or crop and seeds, irrigation systems, etc.
4. Effects of biofuels production on land access and pricing, impacts on small-farmers;
5. The biofuels chain, to avoid the dramas of traditional cash crops, need to retain some flexibility to the changes in feedstock prices, as well as to variations in input prices.

The authors also present the main challenges awaiting the promotion of biofuels in DCs in the off-farm sector:

1. Dealing with the potential biofuels impacts on the employment patterns; mostly unskilled labor to this day (feedstock production), but the need for more skilled labor to start/support the processing sector will increase;
2. How the sector in DCs will cope with the important up-front investment required for the processing and distribution sector

3. The necessary degree of flexibility in transforming the current agricultural production systems into biofuels production systems (there might be technological constraints in doing so); retaining flexibility to world market prices (for the export sector), e.g. the combined production chain of sugar and ethanol in Brazil as the key to avoid stoking up one good when world prices plunge;
4. Changing regulations which impede on efficiency, e.g. laws preventing co-generation electricity to be sold to the grid.

Peskett et al. (2007) class the potential impacts of growing biofuel production in DCs on their food security in three groups. Firstly, biofuels and food production will compete for land, either in the form of a transfer of arable land towards biofuel production or as food crops are deviated from food industry to the fuel industry. However, this swiping statement might not at all apply in cases like Tanzania (Peskett et al. 2007), where only about 6.5% of the country's land under crop in 2005 would have been required to match the country's entire oil imports in the same year (Tanzania imports all of its oil). Other countries with similar favorable condition for biomass production, and low per capita oil consumption, could be in the same position. In many DCs, increasing agricultural land and land and labor productivity will be crucial in avoiding the competition with food, particularly in Africa and also Latin America.

The second channel of negative impacts is through food prices, which in DCs are often more crucial to food security than food availability. So far evidence of such impact is, according to Peskett et al. (2007), largely circumstantial. Until 2006, according to a study by the WB, world grain prices have continually declined in real terms. Nonetheless, I have to add that since then increases have been recorded in maize, sugar and edible oil prices. Of even more concern, as the authors point out, is the fact that global stocks of staples and edible oils have declined, mostly due to the actions of EU, USA and China, for all three largely because of their use for biofuels, which makes global prices a lot more vulnerable to potential shocks. I also question the fact that world prices might not be the most important in the context of very specific population segments and access to food, but local prices in specific (regions of) DCs might be more relevant. In this case, maize might be of less concern than other local staples, such as sorghum, or edible oils. Such prices are not as systematically recorded and thus this sort of impact is so far largely unknown.

Thirdly, biofuels production might have a strong impact on US food aid (dwindling stocks of maize for instance), as the country might resort to using its stocks to sustain its renewable energy policy. This would of course have huge impacts on food deficit DCs relying on food aid, of which US is the major supplier. Such an impact is difficult to predict, as is the impact on the price of locally produced food (farmers becoming more competitive once food aid decreases or disappears).

The authors recommendations, given all the uncertainties about what will happen to global markets and price and the countries' specificities, is to make sure that a biofuel strategy and policy is imbedded in their broader context of rural infrastructure and human capital investments for development within each country. Peskett et al. (2007) also form recommendations for three different types of DCs, based on lessons learnt in three specific countries.

First, they present Malawi as an example of a net energy importing country. The large maize production is unlikely to lead to export prospects, due to the need to feed the country's population and to high transport costs. Jatropha for small farmers has limited prospects as well, biodiesel has so far only expanded to some former tobacco farmers through outgrower schemes (agri-business controls the production process of the small-holders, providing services and expertise against land and labor). For biofuels to be pro-poor in Malawi, and in similar landlocked DCs relying on small-farming, would require improving the market coordination, investing in transport and decentralized processing infrastructures, improve the storage facilities (to decrease the seasonality impacts on labor and to retain some flexibility in the face of price fluctuations).

Second, Indonesia serves as an example of biodiesel (palm oil) producer for the EU market (similarly, Malaysia, Philippines, and Nigeria). Globally, the situation of small farmers is rather good, as they have been able to sell directly to mills. However, they are at a disadvantage when it comes to access high yielding varieties of trees, unless they benefit from specific contacts with large plantations, and there are accounts of small farmers being displaced by large companies. Recent increases in palm oil prices have considerably helped the small-farmers, but there is no guarantee this trend will last. It all depends on the amount of competition from other producers, and on the role of the international stocks. Policy recommendations for a pro-poor biodiesel industry in Indonesia and similar countries include: drawing on existing transportation systems and familiar crop systems, improve the decentralized milling facilities to decrease transport costs, secure the land tenure systems, support small-farmers through active measures such as mills percentage quota coming from small farmers.

Finally, the case of Brazil is discussed, as an example of export and domestic oriented ethanol production (similar: South Africa, other parts of Latin America). Here economies of scale and land concentration have decreased the positive impacts on small farmers, as well as the use of migrant workers in plantations on the local labor markets (many migrants from other regions of Brazil). Policy recommendations include continued support to small-farming (e.g. mills % quotas) and continued investment in biodiesel feedstocks which on the whole are more pro-poor and pro-small-farmers, as there is less room for economies of scale, and also have lower transport costs (yet it seems recent soy farms in N-E are mostly large farms).

The gaps Peskett et al. (2007) identify are:

- the links between biofuels and food prices, food stocks, and food aid flows from OECD countries

- the role of CDM/climate change funds in supporting clean biofuel industry
- the impact of WTO negotiations on biofuel markets and DCs

However, they reiterate that the impacts of biofuels on poverty reduction can only be looked at on a country level!

Greiler (2007), in an issue paper for the Swiss Agency for Development and Cooperation (SDC), gives a good summary of the DCs perspective on biofuels. It includes short notes on the technical aspects of biofuels production and cropping, mentioning the fact that new non-food crops (sweet sorghum, jatropha, …) still require extensive research before playing a significant global role (i.e. large scale cropping). Similarly, the second generation technologies, with their high potential for GHG reduction, abundantly available non-food feedstocks and other advantages, are not ready yet; further, they present more technological problems for adoption in DCs, paired with higher investment costs and larger-scale plantations (less small-farmer friendly). Yet even in the future, low-cost biofuels from tropical DCs should remain competitive.

The author then reviews the different regulatory trends in EU-US-Switzerland, Africa, Asia and Latin America. This review, for DCs, includes current support policies and mentions some of the on-going projects. Next, the paper discusses the potential benefits of biofuels, such as labor-intensive production (as compared to fossils) and employment opportunities they create in rural areas, with the main challenge posed to be the retention of a good and fair share of the value chain by the farmers. Biomass energy, and biofuels are part it, should play a big role in providing energy to those communities who are/will remain without grid-connection. Diesel engines running on filtered vegetable oil can produce electricity (though I think there is now a purpose-built German generator running on SVO). New SVO cooking stoves are also being developed.

The social and environmental risks associated with biofuel production are then presented. The main one is the link between biofuels, land use and food security. The degree of land competition will be largely dependent on the speed of second-generation technologies development and also on the suitability of new plants for marginal lands. In both cases though, plantations could still be in competition with livestock grazing and the most important question for DCs to ask and answer in each specific situation is: how much land should be dedicated to biofuel crops and what opportunity costs does the production of biofuel represent? I believe this question is a crucial one, as would be the determination of the actual opportunity costs (i.e. including food price effects, or not?).

Another social aspect important in the context of expanding biofuel production is that of land tenure, as Greiler (2007) notes and already mentioned in Dufey (2006) and Peskett et al. (2007). Biofuel production has in some cases exacerbated the issue of landless farmers and small farmers without clear property rights being displaced.

As environmental risks posed by biofuel growth, Greiler (2007) mentions the loss of biodiversity and deforestation, two phenomena which so far have only partially been reined in by regulations and law enforcement. Other measures could be taken to reduce biodiversity loss, if not deforestation; they include wildlife sanctuaries and corridors, digital land mapping for monitoring, adequate land management plans. Soil erosion and degradation, excessive water use and pollution can also result from certain biofuel feedstock production techniques, such as irrigation, fertilizing, use of heavy machinery. Until second generation technologies are made available, re-focusing on plants such as jatropha and other perennials rather than traditional agricultural crops (soy for instance) can help reduce many of the biofuels' environmental externalities. Yet I suggest there might be a cost of adopting "temporary energy crop solutions, given the potential of second generation technologies, which should be weighted against the cost of waiting for such technologies. That notion of risk is mentioned in a paper presented in the next chapter.

In a similar global overview of biofuels in DCs, Hunt (2007, and also project leader for the WWI – Biofuels for transportation book), gives the following policy recommendations for immediate actions to help develop a sustainable biofuel global market:

- strengthen the market for biofuels, by creating fleets of vehicles for the new fuels and generally favorable economic environment for biofuels through fiscal, support and investment policies
- accelerate the transition to the 2nd generation technologies, by participating, supporting, creating a framework/incentive structure for R&D
- protect the resource base to secure the productivity, potentially through certification and other means, by maintaining water reserves and quality, as well as other ecosystem services
- encourage wide-spread rural economic benefits, through appropriate fiscal and land use policies
- facilitate international trade, by creating true free trade on international markets
- simultaneously improve the efficiency of the transport sector, e.g. by promoting public transport.

Clearly Hunt (2007) takes the perspective of biofuels promotion for energy security and trade, the food versus fuel debate is absent from her paper. This is not the case in the WWI book (2007) though, where the trade-off is mentioned several times. It must be noted though that none of the predictions on food price increases of about a year ago have proved accurate, as the assumptions on petroleum prices do not reflect the current situation (assumptions are usually around USD 50 to 70 a barrel, current records have reached USD 120+. Whilst small predicted increases of between 4% and 20% for cereals and vegetable oil respectively (under the current level of biofuel use, add an extra 4.2 and 4.3 % in case of increased biofuel use) can be viewed as an opportunity for higher rural incomes (WWI 2007, p.113) and positive externalities of biofuel production, it is a different question when they are added to (or multiplying) the already rocketing food prices, with global food prices reported to have increased by 40% since last June according to the World Food Program, or rice reaching over USD 1000 a ton in April 2008 compared to USD 460 two months ago (BBC interview of the Head of the UN World Food Program, 22/04/2008, http://news.bbc.co.uk/2/hi/americas/7360485.stm). The price impact on food consumption, though rather inelastic, is said to be a 0.75% reduction for each percent increase in prices in DCs (WWI 2007, p.113), compared to 0.33% in ICs. The issue of sustainability is not only uni-directional towards the food market, but it would ultimately also hurt the biofuel market itself, as their production would become less profitable if food prices where to increase by a large margin, making fossils more competitive again.

