

Socio-economics in SRC – a review on concepts and the need for transdisciplinary research

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Abstract

The production of woodchips in short rotation coppices (SRC) presents a new market opportunity, which is strengthened by both the EU agricultural policy and the European emission trading system. This market will grow substantially in the next few decades. Woodchips can substitute for fossil fuel to generate heat and power as well as provide car fuels from biomass. The SRC market will interfere with both the food and feed markets. Farmers and other stakeholders in the woodchip market have to decide whether to go for the SRC option or not. Examples from Sweden and Germany show how different stakeholders along the production line including end-users and financial institutions value chances and risks in the SRC market. The assumption that SRC is an environmentally friendly and economically promising option that can contribute to climate change mitigation (for example Pieprzyk, 2009) is lacking scientific evidence and reliable data. An assessment on the total impact(s) to the environment and society is thus needed. In this paper research concepts are reviewed for a comprehensive analysis outlining a research agenda to evaluate SRC markets. One result of the review is that socio-economic research in SRC requires transdisciplinary work integrating the fields of ecology, technology, business studies, and economics with innovation, stakeholders' involvement, and societal impacts on regional economies.

Keywords: short rotation coppices, carbon emission trading, socio-economic studies, environmental costs

Zusammenfassung

Sozio-ökonomische Studien zu Kurzumtriebsplantagen (KUP) – Ein Überblick über Konzepte und die Notwendigkeit transdisziplinärer Forschung

Die Produktion von Holzhackschnitzeln in Kurzumtriebsplantagen (KUP) ist ein relativ junger Markt. Die EU Agrarpolitik und das Europäische Emissionshandelssystem schieben diesen KUP (SRC) Markt an. Dieser Markt wird in den nächsten Dekaden stark anwachsen. Holzhackschnitzel erlauben es, fossile Energieträger zur Erzeugung von Strom und Wärme, aber auch zur Herstellung von Kraftstoffe für Automobile zu ersetzen. Der Markt für KUP greift in den Markt zur Erzeugung von Nahrungsmitteln und Futter ein. Landwirte und andere Stakeholder müssen entscheiden, ob sie in den KUP Markt investieren wollen oder nicht. Beispiele aus Schweden und Deutschland zeigen, wie unterschiedlich verschiedene Stakeholder ihre Chancen und Risiken im KUP Markt bewerten. Der Annahme, dass KUP eine umweltfreundliche und wirtschaftlich tragfähige Option sind, um den Klimawandel zu beeinflussen, fehlt der wissenschaftliche Beweis und eine Datenbasis, die eine verlässliche Abschätzung der Gesamteffekte auf die Umwelt und die Gesellschaft zulässt. In diesem Beitrag wurden Forschungskonzepte für diese Analyse geprüft und der Forschungsbedarf für die Bewertung von KUP Märkten dargestellt. Ein Ergebnis dieser Analyse ist, dass die sozio-ökonomische Forschung in KUP Märkten Transdisziplinarität erfordert, die sowohl die Forschungsfelder Ökologie, Technologie, Betriebswirtschaft, Volkswirtschaft, Innovationen, Stakeholderbeteiligung und soziale Effekte im regionalen, nationalen und globalen Maßstab integriert.

Schlüsselworte: Kurzumtriebsplantagen, Emissionshandel, sozio-ökonomische Studien, Umweltkosten

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1. Introduction

The consumption of energy as both heat and power is an important driver of society. The World Resources Institute used carbon emissions as an indicator of measuring the level of industrialization in national economies (Hammond, 1994). The increasing demand of energy has induced climate change due to the continuously increasing discharge of climate relevant gases into the atmosphere (Deutscher Bundestag, 1990). The mitigation of carbon dioxide emissions ranks high in the political agenda of the creators of climate protection policies today. The European Union has introduced an emission trading system that should allow cutting carbon emissions in an artificially created market (EU, 2003). Carbon dioxide emission has been selected the indicator to assess the emission status of national economies. Carbon emissions cannot be measured directly so a complex accounting system, along with national registers, deals with this problem in every EU country (for example DHESt, 2008). The basic idea behind the emission trading system is that pollution of the atmosphere with carbon will no longer be without cost or penalty. The emission trading system will encourage industry to invent technologies to reduce their emissions. If industry has to pay for air pollution with climate gases, the price for the permissions is part of production costs, and industry always attempts to cut those costs to a minimum (Dales, 1968).