IFPRI has published a number of studies and briefs on biofuels. Two of them are listed here. Von Braun and Pachauri (2006) provide a global overview (another similar overview is offered by Fritsche 2007), which mostly is a compilation of the major promises and challenges of biofuels in DCs presented in the 12 briefs of the Focus 14 of the IFPRI 2020 Vision project edited by Hazel and Pachauri (2006). Each brief presents a particular aspect of the biofuels debate in DCs. I present below some of the more relevant briefs in the context of rural development and bioenergy. In Brief 2, De La Tore Ugarte (in Hazel and Pachauri, 2006) presents some of the social and economic issues in developing bioenergy in DCs. Particularly the synergies between energy production and rural development are mentioned, potentially through the employment impact of biofuel production. Multiplier effects of biofuel production on rural economies would be substantial, especially if collection and conversion facilities of feedstocks remain in the rural areas. Money created locally will likely be spent locally as well, fuelling the rural economy. Small-farmer organizations could enhance this trend if they own/operate the conversion facilities. Yet, it might be necessary for such process to take place in many countries simultaneously to avoid the “verticalisation” of the biofuel market. A further multiplier effect might stem from the utilization of marginal land, slowly restored thanks to biofuel crops and given back to agriculture. IC will play a role in this process, as agricultural prices will rise mostly due to their actions (decreased food supply and imports of foreign biofuels). The food prices impact on food security is only a problem in the short run, until rural incomes have increased sufficiently to adapt to this increase. The only question is what will be done during the transition phase?

Rosegrant et al. (Brief 3, Hazel and Pachauri, 2006) review precisely that question of food versus fuel production. The trade-off cannot be ruled out in cases where innovations and technology investments are absent and policies regarding trade and investment are not appropriate. Yet the trade-off could be avoided, particularly once assumptions about new technologies are factored in. These results are reflected in their figures on predicted price increases for feedstocks under different production trends for biofuels. The striking fact is that with hindsight, these increases to the 2020 horizon are similar to increases experienced NOW for some of the crops. Nonetheless, the authors mention that countries' simultaneous investments in food as well as fuel production would ensure their food security in the longer term.

Kartha (Brief 4, Hazel and Pachauri, 2006) reviews the environmental impacts of biofuel production. Their carbon balance depends crucially on the crop and the production systems, while negative externalities on soil and water quality as well as biodiversity are strongly influenced by the management systems and are not inescapable fatalities.

Moreira (Brief 8, Hazel and Pachauri, 2006) reviews the situation of Brazil, in particular the reasons which made biofuels a success in the national economy. Whilst some of the factors cannot be replicated exactly elsewhere (geographical specificity, etc.) some policy lessons can be drawn: requirements on the car industry (create market demand for ethanol), subsidized market development until the economies of scale make it competitive with oil, integrating private power producers in the competitive electricity market, supporting private sugar mills to ensure the milling sector's efficiency and stimulating the rural activities that rely on bioenergy. Walter (2006) provides a very similar account of the Brazilian experience, slightly more detailed, with similar recommendations for countries tempted to follow the same path. He emphasizes the importance of identifying all the actors of the supply chain upstream, especially where the sugar cane industry is not already well established, and the necessity to set blending targets that are in line with the national production capacity, including the ex-ante estimation of externalities on the food market and on the environment.

Karekezi and Kithyoma (Brief 11, Hazel and Pachauri, 2006) look at the bioenergy impacts on the Poor, particularly in Africa. Their recommendation to develop a pro-poor bioenergy sector is to focus first on the effective use of available agricultural wastes. This would have the smallest of negative impacts on the poorest rural communities whilst giving them some additional income opportunity. However, this requires developing adequate revenue-sharing mechanisms as well as the regulatory framework for an agro-waste based energy sector to give access to the electricity and the transport fuel market. Only once the agro-waste energy sector is set up and running optimally should dedicated energy plantations be considered, yet still paying full attention to the fuel-food trade-off.

Hazell (Brief 12, Hazel and Pachauri, 2006) investigates the potential biofuel win-win approach for the Poor. Re-affirming that demand needs supply and supply needs demand, and with biofuel development restricted by the fact that the social benefits and costs of bioenergy are not priced by the market, the public sector is bound to play an important role. One of the huge social costs lies in the competition with food production. Public intervention can reduce this cost, for instance by: developing bioenergy crops that bring the highest yields per unit of resource (land and /or water), focusing on crops that generate a lot of by-products usable for bioenergy production, develop biomass crops for marginal land, invest in improving productivity of food crops themselves, remove trade barriers to biofuels, support the appropriate (pro-poor) scale and techniques of biofuel production.

As reflected in most of the papers presented so far, there is a clear tendency to consider the biofuel boom and its different impacts on the global scale. Though the need for a differentiated, yet integrated, treatment of biofuels according to regions or countries is clearly expressed, most of the debate is on the global scale, probably because of the lack of more specific information (except for a few cases like Brazil). Of course the ultimate goal is to understand how large scale biofuel production and trade will affect national economies and world markets. Yet the extent of such an analysis is at the moment restricted by the lack of understanding of what will happen at regional and national levels. Mol (2007) confronts these two views of biofuel production and trade. He predicts that the emergence and increasing dominance of what he calls Global Integrated Biofuel Networks (GIBN) will challenge the support to small-farmers, NGOs and local cooperatives, in favor of large agribusinesses and fossil fuel consortiums (many of whom are growing biofuels now). There is a serious risk this will shift the focus from local, regional issues, such as rural development and access to energy, towards more global and "urban" pre-occupation such as global warming. Yet, large scale biofuel production is responsible for many negative externalities such as deforestation, land degradation, water pollution, biodiversity loss, etc., which should not be overshadowed by (questionable) CO2 reductions; large-scale GIBNs also adversely affect the local availability and affordability of food, exacerbating the food-fuel trade-off. This shift in focus might accelerate with newer technologies, as the second generations technologies are better geared for large scale biofuel production.

Hence DCs will need very careful planning and management in order to fulfill their biofuel aims at a more regional scale. Some have shown real commitment to such strategies, integrating small-scale biofuel networks in their national "scape" (biofuel regions), with the expected win-win results of increased rural income (new products, higher agricutural prices) and increased national income (substitution for fossil imports). Some regions in advanced biofuel production have managed this challenge already, like Minnesota in the US and Sao Paulo in Brazil, maintaining a strong prevalence of farmer-owned processing plants through various arrangements such as cooperatives. Some of the policies which have allowed this prevalence might be replicated in DCs (e.g. Minnesota: loan program to start refineries in-state, up to the first 15 mio. gallons each year, which restricts the scale of the refineries). The question asked by Mol (2007) can be summarized into how governance structures of GIBN can prevent situations where urban life improvement (e.g. climate change issues) are achieved at the expense of rural quality of life (i.e. economic development, health issues, etc.).

Karekezi (2002) looks at the different renewable energy options to deliver energy to the Poor in Africa. Among the options he discusses figure small-scale and large-scale biomass energy technologies. In the latter group he includes combustion for process heat, ethanol, gasification, heat-cogeneration, biogas production and briquetting. The two most established technologies in Africa are cogeneration and ethanol, both linked to the sugar cane industry. Both technologies could be used more intensively to provide more energy. So far they both have largely by-passed the Poor and more systems such as that in place in Mauritius, implementing a revenue sharing mechanism in the co-generation industry, could potentially be developed in more countries. Biogas is reported to take off in Africa, with few results to discuss at the time of the paper. Waste-to-energy technologies, especially in urban areas, are deemed promising for the Poor as a source of energy and of income.

Small-scale biomass energy technologies are very widely spread in Africa and concern a large number of end users (though producing only a small fraction of total energy). Charcoal production is a major source of both employment and energy for the rural poor. Thus replacing this technology would have impacts on rural communities not to be overlooked. Biogas has so far not been a success in small scale technologies, with several problems ranging from difficulty to collect (enough) dungs, prohibitive investment costs impeding on the adoption and efficiency of the technology. With small-scale biomass energy solutions servicing many little industries in rural and peri-urban areas of eastern and southern Africa (fish drying, brick manufactures, lime production, tobacco curing, beer brewing, etc.), there is a real potential for enhanced biomass technologies to bring economic growth in these areas.

The author then reviews the key benefits of renewables, in a global “macro” perspective of the appeal of decentralized solutions and on particular aspects of their dissemination. This leads into the consideration of policy options to promote renewables: they include technological and institutional leapfrogging (i.e. moving straight from the current situation into decentralized energy systems relying largely on renewables, as centralized energy systems have by large not been implemented yet), training and capacity building initiatives, new and flexible financing mechanisms and innovative dissemination of strategies. A few examples are cited for each of these policies. What is of interest to us is the idea of systematizing the decentralized approach when relevant, and the realization that unlike other DCs, many in Africa do not have any established energy systems against which bioenergy will have to fight to find its place and demonstrate its efficiency.