Industry may choose from several options to reduce production costs related to carbon emissions:

1. Increasing the technological efficiency of energy conversion in existing power stations.
2. Replacing fossil fuels with fuel from renewable sources, for example co-incineration technology. The substitution of fossil fuels in existing plants has some technological limits due to the lower heating value of renewable fuels.
3. Expanding the market share of renewable energy, for example in new installations.
4. Cutting energy demand in industry and households, for example with new appliances or a tariff system that reacts to supply and demand disproportions (Factor 10 Institute, 2008).

Options 2 and 3 are related to the SRC topic. Whereas option 2 calls for co-combustion technologies, option 3 is part of a market that also includes solar and wind energy. It is widely accepted by economists that the emission trading system will increase the total costs for energy produced from coal, oil or natural gas and thus improve the competitiveness of energy produced from renewable sources (Helynen, 2007).

Blue-green bacteria, algae and green plants are able to convert solar energy into biomass using photosynthesis. Carbon dioxide and other waste gases, for example nitrogen, may serve as inputs to the process of photosynthesis. The conversion of waste gases from industry into nutrients may cause unwanted effects, for example algal blooms in coastal ecosystems (Gren et al., 1996). Biological systems are able to collect and convert carbon dioxide using sunlight (along with other waste gases or even hazardous substances, Baum et al., 2009). Carbon is stored in biomass and is available for another cycle of energy production (and carbon dioxide release). Unfortunately this cycle is not forming a closed loop. Each and any conversion process is characterised by a "loss" of energy (for example heat that can not be used) or creation of unusable matter (for example ash). As the technological loop cannot be closed in full the economic cycle cannot either (Georgescu-Roegen, 1971).

SRC plants, mainly willow or poplar, use the biological mechanism of photosynthesis and reintroduce carbon into the economic cycle. The main advantage of using trees to produce biomass is that energy can be stored in the fibre structure of the wood. Energy is stored during growth and even after harvest as long as the fibre structure is intact. The technological processes of incineration or gasification extract the stored energy for heat and power (Dimitriou et al., 2009) or synthetic fuel production (ECJRC et al., 2007; DENA, 2006).

The main product of SRC plantings is chopped wood (woodchips). The interest in forest industry is the production of logs. Logs can be used in almost all sectors of the timber industry whereas the market for woodchips is more restricted. The market value of woodchips is low compared to logs. Woodchips can be made of forest by-products such as roots, branches and treetops, or of waste wood, of timber from landscape management or of SRC crops. It is assumed that the market will run short for the lack of resources, for example in the Baltic Sea region in the next years (VTT, 2007). The production of woodchips in SRC plantings may help to overcome shortness in the timber market with forest products.

The history of planting SRC is closely linked to the recultivation of open mining fields (Hüttli, 2001). One may argue on the one hand that SRC may enrich landscapes by adding mosaic structures in the meaning of the Natura 2000 concepts by forming keystone habitats (European Commission, 1992). On the other hand it is argued that SRC can have negative impacts on environmental goods and services for example the ground water table because of the demand of water for SRC. Both arguments need to be evaluated. There are few databases on this issue (see for example Dimitriou, 2009).

This paper will review concepts and conceptualise questions that need to be answered in order to allow a socio-economic evaluation of the SRC market's potential. The socio-economics involved in the SRC market face many challenges:

1. The SRC market is still in an early state of development.
2. The allocation of arable land to SRC plantings and the institutionalization of SRC woodchip production and markets are evolving.
3. The assessment of environmental impacts using cost and benefit analysis (CBA) needs data from environmental impact assessments.
4. The application and introduction of new technologies continuously make the market subject to change.
5. The regional impact on the society with SRC covering large areas and changing landscapes is widely unknown.