A few sources are adamant that the development of major biofuel markets will have predominantly negative impacts on DCs, some even calling biofuels a crime against humanity. They do not present really new elements of analysis, but rather sustain that the (potential) negative impacts associated with biofuel production will not be avoided as pro-DCs and pro-small farmer policies will be superseded by market forces. To summarize, the expected negative impacts can be divided as those arising from the biofuel production in ICs and those arising from biofuels in DCs, whilst some negative impacts arise globally regardless of the country of production. Competition with food production, resulting in decreasing food supplies and increasing food prices, is part of the latter impacts. Negative CO_2 and energy balances are broadly associated with biofuel production in ICs, whilst being sustained with much public money which would be used more efficiently for developing other renewable energy technologies. Biofuel production in DCs often leads to deforestation and biodiversity loss, excessive water use and pollution, thereby increasing the environmental problems faced by these countries. Deforestation might also put a question mark on the CO2 balance of biofuel production in many DCs. For two of the more structured discussion of the negative sides of biofuel production, one can refer to Barbara (2007) and Runge and Senauer (2007). Interestingly these authors are all American and when they mention biofuels, they specifically target bioethanol and mostly as produced in the USA. The potential positive aspects of growing biofuels in DCs as a mean to increase rural incomes in these regions are quickly dismissed as being temporary, until larger companies manage to lay their hands on the resources, whilst food price increases won't be temporary. Again, all these arguments have been discussed earlier, together with the need for policy actions in order to ensure the positive impacts of biofuel production do not elude DCs. In Barbara (2007) and Runge et al. (2007), the same arguments are presented as ineluctable.

Many papers and reports present, in a descriptive way, different aspects of specific bioenergy types in given countries. These papers, whilst they do not provide us with much analytical insight, give an account of various uses, technologies and issues of current importance. A few of them are listed below, highlighting some of the questions which I think could be of importance for our project at ZEF.

Azar and Larson (2000), in an early paper dealing with bioenergy and land use competition, show that in the case of North-East Brazil bioenergy crop plantations on marginal (cheap) land is unlikely to take place as the additional cost of acquiring more fertile (expensive) land is outweighed by the increased yields. Hence the use of marginal land for dedicated bioenergy crops, in this case eucalyptus trees, would require targeted government policies; otherwise, forestry companies would find it profitable to displace current activities (e.g. food production) from good land. Though the definition of "good" and "bad" land can vary a lot between locations and the crop considered, a similar problematic will emerge for all bioenergy solutions tagged to be implemented on marginal land (e.g. jatropha, grass, Pongamia, etc.).

GTZ (2005c) participated in this Brazil country report on the biofuel for transportation sector. The report presents the state of affairs in ethanol and biodiesel production and research (prior to 2005 of course). For biodiesel for instance, over 100 native species have been identified as potential crops, though financing efforts are currently focusing on soybean. The potential of the different crops with regard to the sustainability issues (food production, biodiversity, deforestation, etc.) are discussed, albeit at the surface level. An interesting note states that the use of SVO should be promoted in isolated regions particularly in the Amazonia with the diffusion of diesel engines conversion kit technology (potentially for generators as well). Castor oil and palm oil are the main crops identified as good prospects for small-farm production, whilst research should be supported to increase the yields in these two crop types. It is interesting to note that most recommendations of the report focus on the biodiesel trade chain; ethanol is considered to be "up and running" in an efficient way which does not call for new interventions.

A country which could gain substantially by following the example of the ethanol industry in Brazil is Indonesia. It seems that bagasse is hardly used in the country and the co-generation of electricity by ethanol mills, a huge factor in the economic success of the Brazilian ethanol industry. Restuti and Michaelowa (2007) review the potential of bagasse co-generation in Indonesia to raise CDM financing, which is found to be substantial (over 1mio$) with the most CO2 reductions achieved in the regional grids of Java-Bali and Southern Sumatra. The lesson for us is to consider by-products very carefully when looking into bioenergy projects, as these are often important factors to ensure the economic efficiency of the project. To this effect, surveying comparable projects in other areas is the main source of information.

The UNDP and the Tata Energy Research Institute (TERI) in India conducted a project developing a gasifier-based system for the silk industry (Pachauri 2003). This represents a good example of bioenergy solution serving an industry, leading to increased productivity and profit margins as well as decreased negative externalities (water savings, pollution and fuelwood use). Whilst we don't envision embarking in major technology developments, the approach they used in the project to ensure that a technology was brought successfully in an existing industrial activity should be followed. Identifying and including all stakeholders was considered as key to the design of the solution, demonstration and effective capture of the benefits of the new technology was key to its adoption, relying on favorable credit arrangements to entice purchasers.

GTZ has been an important partner in biofuels and especially biodiesel research in India (GTZ 2005a, Sieg 2007), as well as other German research and cooperation institutions (Sieg 2007). A large part of that cooperation has focused on establishing jatropha plantations, with the main bottlenecks currently identified as: first, identifying which of the wild plants deliver the best yields (seed and/or oil content) and under which soil, water conditions, etc. Second, propagating the optimal plant variety is a big problem, as matching the demand for cuttings and transplants is virtually impossible, which means that most jatropha plantations currently developed have been supplied with seeds whose yields are unpredictable; thirdly, research is conducted on the best ways to use the oil cake, by-product of oil production, which can be used as fertilizer, livestock food (after neutralizing the toxic substance), or the use glycerin obtained after the transesterification process. GTZ has assisted also in setting up the first commercial biodiesel plant in India. Regarding the potential of biodiesel in India (GTZ 2005a), it is clear that the country will have trouble satisfying the domestic demand (reaching a mere 0.5% of total demand for diesel by 2012, if the plan to cultivate jatropha on 400'000 ha of wastelands goes through); similarly the benchmark of 5% ethanol blend will be difficult to achieve. The report indicates that in India, biofuels might play a more important role in applications other than transport fuel, for instance in electricity generation for rural communities. The research mentioned above with respect to jatropha needs to go further and deliver answers soon, whilst alternatives to sugar cane molasses need to be found if ethanol supply is to be enhanced, as well as improvements towards 2nd generation technologies. From the socio-economic angle, the report sees biodiesel particularly well suited to India; it is estimated each hectare of jatropha provides

313 person-days in the first year, and even more in subsequent years when the yield reaches its potential; women can potentially be employed in nurseries, enhancing their participation to the local economy. The institutional framework is thought to be decisive in determining the distribution of the benefits of biofuel development, through its choice of model: industry-farmer partnerships, joint forest management, farmer and/or oil producer cooperatives, etc. As of the date of the report (2005), there were no legal guidelines promoting small-scale farmers for instance. Such guidelines need to be designed. A separate legislation dealing exclusively with all aspects of biofuel production would be advisable. A global policy outline that is also advised should statute on incentives to promote the use of the biofuels, set quality standards and tax regimes for biofuels, settle the ownership issue of the government wastelands (whose value should increase if biofuel programs are successful) to ensure the distribution of the resource rent, set production targets, involve and determine the role of the private sector. All these aspects are directly or indirectly related to the impact of biofuels on rural development.

Peters and Thielmann (2008) discuss the economic justification of biofuel promotion instruments in DCs, based on data from India and Tanzania (two countries where GTZ and other German institutions are active). Brazil is not included, as it is the exception where production costs are lower than for fossil fuels. In particular, they look into the financial costs of promoting biofuels through preferential tax treatment. They argue that globally, positive environmental externalities are the only valid reason for tax exemptions. However in the case of biofuels, the environmental footprint is questionable (questionable GHG reduction versus deforestation and biodiversity loss). Other positive impacts of biofuels are expected on rural employment and development. The authors argue nonetheless that the employment effect at country level is unclear, as biofuel-related employment opportunities in rural areas might be compensated by reductions elsewhere due to crowding out effects (in rival mineral oil sector) and budget effects (increased fuel and food prices due to biofuels decreasing consumer budgets). Thus in their view biofuel tax exemption is only justifiable for proven positive environmental externalities or if rural employment is part of a targeted regional development strategy (i.e. justifying the trade-offs mentioned above).

Next the authors report current and projected direct production costs (including subsidies and tax exemptions but excluding indirect effects, positive or negative, as mentioned in the previous paragraph) for ethanol in India and for Jatropha in India and Tanzania. Using these production costs, they compute the costs of replacing 10% of gasoline and diesel fuels in both countries. These replacement costs are shown to reach between 1.6 and 10+% of Tanzania’s total tax revenue(depending on current or projected figures), and between 0 and 7% in India (India has a very large production costs range for biodiesel, due to current uncertainty about yields). Thus they conclude that before engaging in large scale production of biofuels, DCs should intensify research efforts to decrease costs and uncertainties on cost projections (brings us back to the importance of 2nd generation technologies). The production cost figures come from the GTZ (2005a and 2005b) studies.

GTZ (2005b) produced a comprehensive report on biofuels for transportation in Tanzania, on a similar basis as its report on Brazil, China and India, within the global framework of the WorldWatch Institute survey. Tanzania relying exclusively on imports for its oil supply, biofuels are seen as having a large potential to create economic growth through cheaper fuel, freed up foreign exchange (though the effects of such indirect benefits have never been quantified), new industries and rural development mainly.

The report: assesses the current situation of biofuels for transport in the country, including the identification of the most relevant crops and resources; estimates the nation's gross bioenergy potential and different scenarios of demand; investigates the sustainability of the potential for production, underlying the importance of a certification schemes that recognizes the complexity and site-specificity of characteristics of biofuel production, thus relying on broad sets of standards underpinned by detailed measurable criteria, noting that presently (as of 2005) no regulatory system could prevent biomass being over-exploited. The report finally formulates a set of concrete policy recommendations, such as: establishing a country Biofuel Task Force and a Producer association, set up policies promoting increased use of biofuels, establishing regional cooperation, integrating biofuels programs in the relevant cross-departmental actions of the government, etc. As in the case of the other GTZ reports on biofuels, the focus is on global national production, not looking into specific rural and regional aspects. The reports are however good sources of information regarding current programs and partnerships in the biofuel sector, and identification of the developmental stage of the industry in the different countries studied.

Based on Jatropha production in Haubi, Tanzania, Del Greco and Rademakers (unknown date, but post 2005) focus on the village level viability of a "Jatropha Energy System". Whilst the social, economic and cost analysis is briefly discussed and should be considered cautiously (the authors are part of the NGO "Engineer Without Borders"), the jatropha energy system is interesting in that it consists of several sub-systems, the sum of whose separate values are less than the value of the integrated system, which can deliver a range of services to the village community: electricity for its dispensary through the SVO operated generator, extra oil for sale, milling services (also run on the SVO), residuals for the fabrication of soap, seedcake as fertilizer. The system is proposed to operate under two para-statal enterprises, one running the dispensary (the client, energy buyer) and the other one the nursery, the expeller, the oil filtering, and the generator which produces power for the dispensary and extra power for the village mill and other services. The necessity to have two separate "state-run" enterprises was due to the legal barrier for a private entity to sell power to the state-run dispensary. Other models could of course be trialed, though the Haudi model raised the perception of the villagers that their government cares about them. Other positive externalities: private mill operators might start buying jatropha oil to the village, which is cheaper than diesel.

Van der Plas and Abdel-Hamid (2005), report on a study conducted in 2003 in Chad and based on World Bank experiences in addressing woodfuel supply to urban centers in Niger and Mali. What is of particular interest in this paper in the context of a bioenergy for rural development project is in the relationship between urban and rural sectors, the former creating the demand (which needs to be harnessed and monitored) for energy resources owned by the latter. In Chad, as is probably the case in many DCs, the monitoring costs to ensure the sustainable use of the resource are too high for the public sector. Thus a private entity was subcontracted for the verification of the woodfuel tax payment. The interesting part of the project lies in the way institutions, i.e. the legal framework for the village ownership of the resource, the set of rules by which they are contracted, the verification schemes for tax collection around the capital city, the distribution of the resource rent, etc., were designed to ensure maximum transparency and efficiency. The model was tailored to the local conditions in Chad, where the government does not have a traditionally strong and influent Forestry Department, which facilitated the private sector integration in the process. Nonetheless, the example could be replicated in similar cases of rural to urban bioenergy trade. Rural areas in the process gained more revenue, urban consumers retained their supply of cheap energy source, and resource use has become more sustainable.

4 Energy and bioenergy in DCs - modeling their impacts of socio-economic and environmental interactions

Two articles are dealing with modeling of the global impacts of bioenergy, precisely biofuels, on the agricultural sectors of different countries and on world agricultural markets. First, in a study of the Organisation for Economic Co-operation and Development (2006), information on production technologies, costs and policy measures in the main biofuel producing countries (i.e. United States, Brazil, India, Australia, Canada, EU countries, etc.) are, at first, qualitatively described. The quantitative part of the study analyzes the relative competitiveness of biofuel production across these countries and their impacts on their agricultural markets using an *adjusted*[4] OECD partial equilibrium, Aglink, and Cosimo (Aglink is a dynamic partial equilibrium model for agricultural product markets developed by the OECD; the Cosimo model was developed by FAO and is based on the Aglink modeling methods), and the OECD World Sugar Model.

A set of scenarios (constant 2004 biofuel production scenario, biofuel policy target scenario (10%) and sustained high oil prices scenario (USD60/barrel)) are simulated and compared with each other in order to identify the impacts of the expected growth in biofuels production as well as changes in world crude oil prices. According to the available data which was used to estimate the production costs, the results showed that, in an economically viable manner, only Brazil would be able to produce ethanol with a world crude oil price of around USD 39, using only 3% of the land to replace 10% of its transport fuel consumption by biofuels. In order to attain the same goal in the US, Canada, and the EU, the production cost estimation suggested that without public support, crude oil prices can be expected to achieve a higher level – at prices between USD 44 and USD 145 - with area requirements between 30% and 70% of their respective current crop area. The comparative advantage to Brazil is quite clear (unfortunately other DCs are not described in this analysis). The strongest impact on the international price levels of agricultural commodities can be expected for sugar which could increase by up to 60% in 2014. Vegetable oils and Cereals prices are expected to increase respectively by up 20% and 4% (reminder: only biofuels production in Brazil, US, EU and Canada is explicitly covered in this analysis, in terms of (i) an unchanged biofuel production at its 2004 level as the baseline, and (ii) the increase to match the 10% blending target by 2014).

[4] A number of modifications are made to the models to observe the impact of changes in crude prices on agricultural production costs.

In contrast, a longer- term analysis suggests that the technologies are expected to lower biofuels production costs and it is possible to expect a lower land requirement per unit of biofuel energy. Thus, it seems very likely that effects on agricultural commodity markets will be less pronounced in the longer run. However, the social and the environmental implications as well as the sustainability of biofuel production that are subject to intensive debate until now are not covered in this study that is confined to describing the policies and the economic results in certain biofuel markets.

In the word of the authors, there are a number of things that were left out of their analysis, some of which are of importance in the context of DCs, all of them important in the context of biofuel international trade and world agricultural prices:

> *"A number of caveats on the quantitative analysis in this study need to be mentioned. First, data availability for biofuel production costs and quantities is relatively poor in numerous countries that are or may become important players in this area. Consequently, several simplifying assumptions are made with respect to production technologies across countries, and some potentially important biofuel producers, most notably China and India, as well as a number of feedstock commodities are not taken into account. Second, both the calculation of production costs and area requirements as well as the model-based impact analysis ignore the potential benefits of "advanced" biofuels. Third, the calculation of area requirements remains perfectly static as opposed to projections into the future in that it represents unchanged 2004 conditions in terms of technology, feedstock mix and area use. In addition, neither the potential use of currently unproductive land nor the implications of international trade are taken into account. (OECD 2006)"*

Second, Elobeid et al. (2007) used a two-step approach to assess the long term effects of corn- based ethanol production on the US and world agricultural prices. First, they examined the critical level of profitability that will cause investment in ethanol plants to stop. Thus, determining the long-run equilibrium ethanol price at this critical level allowed them to calculate how much the corn-based ethanol production will extend to reach this (break-even) level. In a second step, they introduced the additional demand for corn used in the rising ethanol production in a large-scale commodity model of US and world agriculture.[5] Such a model provides multi-commodity international coverage and the cross-commodity inter-linkages that are required to examine the possible long- run equilibrium corn prices, and how the world agriculture will respond to these sets of pricing. The authors find that, in the US market, the corn-based ethanol industry will continue to increase by 21% until the market price of corn reaches USD 4.05. High corn prices will provide an incentive to plant more corn acres. Adjustments of the agricultural world food markets are then expected: wheat and soybean prices, for example, are assumed to increase. The potential beneficiaries who will profit from the increase in corn prices and in land rents are landowners, crop growers and owners of ethanol production. In contrast, farmers who do not own shares in ethanol plants like pork and poultry producers in the US will lose. Although this paper focuses on the American agricultural market and ethanol production, part of its

[5] The employed model consists of a modified version of models developed at the Food and Agricultural Policy Research Institute (FAPRI) at Iowa State University and the University of Missouri.

methodology is interesting, especially in calculating the break-even corn price for ethanol production.

The next three papers look into the certification and the governance of bioenergy systems to ensure their sustainability.

Verdonk et al. (2007) look into the question of how to best govern bioenergy systems in order to promote their sustainability. First they list the sustainability concerns linked with bioenergy systems. Their list of land use patterns, natural resources and pollution, socio-economic conditions and other concerns are similar to the concerns already mentioned (deforestation, regional food and energy supply shortages, soil degradation, use of GMOs instead of native species, water issues, child labor, land tenure conflicts, poor income prospects for farmers, regional welfare, etc.). The authors review existing governance system for similar commodities, pointing out their weaknesses and advantages. They review the governance systems of global coffee trade, fair trade coffee, the global and the EU sugar market and the Forest Stewardship Council wood. Based on their comparison, they map out a preliminary bioenergy governance system and then proceed to its “ex ante evaluation”. Their recommendation consists of a two-pillar system based on a bio-energy labeling organization and a United Nations Agreement on Bioenergy.

Fritsche et al. (2006), in a study commissioned by the WWF Germany, set out a platform for sustainability standards in bioenergy production. They list all standards who ought to be included in a bioenergy certification scheme, at international, regional (e.g. European), national or local level. The strong focus is on environmental sustainability. The international, European and national (i.e. German) legal frameworks are discussed, as well as the various instruments for the implementation of standards. An interesting part of the work Fritsche et al. (2006) have done is the comprehensive review of certifications systems, environmental and social standards for biomass (in their annexes) which could serve as reference should we venture in the direction of standards and certification.

Finally, in another article linked with standards and certification, Sebitosi and Pillay (2007) are advocating for a yardstick for sustainable energy dissemination in rural Africa. Their point comes from the observation that many electrification programs suffer from poor post-project reporting, impeding on the sustainability of the energy systems (a point that was emphasized by the WB-IEG 2008 report as well). This negatively affects the energy system of the particular project (if failures are not reported, there will be no external help to fix the problem) as well as future projects which can draw from the past experiences of these unreported failures. A “usability engineering” procedure (usability is a recognized criterion by the International Standard Organisation (ISO)), along the lines of those developed by software designers, could help fill that gap, together with specific ISO standard linked with usability. The idea is to step away from “self-reporting”, where-by the project designers and implementers have to statute on how well they did and how satisfactory the energy system is to the users, by enforcing a systematic user feedback process and an objective standard for usability. The authors outline some of the aspects that the combination of the two approaches should include.

The next four papers all present different methodologies to estimating the socio-economic and environmental impacts of energy (or bioenergy) supply or production.

Firstly, van Eijck and Romijn (2008) have analyzed the potential of Jatropha-based energy production in Tanzania, which can create additional income for the rural Poor and provide a major source of energy for the rural community. Their methodology is based on a Strategic Niche Management approach (SNM), used to examine patterns of strategic introduction of jatropha as a substitutable new source for the domestic energy demand. The scope for this energy transition is influenced by factors and actors within the overarching “landscape”, the sectoral “regime” and the “niche” within which the new technology develops and is diffused. The “data” is collected by surveys with the potential network actors and other knowledgeable sources (i.e. officials, NGO representatives, academics, and private entrepreneurs). The analysis showed that Jatropha activities in its different stages of production chain consist of a loose set of experiments and thus, the development of a Jatropha-based biofuels in Tanzania is still in a very early phase. Further, the present domestic tax regime does not favor the adoption of biofuels and the government should temporarily facilitate the protection of Jatropha niches. The potential actors mentioned above can play a complementary role by stimulating simultaneous experiments at all stages of the Jatropha production chain. However, so far scant attention was paid to the needs and preferences of the rural Poor. If investment in Jatropha does tack off in earnest, the sector could be taken over by big commercial players interested in setting up large plantation. Such large investments could also lead to undesirable effects on food markets.