2. Material and methods

This paper uses literature, national or European Union regulations, project reports and interviews with stakeholders for the analysis. Most of the project reports were funded by the EU and addressed the local, the regional, the national, or the EU levels. All these studies focussed on the market potential of woodchips produced in SRC plantings. Data on environmental and societal impacts that the production of woodchips in SRC may induce directly or indirectly (Leontieff, 1986) are rare or even missing. There are some preliminary studies only assuming that SRC plantings will increase the demand on labour in the rural areas (Tack et al., 2002; Baltic Sea Agro-Industrial Network, 2004). VTT (2007) assumes that the SRC market will be pushed by the European emission trading system since forestry cannot deliver the expected increasing demand on timber and invite new stakeholders in this emerging market.

This paper is part of an on-going research project using study sites for ecological analyses and impact assessments in Sweden and Germany (Dimitriou et al., 2009). Along with the ecological research the socio-economic studies are conducted in the same regions.

This paper represents research questions the socio-economic part of the project intends to answer. The paper is divided into sub-sections. Each sub-section describes the research question of the specific sub-section and the tools used to analyse and evaluate data and individual or social aspects a SRC market will have on the environment and the social system.

This paper bases on literature and interviews mainly.

3. An emerging market

This sub-section tries to analyse

- Why are woodchips produced in SRC seen as an economic and political option to support a market that is historically based on forests only?
- Why does this market attract new stakeholders?

The history of the use of timber as a fuel dates back almost 790,000 years (Goren-Inbar et al., 2004). Weeber (1990, 11-12) analysed historical documents from the ancient world and could show that devastation of landscapes and changes in the regional climate due to clear cutting of forests had already occurred BC. Fischer (1996, 22, 76, 124) observed that the availability of timber (firewood) had a great impact on human history in Europe. He analysed the evolution of prices of agricultural products including firewood over a period of 800 years. According to his studies firewood prices indicated the emergence of economic and social crises in Europe much earlier than the increase of prices for food. Interpreting these results one may conclude that the allocation of land to produce timber or food was already an economic problem in the Middle Ages.

Fossil fuels have replaced timber as the main source of fuel only since the 19th century. This is due to (1) the rapidly increasing demand for electricity, (2) the supply of fuels for transportation, and (3) the hunger of the chemical industry for resources such as coal, oil, and natural gas. The extensive use of fossil fuels caused a steadily increasing release of carbon into the atmosphere. The amount of carbon a society emits served as an indicator of the level of a nations' industrialization (Hammond, 1994, various tables).

IPCC addressed carbon dioxide as a main driver for climate change (IPCC, 1995). IPCC (1996) assessed the economic and social dimensions of climate change, developed response strategies, evaluated costs for response options, and demanded integrated research to assist the development of policy instruments for combating climate change. IPCC (1995, 13) demands "stabilizing carbon dioxide concentrations in the range of 350 ppmv (near current levels) to 750 ppmv." IPCC (1996, 6) calls for cost-effective measures to reduce carbon emissions in line with applicable international agreements. Economic measures mentioned in the IPCC report include "encouraging forms of international cooperation to limit greenhouse gas emissions, such as implementing coordinated carbon/energy taxes, activities implemented jointly, and tradable quotas." The emission trading system introduced in Europe in 2003 (EU, 2003) is based on the tradable quota principle recommended by IPCC in 1996.

The member states in the European Union had to introduce national registers for carbon emissions because of

the 2003 directive. The total sum of those registered emissions formed the initial European market for carbon emissions. In a grandfathering process the shares in this market were distributed to the involved industries for free. In next step the policy will cut the market volume. This procedure will be repeated by policy until an environmental sustainable level is achieved (Goodland, 1995). The reduction of the market volume will increase prices for the individual pollution rights traded in this market. National agencies record and supervise the national emission trades (for example in Germany, DEHSt, 2008). The increase in prices will steadily make the use of fossil fuels more expensive, thus will improve the competitiveness of renewable fuels. Stakeholders in the biofuel market expect an increasing demand on biomass and particularly SRC woodchips (VTT, 2007; Pieprzyk, 2009). One result of the introduction of the European emission trading system is that new stakeholder groups feel invited into this market. We learned from interviews and direct request for consultancy that companies which usually trade oil (for example GEE, 2008) or provide financial services (for example WestLB, 2007) are investing in SRC especially in Eastern Europe.