The description of the biofuels “landscape” in Tanzania provides statistics on energy consumption and imports, and “physical” potential for Jatropha. The main weakness of the country is identified at the institutional level, as the National Energy Policy does not give an explicit role to renewables, though the creation of the Biofuel Task Force, Rural Energy Fund and Agency should help in the future. The “regimes” of interest are identified as the energy, agricultural, vegetable oils and financial regimes. Interesting elements of these regimes include: the recognized versatility of the jatropha oil (though it requires some adjustments in engines and generators), its current higher price than fossils (though the difference varies, with diesel price significantly higher outside of towns and away from bitumen road networks, example of such a 30% mark-up is given p.7 of the article), the problem that vegetable oil presses cannot be used and new presses need to be developed, the financial regime is typical to a DC (risk averse farmers, extra initial cost of technology decreases adoption, …), and the agricultural regime has shown positives (e.g. jatropha fits traditional practices and farmers are looking for alternatives sources of income) and negatives (no established market for jatropha seeds, which will be problematic once larger quantities are produced; the period of 2-3 years before first harvest, but that can be solved by intercropping and hedging; the seedcakes are harder to handle than usual fertilizers; psychological aspect of using poisonous fertilizer in food production).

The formation of niches at cultivation, processing and end-use stages is reported. The main points that can be drawn out of this analysis are:

- *For the cultivation stage:*
    - The network of actors is very diverse and expending fast, though there does not seem to be systematic sharing of experiences, potentially reflecting the poor quality of the actors' network, which impedes on the learning process;
    - The learning process itself shows little reflection by farmers on the reasons for growing jatropha and the impacts it may have on their environment; in fact it was noticed that watering and fertile soils (i.e. both in contradiction with the assumption on suitability for marginal land) can considerably increase yields; land tenure impacts the way producers can enter agreements with buyers; and trust relationships between villagers and buyers are important to secure supply; cultural factors (jatropha = grave-marker) affect perception of tree;
    - The expectations of producers and buyers are high, based on current short term prospects of benefits and "rumors" about the jatropha potential.

- *At the processing stage:*
    - In Tanzania the actors network is diversifying, but they all seem to be linked through the same NGO, which seems to be selective in sharing and releasing information ("star" structure, all info runs through the NGO)
    - This affects the learning process, which focuses on the technical operation of the presses and the seed quality; no social or institutional considerations, no "managerial" or setting-up considerations, how to store seeds, etc.
    - Expectations are unclear in this segment of the jatropha chain, and it seems impossible to foresee if the sector will go to small expelling units or larger centralized operations; transport and maintenance and financing are barriers; yet according to the authors' calculations, the economics of oil pressing show very good prospects (for the two-types of expellers used so far) and cost recovery possible after 165l. with manual press and 2000l. for the mechanic press (without accounting for the use of seedcakes).

- *At the end-use stage:*

The authors report that networks, learning experiences and expectations vary considerably according to the type of end-use, so

- as diesel-fuel: only 3 actors (paper first submitted early 2007) – 1 transnational company, the Uni of Daar es Salaam and a development project; no learning process in place (though on international basis there is one, albeit with remaining uncertainties on the impact on engines etc.); positive expectations but vague;
- as seedcakes: uses include biogas installations for stoves, briketting and fertilizer; there is no information coming out of the biogas application, other than the fact that seedcake gas burns well and that the cake produces a lot of gas; no information at all on the briketting (only done in one village); the best prospect is linked to the fertilizing property of the seedcake, the network exists (farmers and oil pressing "companies"), but the learning experiences are limited as there is currently no systematic study of the impact of the seedcake as fertilizer;

- as fuel for lamps: one NGO produces the lamps, no other actor; the learning experience is limited to slight modifications of usual kerosene lamp (thicker wick); no clear expectations;
- as fuel for cooking stoves: the expectations are negative for this application, due the poisonous tag of the seedcake; no network, no learning process;
- as raw product for soap; there are many learning experiences by small-scale operations using jatropha seedcakes for the production of a soap with antiseptic properties, often undertaken by women groups, which has also encouraged the network formation; the expectations is that this market will not expand much, as the soap is relatively more expensive than ordinary soap (due to antiseptic quality) and thus restricts the customer base.

As was mentioned earlier, and is confirmed by the description above (the SNM) of the different activities linked with Jatropha in Tanzania, there is not one clear production chain with by-products off-shoots, but rather experimentation taking place a different levels by different actors and mostly in isolation, not in an integrated, systematic way with multi-directional (reciprocal) information flows. The paper also offers some technical information about current Jatropha production in Tanzania, none of which differs much from other figures and production chains in other DCs. Tanzania has good soil and climate conditions for Jatropha and in good cases the yields are in the high range (around 10 tons per hectare per year).

The next paper, by Buchholz et al. (2007) exposes how a participatory systems approach should be tailored in the case of an adaptive system under uncertainty such as a bioenergy one, in order to help answering the crucial questions that decision-makers need answered: how, where and when to deploy bioenergy systems for creating/supporting sustainable development. The paper gives a conceptual framework for developing a multi-criteria approach as a tool for implementing an adaptive systems approach to describe the sustainability of the bioenergy system as a way to integrate all different aspects (socio-economic and environmental) of the problem. The participatory approach is crucial to assess the sustainability of the system.

I agree with all the elements of the authors' assessment of the gaps and missing elements of analysis in the current literature on bioenergy systems. They rightfully point out that most of the early work on bioenergy systems focused on technical elements of these systems. Integrated methodologies to model bioenergy systems while including all social, economic and ecological assessments are still missing. In fact they identify this point as the major bottleneck for "broad replication of bioenergy systems". As they suggest, coming up with an integrated tool (model) which can be replicated in many situations requires to generalize the obstacles experienced by bioenergy systems so that they can be included in a universal tool capable of predicting the impacts of bioenergy systems on the communities they will serve. That sustainability as an adaptive and evolving concept, and how we assess it in the case of a bioenergy system, requires deeper analysis than a usual dynamic system (which typically aims for an optimal stable state) I also agree with. In fact that is what we do at ZEF, where the transdisciplinary approach ensures that deeper level of analysis. Dealing with uncertainties (which as Buchholz et al. (2007) point out differs from risk in that it cannot be solely specified by probability distributions) and the many criteria factoring in the assessment of a bioenergy system, and to make it universal in its treatment within the analysis (i.e. quantifiable), in their view justifies and requires the use of a participatory approach leading to "adaptive management".

However, if the paper provides a justification for applying the general methodology they suggest and describes the broad "theoretical" or conceptual framework in which to develop a participatory multi-criteria approach to assess the sustainability of a complex adaptive system such as a bioenergy system, the paper does not to my understanding provide a concrete example or the concrete measures that their global methodology boils down to. In this sense, all I take away from the article is the necessity to conduct an integrated assessment, in which the treatment of uncertainty ought to be, at least in parts of the assessment, conducted through a participatory approach and that a multiple criteria analysis can be used in this context. The authors admit that an MCA can be used in complement and in parallel with other methodologies more largely used in economic assessments of sustainability problems, such as life cycle analysis, operations research and simulation modeling. They suggest that lists of important criteria already exist and point to useful references. According to them what misses in these lists are a ranking of the importance of the factors and linking these factors through their interactions (hence the participatory approach), and to extend these criteria so that different applications scales and scope can be assessed within the entire system relevant to the bioenergy solution studied.

The paper by Cherni et al. (2007) precisely fills the gap suggested in Buchholz et al. (2007). They describe the use of a multi-criteria and participatory support system developed with the intention to do exactly what the previous paper suggests: provide decision-makers with a tool to help them decide where, how and when to apply which (bio)energy system. The "sustainable rural energy decision support system" (SURE DSS) is described as a complete software package designed by the Renewable Energy for Sustainable Rural Livelihoods (RESURL) project funded by the UK Department for International Development. The paper only briefly describes the model itself, but its output in the case of a Colombian village seems very interesting. Based on household survey and data from regional sources, it points towards specific technologies as well as their impacts on the set of "assets" (economic, social and environmental) of the community, thereby pointing out to the different trade-offs that the technical solutions involve. The five resource vectors o which the technology has an impact are broadly described as "Physical", "Financial", "Natural", "Social" and "Human". The maximum value achievable along each vector according to some baseline scenario is normalized to one. Each technology will engender different trade-offs of values less or equal to one along each vector.

Another paper using another type of model for energy crops and socio-economic impacts at regional level was written by Panoutsou (2007). The author focuses on crops for heat generation in Northern Greece, but his methodology is interesting in that it uses another type of modeling approach. The justification for the focus on dedicated perennial energy crops is their higher productivity per land unit and their more homogenous physical and chemical characteristics, which makes their "processing" easier.[6]

The first level of analysis is based on the comparison of income generation for the farmers between their conventional crops (wheat, cotton, etc.) and the two chosen energy crops (cardoon and giant reed). All aspects of the financial comparisons are modeled (prospective output, price variations, subsidies received for the different crops, input requirements, etc.). To look beyond the income generation of the crops and account for wider economic and socio-economic impacts of the move to dedicated energy crops for small-scale district heating plants, the author applies the BIOSEM model (Biomass Socio-Economic Multiplier), developed under the FAIR program (European Commission, more details in Panoutsou 2007). In this type of model, from my understanding similar to an input-output analysis, the main "wider socio-economic" impacts are through multiplier effects in the local economy and the local job market. The model makes predictions about:

- direct income and employment resulting from construction workers in the initial phase.
- indirect employment resulting from the biomass plants expenditure and growing energy crops and using forestry products; and
- induced employment arising from the "multiplier" effects of the increase in expenditure in the local economy from the wages of those who have, directly or indirectly, gained employment as a result of the project.

Note: The data requirements for such models are substantial and thus their applicability in the context of DCs can be debated (though participatory approach with household surveys is also data intensive).

To test the viability of the district heating plant, the RECAP (Retail Capacity) model was used (developed by the UK New and Renewable Energy Program). RECAP is originally an empirical retail expenditure allocation model which allocates available shopping catchment areas expenditures to town centers and other shopping destinations on the basis of detailed and extensive household surveys. In the present paper, the calculation of retail capacity is made for the range of retail locations within the study area based on changes in available expenditure and changes in market shares of centers (i.e. with given feedstock and power/ heat-selling prices, RECAP calculates the internal rate of return and net present value for the producer and the farmer, and the net margin for the farmer.)

Panoutsou (2007) has presented a more "traditional" approach to economic and "socio-economic" impact modeling than the previous papers. One can note that the BIOSEM model dates back to 1996. The multi-disciplinarity of the study (Panoutsou 2007, p. 6047) was present only in so far as the type and sources of data used to select the region, the crops and their management (i.e. prospects of supply, input requirements, alternative land use options, etc.) and

[6] Whether these considerations remain of primer importance after the introduction of commercial second generation technologies relying on wider biomass types, is of course not guaranteed. But this seems true for the time being.

the institutional framework in which the system is located. The analysis is mostly "economics-driven", as compared to the two previous studies. As a last note, I can mention another type of modeling approach which is used in energy systems and can be used for a specific bioenergy focus. This is the MARKAL model, which a current ZEF student is using in his thesis. MARKAL is a generic model tailored by the input data to represent the evolution over a period of usually 10 to 50 years of a specific energy system at the national, regional, state or province or community level (though like for CGE a wider scale analysis seems easier to undertake). It was developed by the Energy Technology Systems Analysis Programme (ETSAP) of the International Energy Agency, firstly with a focus on GHG emission reductions and their cost. It can also be used for:

- Identifying least-cost energy systems.
- Performing prospective analysis of long-term energy balances under different scenarios.
- Evaluating new technologies and priorities for R&D.
- Evaluating the effects of regulations, taxes, and subsidies.
- Projecting inventories of greenhouse gas emissions.
- Estimating the value of regional cooperation.

The model requires as input

- Projections of energy service **demands** (e.g. room space to be heated or vehicle-miles to be travelled),
- Projected resource **costs** and
- A **reference** case in which, for example, no measures are required to reduce carbon dioxide emissions, or any other constraint one might want to impose

Next, a series of runs is computed, with successive reductions in emissions or other requirements. In each case, the model will find the least expensive combination of technologies to meet that requirement. The total future costs of meeting the requirement is calculated according to how severe such restrictions may become, and the marginal cost of the requirement in each time period is determined.

Chen et al. (2006) produce a traditional economic analysis of the factors which determine the choice of energy source (between forest wood fuel or coal mostly) and the adoption of new technologies in three Chinese villages, all of which are in forest-rich regions but only two have easy market-access to purchase coal. The paper uses a traditional empirical approach with a non-separable household model. The choice of fuel is linked to the labor decisions in terms of unit of time spent collecting wood. The results of the analysis are used to formulate policy recommendations in terms of how to affect the choice of fuel and labor allocation to wood collection. In that respect it is indirectly linked to sustainability, though wider social, environmental and also economic impacts cannot be looked at explicitly within the model as was the case in the approaches of the previous two papers. This approach is nonetheless very robust theoretically and well-suited to answer the specific questions of fuel and labor allocation choices and is typical in micro-development economics.

One last paper in this group of “modeling” papers is Shi et al. (2008). The focus of the paper is on the transport cost problem encountered for large scale bioenergy production, especially for power plants. They present a procedural framework to use technology such as GIS to better locate bioenergy power plants and report on a case study using their methodology in Guangdong, China.

5 Bioenergy in DCs - current state of "technical" research and projects

A large range of literature can be found on the technical aspects of bioenergy. It ranges from refereed scientific articles, to project presentations, scientific newspaper articles and technical association websites promoting their technology. It would be too long to cite all of them here, and not necessarily useful. The best way to search for such literature over the internet is by type of technology. The advantages of taking a browse of such literature, which develops very quickly, almost on a weekly basis, is to keep a eye on the technical solutions that are available, those currently implemented in funded projects, and the gap between the latter two and the range of technologies covered in the more academic literature on social and economic impacts of these brand new technologies. The technologies I am broadly including in this statement are biogas, gasification and biofuels. Jatropha alone counts many dedicated associations and websites. As an indication of the newest technologies, responding to the idea that biomass from dedicated crops or wastes would either compete with other agricultural production and land use options (including ecosystem conservation) and might break soil nutrient cycles, scientists have developed algae plantations to produce biofuels, ethanol and biodiesel extractable from the same plants. Some projects even include indoor plantations in vertical "containers" to minimize land requirements.

Of course, many of these new technologies will not be appropriate in the context of DC communities. Nonetheless new biogas and gasification technologies will hopefully be transferred to DCs at some point. One particular plant which is the subject of much scientific research at the moment, and is almost exclusively a DC plant, is Jatropha. Developments of jatropha plantations and processing of the oil are taking place in many countries in Latin America, Africa and Asia. Many private companies are already interested and part of such projects. In Africa alone, over 1000 million hectares of land have been deemed suitable for growing jatropha. The scene is set for jatropha-based diesel production to explode. As mentioned earlier when referring to Sieg (2007), there are still many unknowns when it comes to seed selections, propagation and yields. Only a few scientific studies have to date been produced. Three such studies are Kaushik et al. (2007) on the genetic divergence of Jatropha accessions with regard to seed traits and oil content, Sunil et al. (2008) for a methodology for in situ identification of superior phenotypic traits (i.e. seed sizes, weight, oil content, leaf sizes, etc.) and Tiwari et al. (2007) for an optimized process of biodiesel production from jatropha oil (improved transesterification process). The former two are of primer importance, since jatropha plants do not start to produce seeds before 2-3 years, making the identification of the trees from which saplings or seeds are taken absolutely crucial.

Other technical aspects, whose results have not yet been published in refereed articles but are mentioned in many jatropha projects (such as GTZ in Peru and India, and the COMPETE project for arid and semi arid Africa, all presented at the conference “Policies against hunger VI – Bioenergy and Food security, December 2007 Berlin) are documented impacts of jatropha oil on diesel engines, modified diesel engines, diesel generators, modified diesel generators and multi-functional platforms, those effects having an impact on maintenance costs and techniques. GEXSI is also currently undertaking projects on sustainable jatropha production, in particular in Tanzania (due to finish in June 2008). The project is divided in seven modules, each of them responding to particular questions and concerns, several of which are of interest to us:

1. How to frame larger scale jatropha biofuel projects in a way that the local population benefits (e.g. no displacement of food production) and that there will be no harmful effects on the environment?
2. How to create jatropha based local value chains through adapted technologies?
3. How to replicate, bundle, and finance successful community based initiatives?
4. How to make use of carbon-finance co-funding schemes (CDM)?
5. How do regulatory frameworks in different parts of the world impact on jatropha biofuel projects?
6. How to speed up agricultural research on jatropha and related biofuel crops? How to promote the dissemination of research knowledge?
7. What are projects to be recommended to social investors based on the criteria defined in this process?

No results or publication was available at this time, but the general methodology and approach to biofuels and rural development seems to be in the same line as what we have suggested: local bioenergy production and markets for rural development in DCs.

6 Conclusions and open questions

To conclude on this review of existing studies on (bio)energy access to rural populations in DCs, I would like to outline once more the main issues presented in the previous chapters, as well as remaining open questions.

The main focus of Chapter 2 was to present an overview of the role of rural electrification, in some cases through RETs, in the development process of rural communities. A major issue in this context is the marginalization of the poorest segments of the communities. This fact has been acknowledged by the World Bank in its assessment of its own RE programs (WB - IEG 2008). Off-grid and grid electrification programs have displayed similar failures.

A global lesson of cost-effective RET programs is that they should be tied to productive uses to be financially viable and to have the strongest developmental impacts. As many local businesses already rely on small-scale biomass energy solutions for their operations (fish drying, brick manufacturing, beer brewing, etc.) there is a real potential for enhanced biomass energy technologies to spur further economic growth in those remote areas.

In off-grid RE, mostly relying on RETs, the World Bank adopted a business model, sticking to financial viability criteria. Whilst it ensures sustainability (economically), it tends to discriminate against the Poor. Even affordability measures such as rental contracts are ineffective for the poorest: due to the credit risk they represent they are refused access, or at worst conditions.

Our open question here is: can a bioenergy focus achieve better results, by tying rural poor “usual” activities with energy production (and consumption), the two feeding of each other? At this stage very few such projects exist, and results are either not yet published or not systematically documented and reported. Thus it is difficult to use past experiences to transfer/replicate findings on a large scale. Problems associated with off-grid RE are known, what lacks is a number of actually implemented programs with lessons learnt and information-sharing processes. This is similar to the WB’s business model approach which requires further systematization and referencing so as to allow replicability. Whilst WB’s (and others’) RET programs are thought to have had good impact on development, these impacts have actually barely been measured as monitoring and evaluation are often absent (or biased) from programs at the outset.

RETs and bioenergy solutions face a number of problems. Notably, due to the many subsidies distorting the energy markets, RETs’ market penetration can be difficult. Thus new renewable technologies need subsidies to be competitive. But it is important to choose smart subsidy schemes, self-cancelling once RETs can compete on the energy market, and causing minimum distortions. Further, the development of RET-based rural “industries” is often difficult and requires government support in other forms, such as information dissemination, service networks, etc. This is especially true for “larger” bioenergy options such as biodigesters and gasifiers. It is possible that biofuels will not suffer from similar hurdles on the consumer side (liquid fuels are known and easy to use) and support will only be required on the production side.

One point in disfavor of biofuels is the lack of regulation and standards resulting in low or uneven product quality. This may ultimately hurt consumers’ confidence and the expansion of the consumer base. Whilst it is good (in a pro-small farmers and pro-poor sense) to retain flexibility in producers’ market access, it is also important to guarantee quality. This could be a trade-off, but solutions exist to overcome it.