The idea of SRC plantings is based on the experience of recultivation processes. The mining of coal released large, ecologically devastated areas to society. One option for recultivation is planting trees able to cope with those harsh environments (Hüttl, 2001). Special breeds of poplar and willow have been developed and adapted to those conditions. Both species grow fast, use sunlight and carbon dioxide as inputs, enrich carbon in the soil and store energy in biomass. The crops of SRC plantings are chipped and these woodchips return to the economic cycle biomass.

EU agricultural policy (BMVEL, 2006) supports the use of arable land to plant SRC in order to substitute as much fossil fuel as possible with renewable ones (Dimitriou et al., 2009).

4. The allocation of arable land, opportunity costs and the institutionalization of the market

The planting of SRC requires assigning land for this specific use. One option EU policy supports is using arable agricultural land. This land can be used either for the production of human or animal food or for SRC. SRC compete with those uses. Since agricultural land is a limited resource costs will rise. The first part of this section deals with those aspects.

The second part of this section is related to another economic question, that of market organization or institutionalization. The economic issue behind this question is transaction costs.

Both aspects are related to each other and to decision making processes in SRC and will be explored in detail during this research project (Dimitriou et al., 2009).

The assignment of arable land to SRC plantings is clearly an economic issue. The supply of arable land is short and the demand on arable land for food and feed production will compete with SRC plantings. Any allocation of scarce resources always relates to opportunity costs.

The concept of opportunity costs is an artificial construct that allows comparing expected returns on investment for alternative uses of the same resource, i.e. soil in this example. The calculation of future earnings may include risk or uncertainty factors (Stiglitz, 1997, 41). It is possible to calculate risks but not uncertainties. Risk is an expectation on a probability of outcomes in the analysed process. Uncertainty, to the contrary, also includes unforeseeable impacts and thus cannot be quantified. For example, fourth measure impacts are seen as an uncertainty (Raiffa, 1968).

We have learned from interviews in Germany that farmers compare outcomes from SRC with those from annual crops, for example wheat (Tack et al., 2001). Experiences in Mecklenburg – Western Pomerania show the SRC market does develop as expected. For example, only three farmers in an area of about 400.000 ha grow SRC on approximately 50 ha of arable land. That result was picked from an official database of EU-subsidised farmers for planting SRC on arable land this year (AFL Bützow, 2009, interview August 10, 2009). One of the three farmers grows 20 different clones of willow on a 30 hectare plot. Choren Industries has contracted him to grow willows in the SRC mode (Bauernzeitung, 2009). Farmer did not succeed since the Choren BTL plant was not built, this farmer could not sell the produced woodchips. Thus the farmer's investment did not provide the expected returns.

EU subsidies have compensated the losses to a certain extent. EU pays, for example, about 300 € per hectare per year for the use of arable land. In addition, EU also pays a premium of about 56 € per hectare for growing energy crops. This premium however will be paid for the last time in 2009 (AFL Bützow, 2009, interview August 10, 2009).

The farmer can reduce opportunity costs using marginal soils for SRC plantings, growing cereals or other annual crops in better quality soil. For example, the soil quality at the particular willow spot reported here was too low to grow wheat. The contract with Choren Industries to grow willow allows the farmer keeping the plot within the register of arable land. So the EU payments for arable land compensated the losses in part in this example (Schaack, 2008, interview in 2008). If spent costs are not covered by earnings the real losses turn in to sunk costs (Stiglitz, 1997, 42f).

In an earlier project entrepreneurs (Michel-Kim et al., 1998) initiated a ten hectare SRC planting with a farmer

growing willow, poplar and alder to produce seedlings. No seedlings and no woodchips could be placed in the market. Consequently, the farmer cut the plantings clear and converted the plot back into a wheat field. These examples are well known to the farmers in the region and made farmers cautious with regard to growing SRC in North-East Germany.

The German example shows that the opportunity costs early birds face in new markets (Slater et al., 2006, 32) may form a barrier for investments since the risk is too high. The EU subsidies buffer the risk of total losses. Since EU pays the subsidies on a per hectare calculation the resistance of farmers against the new crop still is relatively high.

If one compares the situation in Sweden with the one in Germany the picture is almost completely different. The arable land covered with SRC plantings is substantially larger (Dimitriou et al., 2009). One reason for this is that the market is institutionalised and mediated by a farmers' organization in Sweden. This organization mediates the marketing and offers (full) services to farmers and landowners along the whole SRC production chain (Agrobränsle, 2009). The growing of SRC plantings is based on contracts with end-users to avoid sunk costs.

Furthermore, Swedish law permits the use of ash and sludge mixtures as fertilizer, and it permits watering the SRC plantings with treated wastewater. The farmers may avoid additional costs for irrigation and fertilization of the SRC fields because of this regulation (ENA, 2009). The use of ash from CHP plants fired with woodchips from non-polluted sources is not permitted in Germany whereas it is common practice in Sweden. Ash from the combustion of non-polluted woodchips is seen as a waste according to German law (AVV, 2007, 100103).

The institutionalization of the Swedish market includes contracting of farmland, planting, weeding, harvesting SRC and trading SRC woodchips. Farmers are used to the institutionalised and mediated market since it is somewhat to markets with annual crops. Opportunity and transaction costs are reduced in an institutionalised market (North, 1984).

The institutionalization of the market has, according to interviews with stakeholders, the following advantages:

- Costs for purchasing adapted technology for planting, weeding and harvesting SRC are avoided due to the "full service offer" of the farmers' organization.
- The market for SRC woodchips can grow fast and deliver large quantities of woodchips to end-users.
- The end-user industry can trust in a market serving their demand.
- The end-user industry has to deal with large suppliers only. They can be sure that the suppliers will deliver

a product on contract at a negotiated (accountable) price and in large quantities meeting the demand for example of a CHP plant.

- A relatively fast substitution of fossil fuels with SRC woodchips is technologically possible and economically feasible.
- The risks and costs of planting SRC to the individual farmer can be reduced.
- The opportunity and transaction costs are relatively low.
- The main players in the SRC market can push the market lobbying for the products using climate protection arguments.
- The market attains public awareness.

The disadvantages are:

- The market lacks competition. A few suppliers may dominate an individual farmer's interest and may squeeze farmers' income from SRC planting.
- Few suppliers of seedlings, planting, weeding or harvesting technology dominate the market. The innovation rate may slow down.
- The market "invites" new players, for example financial institutions or other investors. The formerly farmers' business may shift into an investment business.

5. The assessment of environmental impacts, costs and benefits

Ecological research needs to be translated into economic terms when a policy intends to interfere in markets with cost-effective measures as IPCC (1996) demands. This section names and reviews the underlying basic concepts of environmental and ecological economics that should be applied one way or the other in this research project.

It is necessary to quantify and to evaluate environmental impacts related to SRC plantings in order to increase acceptance (Dimitriou et al., 2009). The ecological data need to be translated into an economic language using prices and quantities. As long as those data are missing an evaluation using the methodological frameworks of environmental (see for example Bromley, 1995) or ecological economics (see for example Costanza, 1991) is impossible. This paper reviews the concepts of environmental and ecological economics and proofs their applicability for an economic evaluation that will fit into a comprehensive socio-economic evaluation of SRC.

Every human activity on Earth impacts the environment. Pigou (1920) highlighted the fact that human wealth depends on a healthy environment in economic literature for the first time. The entrepreneur who cares for the environment with his business may face higher costs than com-

petitors in the same market who do not. Pigou calls for a mechanism that ensures that the entrepreneur who cares for the environment can survive in the market. In principle, there are two options solving this problem: First, making the polluter compensate the cleaner business, second, regulating the total load of pollution by political intervention in the market.

It took almost fifty years until economic theory proposed instruments that can cope with the environmental issues. The book of Rachel Carson (*Silent Spring*, 1962) served as a wake-up call for an environmental policy. Economists proposed three main strategies, the concept with standards and prices (Baumol et al., 1971), the property rights approach (Dales, 1968) and the environmental liability tool (IPCC, 1996; EU, 2004).