Finally, it is clear that GTZ is strongly involved with technical projects of biofuels production (especially w.r.t. transport) but at this stage there are no studies on the potential of these technologies in terms of operation, output and sustainability. Operation and output studies are under way in number of pilot biofuel processing plants (some privately sponsored), but what about sustainability, as a border concept (i.e. socio-economic and environmental)? This question has not been studied as yet.

Biofuels, meaning liquid biofuels, have largely dominated the literature on bioenergy in the last couple of years, as it appears from the studies presented in Chapter 3. A large share of that literature focuses on the promises and challenges of biofuels, in terms of rural development (in ICs and DCs) and environmental, social and economic sustainability. The main issues debated under the general umbrella of biofuel sustainability are: their potential for energy supply, their role for rural development, their impact on climate change, the extent of their competition with food production and the problems associated with trading biofuels on the international market.

Most papers look at these issues on a global level with ICs playing a central role as producers and consumers of biofuels and DCs are considered globally as potential suppliers to ICs markets. Biofuel production is then demand driven, with the bulk of that demand coming from the ICs. Yet DCs producers a very heterogeneous and the sustainability and development impact of biofuel markets call for a differentiated analysis. The differentiation should reflect the regional conditions (physical, institutional and socio-economic) as well as the different crops available. Such differentiated analysis, though often mentioned, is largely missing at this stage. This is for instance reflected in the list of general “guardrails” for sustainable biofuels promotion offered by Fritsche et al. (2005). However at this stage measurements, indicators and assessments by biofuel stakeholders in specific regional and crop production systems are lacking, inhibiting the systematic, differentiated and integrated analysis of their impacts (i.e. interactions with other sectors and production systems, e.g. food production systems). Dufey (2006) suggests a regional and feedstock approach to such analysis. The feedstock processing segment of the production chain is particularly poorly understood and studied.

The potential of biofuels for development in DCs is regarded as dependent on the choice of biofuel production system. With a few exceptions (notably Brazil), an industrialized agricultural system similar to existing cash crop systems, would achieve the largest global development, albeit with the usual distributional drawbacks. In comparison, local biofuel markets relying on more traditional and pro-small farmers production systems would have a higher impact on targeted rural development.

In general, without considering specific production systems, here are the main issues associated with biofuels (but keeping in mind that the choice of production system can help mitigate such impacts). Firstly, like other cash crops, biofuels are expected to have negative impacts on land access for the Poor and the small-farmers. The development of biofuel cropping on marginal land will also pose the problem of ownership and pricing of such land. The impacts, environmental and socio-economic, of the sudden valorization of marginal lands have not been considered at all at this point.

Secondly, food and biofuel production are expected to compete on three levels: first, competition will occur as land and food crops are diverted towards biofuel production, reducing food quantity; second, the competition just mentioned will impact on food prices, often the main factor impeding on food access in DCs – though at this stage the exact channels and magnitude of such price effects are difficult to extricate from recent trends in food prices (climate impacts, high oil prices, speculation, change in consumption habits, …); and third, the re-directing of US and EU food surpluses towards biofuel production might decrease food aid to DCs in food deficit.

Another challenge of biofuel production systems is the retention of a fair share of resource rent in the feedstock producing region or country. This is due to the existing economies of scale associated with many feedstocks and processing technologies, pushing for a concentrated market, and also due to the existing trade legislations giving incentives to export raw or intermediary biofuel products (feedstocks, unrefined oils, etc.).

The environmental risks associated with biofuel production in DCs are broadly listed as deforestation, biodiversity loss, excessive water use, water pollution, soil erosion, disrupted nutrient flows. These problems have only partly been addressed by current legislations. Many of these problems could be mitigated by focusing on specific biofuel crops and plants such as jatropha and other perennials like Pongamia and switch grass, as well as by judicious choices of production systems.

The key issue of sustainability is not uni-directional, from biofuels production to food markets, but goes in the other way as well, as biofuel markets would be hurt by higher food prices, making fossil fuels more competitive again. Further, some authors strongly believe that the food-fuel trade-off is not inevitable, particularly with the newly emerging technologies and crops. A crucial point for all DCs is to set blending mandates that are realistically linked to the domestic biofuel production capacity, including the food-fuel and other social and environmental externalities. This point is also emphasized in Peters and Thielmann (2008) with regard to the financial costs of biofuels' support policies. At this stage though, blending targets seem to be set arbitrarily, just like they have been in ICs. To improve this situation, some authors have recommended that biofuel development in DCs should first focus on the use of agricultural waste, then only on dedicated crops.

Given that many benefits and costs of biofuel/bioenergy are not priced, there is room for public intervention. For instance, the cost of dedicating good agricultural land to biofuel production could be mitigated by a legislation putting food production first, enforcing the culture of biofuels on marginal land. Certification can also act to that effect. More generally, softer policy options (i.e. incentive based and not command and control) cover: developing bioenergy crops that bring the highest yields per unit of resource (land and /or water), focusing on food crops that generate a lot of by-products usable for bioenergy production, develop biomass crops for marginal land, invest in improving the productivity of food crops themselves, remove trade barriers to biofuels, support the appropriate (pro-poor) scale and techniques of biofuel production.

Nonetheless perceptions that such guided policy interventions will ensure sustainable biofuel markets (in all the senses expressed earlier) is overshadowed by the emergence of global biofuel networks involving large, multinational companies with effective market power. This is the main argument against biofuels: all their negative impacts will actually be realized as market forces will be stronger than social and environmental considerations, overlooking the sustainability guardrails that have already been formulated. As an example, Azar and Larson (2000) have shown that in North-East Brazil the extra cost of fertile lands are more than compensated for by higher yields than marginal lands in the case of eucalyptus plantations for electricity production. The answer to such problems is of course policy work relying on multidisciplinary analysis to understand the sustaining market forces as well as the socio-economic and environmental conditions in which they come to play.

Indeed, the GTZ (2005a) report on India indicates that the potential future of biofuels might lie more in the provision of a clean domestic energy source for rural areas than in the large scale supply of (export) transport fuels, a conclusion that is validated by the predicted financial burden of biofuel support policies in India and Tanzania (Peters and Thielmann 2008). GTZ too underlines the importance of the institutional framework in shaping the choice of biofuel production system, and thus the distribution of the resource rent. An important note here is the current absence of legal guidelines and framework for small-scale biofuel production. This includes the incentive structure necessary to promote the use of biofuels, setting quality standards (by regulating the production techniques?) and tax regimes for biofuels, marginal land tenure/ownership contracts, etc.

One last issue of this global overview of biofuel/bioenergy markets is the lack of studies which have looked into the relationship between rural producers and urban markets. Institutions are required at both levels in order to impact on the sustainability of the bioenergy production. One paper looked at it in the case of woodfuel (van der Plas and Abdel-Hami, 2005). This could serve as a model for similar set up in the case of other bioenergy types, including biofuels.

Finally, in terms of climate change mitigation and CO2 balances, biofuel production and consumption in ICs is the key focus, though the final impact of biofuels is usually not believed to present a real long term solution to climate change. ICs also hold the key to the potential of biofuels for global development (i.e. large scale DCs biofuel production systems) through their weight on the international market and the impact of the support offered to their own (less competitive) biofuel producers. The complexity of the biofuel trade legislation under the WTO and other trade regimes makes most authors skeptical about the establishment of a sustainable world biofuel economy. These two issues are thus not primarily targeted in the context of DCs rural development and domestic biofuel markets.

In Chapter 4, I presented a number of attempts to model the impacts of biofuels on the agricultural markets, nationally and internationally. They have relied on the dynamic partial equilibriums models of a number of already existing computable models (see OECD 2006 and Elobeid et al. 2007). However, their predictions suffer from the absence of social and environmental implications on the sustainability of "integrated" biofuel sectors. This is not to say their methodologies are bad, but simply that not all the factors affecting the sustainability of biofuel markets are covered, especially not within a more "regional" focus. BIOSEM, used in Panoutsou (2007) integrates social implications in a limited way, much in the vein of an Input-Output multiplier analysis, by including unemployment and linkage effects in the regional economy. Clearly that is not entirely satisfactory as the linkages to the other regional production systems are not all covered.

The question of certification is the subject of a number of papers. Governance systems have been proposed (labeling system coupled with a UN agreement on bioenergy) in Verdonk et al. (2007) and an extensive review of existing certification/labeling schemes was presented (Fritsche et al. 2006). No unified certification system is showing any sign of being put in place soon though, and maybe this reflects the international market interest in keeping the situation as is (especially IC producers). The role of standards/certification in a domestically supplied market also needs to be investigated, as mentioned earlier in the context of product quality.

A strategic niche management analysis of jatropha production in Tanzania has revealed that there is no clear production chain with by-products off-shoots currently in place, but rather various experimentation projects at different levels of the production chain, by different actors, and only little integration and systematization of results and experience sharing. Again, what is required is a methodology, if possible replicable to other fuels and regions, to answer the questions of how, where and when to deploy specific bioenergy systems to support development.

Indeed, Cherni et al. (2007) have devised a multi-criteria and participatory support system to answer just these questions, in the form of a software. Their approach was to investigate how specific technologies would impact a number of community “assets” (economic, social and environmental), highlighting the different trade-offs that the technical options entail. This is in line with the idea of biofuels opportunity costs in a large sense, and this line of study, in a conceptual way, is worth pursuing.

Other papers looked into traditional household modeling to describe the choice of fuels and the adoption of new energy technologies in rural settings, or have modeled the location of bioenergy plants according to feedstocks and transport costs. Whilst they in themselves do not hold the answer to how, where and when implementing a specific bioenergy technology, they can provide precise elements of answers to specific part within such policy questions. Solutions will need to pool the results of several studies on specific aspects of bioenergy and rural development, much in the same way put together in the GEXSI project (Chapter 5), rather than relying on one fit-all model (Cherni et al. 2007). As this review shows, there are still many issues that are raised at this stage of bioenergy development and implementation, but have not been systematically addressed. Multidisciplinary research projects with regional foci and cross-regional comparisons need to take these needs into consideration to help filling this gap and promoting some degree of systematization.

References

Azar, C. and E.D. Larson "Bioenergy and land-use competition in Northeast Brazil." Energy for Sustainable Development 4(2000): 64-71.

Barbara, J.S. The false promise of biofuels. (2007). The international forum on globalization and the institute for policy studies.

Barnes, D.F. and W.M. Floor. "Rural energy in developing countries: A Challenge for Economic Development." Annual Review of Energy and the Environment 21(1996): 497-530.

Bringezu, S., S. Ramesohl, K. Arnold, M. Fischedick, J. von Gelbler, C. Lledtke and H. Schütz. Towards a sustainable biomass strategy. (2007). Wuppertal Papers No 163.

Buchholz, T.S., T.A. Volk, and v.A. Luzadias "A participatory systems approach to modeling social, economic, and ecological components of bioenergy." Energy Policy 35(2007): 6084-6094.

Carpentieri, A.E., E.D. Larson, and J. Woods "Future biomass-based electricity supply in Northeast Brazil." Biomass and Bioenergy 4(1993): 149-173.

Chen, L., N. Heerink, and M. van den Berg "Energy Consumption in Rural China: A Household Model for Three Villages in Jiangxi Province." Ecological Economics 58(2006): 407-420.

Cherni, J.A., I. Dyner, F. Henao, P. Jaramillo, R. Smith and R.O. Font "Energy supply for sustainable rural livelihoods. A multi-criteria decision-support system." Energy Policy 35(2007): 1493-1504.

Del Greco, G.V. and L. Rademakers. The Jatropha Energy System: An Integrated Approach to Decentralized and Sustainable Energy Production at the Village Level. Ingegneria Senza Frontiere (Engineers Without Borders –Italy). Accessed on-line 22 April 2008 http://www.isf.lilik.it/files/jatropha/jes.pdf.

Doornsbosch, R. and R. Steenblick. Biofuels: Is the cure worse than the disease? SG/SD/RT (2007)3. 2007. OECD.

Dufey, A. Biofuels production, trade and sustainable development: emerging issues. Sustainable Markets DP 2. (2006). IIED.

Elobeid, A., S. Tokgoz, D.J. Hayes, B.A. Babcock and C.E. Hart "The long-run impact of corn-based ethanol on the grain, oilseed, and livestock sectors with implications for biotech crops." AgBioForum 10(2007).

FAO. Introducing the international bioenergy platform (IBEP). (2006).

Fritsche, U.R. "What is driving bioenergy's exceptional upswing?" Agriculture & Rural Development (2007): 22-24.

Fritsche, U.R., K. Hünecke, and K. Wiegmann. Criteria for assessing environmental, economic, and social aspects of biofuels in developing countries. Oeko-Institut. (2005). Oeko-Institut.

Fritsche, U.R., K. Hünecke, A. Hermann, F. Schultze and K. Wiegmann Sustainability standards for bioenergy. (2006). WWF Germany.

GEXSI. Program outline – Jatropha Biofuel 2006-2008: Promoting investments with social and economic benefits. (2007). The Global Exchange for Social Investment (GEXSI). Available on: http://www.gexsi.org/downloads/BiofuelJatropha_work%20programme2006-2008.pdf

Goldemberg, J. and S.T. Coelho. Renewable energy – traditional biomass vs. modern biomass. Energy Policy 32(2004): 711-714.

Greiler, Y. "Biofuels, opportunity or threat to the poor?" (2007). Swiss Agency for Development and Cooperation (SDC) – Natural Resources and Environment Division.

GTZ. Liquid Biofuels for Transportation in Brazil – Potential and implications for sustainable agriculture and energy in the 21st century. (2005c). GTZ, BMELV, FNR.

GTZ. Liquid Biofuels for Transportation: India country study on potential and implications for sustainable agriculture and energy. (2005a). TERI, GTZ, BMELV, FNR.

GTZ. Liquid Biofuels for Transportation in Tanzania – Potential and implications for sustainable agriculture and energy in the 21st century. (2005b). GTZ, BMELV, FNR.

GTZ. Liquid Biofuels for Transportation in Brazil – Potential and implications for sustainable agriculture and energy in the 21st century. (2005c). GTZ, BMELV, FNR.

GTZ. International Fuel Prices 2007. 5th Edition. (2007). GTZ Division 44 Environment and Infrastructure.

GTZ. Energising sustainable development: concepts and projects. (2007).

Gundimeda, H. and G. Kohlin "Fuel demand elasticities for energy and environmental policies: Indian sample survey evidence." Energy Economics 30(March 2008): 517-546.

Hazell, P. and R.K. Pachauri (eds). Bioenergy and agriculture: promises and challenges. IFPRI 2020 Vision Initiative, TERI. 2020 Focus 14 (2006).

Hunt, S. "Potential challenges and risks of bioenergy production for developing countries." Agriculture & Rural Development (2007): 30-33.

International Energy Agency "Renewables for power generation: Status and prospects." Paris and Washington (2003): 189.

Karekezi, S. "Renewables in Africa—meeting the energy needs of the poor." Energy Policy 30(2002): 1059-69.

Kaushik, N., K. Kumar, S. Kumar, N. Kaushik and S. Roy. Genetic variability and divergence studies in seed traits and oil content of Jatropha (*Jatropha curcas L.*) accession. Biomass and Bioenergy 31(2007): 497-502.

Martinot, E., A. Chaurey, D. Lew, J.R. Moreira and N. Wamukonya "Renewable energy markets in developing countries." Annual Review of Energy and the Environment. (2002).

Munasinghe, M. "The economics of rural electrification projects." Energy Economics 10(January 1988): 3-17.

OECD. Agricultural impacts of future growth in the production of biofuels. (2006). OECD.

Pachauri, R.K. Biomass gasification: for the silk industry: India. (2003). United Nations Development Programme. Accessed on-line at http://tcdc.undp.org/sie/experiences/vol8/India1.pdf

Painuly, J.P. Barriers to renewable energy penetration; a framework for analysis. Renewable Energy 24(2001): 73-89.

Panoutsou, C. "Socio-economic impacts of energy crops for heat generation in Northern Greece." Energy Policy 35(2007): 6046-6059.

Peskett, L., R. Slater, C. Stevens and A. Dufey. Biofuels, agriculture and poverty reduction. (2007). Overseas Development Institute.

Peters, J. and S. Thielmann. Promoting biofuels: implications for developing countries. Energy Policy 36(2008): 1538-1544.

Reiche, K., A. Covarrubias and E. Martinot. Expanding electricity access to remote areas: off-grid rural electrification in developing countries. World Power (2000): 52-60.

Runge, C.F. and Senauer, B. How biofuels could starve the poor. Foreign Affairs. (2007). http://www.foreignaffairs.org/20070501faessay86305/c-ford-runge-benjamin-senauer/how-biofuels-could-starve-the-poor.html

Restuti, D. and A. Michaelowa "The economic potential of bagasse cogeneration as CDM projects in Indonesia." Energy Policy 35(2007): 3952-3966.

Sebitosi, A.B. and P. Pillay "Modelling a sustainability yardstick in modern energisation of rural sub-Saharan Africa." Energy Policy 35(2007): 548-552.

Shi, X., A. Elmore, X. Li, N.J. Gorence, H. Jin, X. Zhang and F. Wang "Using spatial information technologies to select sites for biomass power plants: A case study in Guangdong Province, China ." Biomass and Bioenergy 32(2008): 35-43.

Sieg, K. "Nut-oil to biodiesel." Agricultural & Rural Development (February 2007): 37-39.

Steenblick, R. Liberalisation of Trade in Renewable Energy and Associated Technologies: Biodiesel, Solar Thermal and Geothermal Energy. 2006-01. (2006). OECD.

Sunil N., K.S. Varaprasad, N. Sivaraj, T.S. Kumar, B. Abraham and R.B.N. Prasad. Assessing *Jatropha curcas L.* germplasm in situ – A case study. Biomass and Bioenergy 32(2008):198-202.

Tiwari, A.K., A. Kumar and H. Raheman. Biodiesel production from jatropha oil (*Jatropha curcas*) with high free fatty acids: an optimized process. Biomass and Bioenergy 31(2007):569-575.

UNDP. World Energy Assessment – Overview 2004 update. Editors Goldemberg, J. and T. b. Johansson. (2004). United Nations Development Programme.

van der Plas, R.J. and M.A. Abdel-Hami "Can the woodfuel supply in sub-Saharan Africa be sustainable? The case of N'Djaména, Chad." Energy Policy 33(2005): 297-306.

van Eijck, J. and H. Romijn "Prospects for Jatropha biofuels in Tanzania: An analysis with Strategic Niche Management." Energy Policy 36(2008): 311-325.

van't Veld, K., U. Narain, S. Gupta, N. Chopra and S. Singh "India's Firewood Crisis Re-examined." Resources for the Future (2006).

Verdonk, M., C. Dieperink, and A.P.C. Faaij "Governance of the emerging bio-energy markets." Energy Policy 35(2007): 3909-3924.

von Braun, J. and R.K. Pachauri. Essay: The promises and challenges of biofuels for the poor in developing countries. (2006). IFPRI.

von Lampe, M. "Economics and agricultural market impacts of growing biofuel production" German Journal of Agricultural Economics 56(2007): 232-237.

Walter, A. "Is Brazilian biofuels experience a model for other developing countries?" Agriculture & Rural Development (2007): 40-41.

Wisions. Sustainable energy for poverty reduction. Issue II(2007). PREP 10. www.wisions.net

World Bank – Independent Evaluation Group. New Renewable Energy: A review of the World Bank's assistance. (2006). WORLD BANK.

World Bank – Independent Evaluation Group. Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits. (2008). WORLD BANK.

Worldwatch Institute. Biofuels for transport – global potential and implications for sustainable energy and agriculture. (2007). Earthscan.

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ISSN: 1436-9931

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