A policy sets taxes or subsidies (prices) and standards permitting a limited pollution using safe minimum standards or critical loads (quantities, Baumol et al., 1971). If an industry cannot cope with those limits, it has to pay a fine (tax). Private or public environmental management systems, for example a wastewater treatment plant, have to cope with the additional pollution. They get paid from the polluter but may also be compensated by using the fine paid by the polluter to improve the treatment system. The main problem, however, is setting the "right" standards and prices.

The application of Dales' proposal will indirectly push the SRC business. Dales (1968) proposed to regulate environmental markets by issuing pollution rights. The basic concept to protect the common good, "clean air", (Hardin, 1978, 1244) is to assign property rights for a limited amount of pollutants emitted, for example, to the air. Policy regulates or reduces the total amount of pollution until a sustainable level of pollution can be approved. This environmental management should induce at least two effects: First, industry reacts in developing more efficient technologies to avoid payments due to the emission trading system and second, the trade in the emission market will generate a pricing system internally within the rules of a market economy. The carbon emission trading scheme applies Dales' approach in Europe (EU, 2003). VTT (2007) sees in the emission trading system a good chance for the bioenergy business to grow.

Environmental liability has been regulated in an EU directive of 2004. The economic concept on environmental liability is based on insurance concepts.

All three concepts are to some extent related to SRC planting:

1. Setting environmental standards affected technological changes in combustion processes. The co-incineration of timber in coal-fired power stations was introduced to reduce sulphur emissions due to the fact that timber

does not emit sulphur. Co-incineration is seen as a technology that allows substituting fossil fuels with timber (woodchips) within certain technological limits today.

2. Setting climate protection targets using carbon dioxide as the only indicator for climate gas emission. The emission trading system increases the demand on renewable fuels since they are accounted "neutral" to carbon emissions. The emission trading system will also push the development and application of new technologies that convert and use energy more efficiently.
3. Environmental liability affects the overall planning process for any process generating heat and power. The costs related to environmental liability cases are accounted in the internal cost schemes of the enterprises.

All three economic concepts make environmental costs and benefits part of the business accounting scheme. Life cycle analysis (LCA) may report on all impacts that a certain product or service generates during its whole life (cradle to grave cycle). Various concepts have been developed to assess environmental costs and benefits of products (for example Rees et al., 1994; Bishop et al., 1995; Bockstael, 1995; Freeman III, 1995; Tietenberg, 1995; Pulm, 2001).

This project (Dimitriou et al., 2009) will analyse environmental impacts of SRC plantings along the production chain, trading and timber industry, the results on environmental impact analyses (other papers) and market data on woodchip handling and industry. The socio-economic analysis tries to translate those ecological and technological data into economic terms. The main focus is on an economised LCA methodology along with concepts of environmental valuation of costs and benefits (Bishop et al., 1995).

It can be expected that the Dales' concept and its application in the European emission trading system will have the strongest impact on the development of the SRC market. However, the results of the analysis and the economic evaluation of the impacts will show "how green energy production with SRC really is".

6. The application and introduction of new technologies

Technological development is a driver in markets since it influences substitution of products, production modes and the main market indicator price. One can expect that technological change and changes in the management scheme will influence the SRC market. Böhlcke et al. (2006) report that the annual growth rate may increase by a factor of three or four if the rotation period (management scheme) is changed from three to six years.

The breeding of new clones:

Growing faster and allowing larger yields and returns on investments.
 Growing in environments that did not allow any crop to grow. The new clones may "re-cultivate" harsh environments.
 Improving changes to / changing environments – less rain than before, salty soils etc.
 Resistance to pests or long droughts.

The planting of seedlings:

Making planting less costly.
 Lighter machinery decreases pressure on soil.

The protection of SRC plantings against pests and weeds:

Applying less harmful pesticides to the environment.
 Supporting soil symbiosis factors.
 Making clones resistant to various kinds of pests.

The stimulation of plant growth:

Using various irrigation technologies to water SRC fields depending on the regional climate conditions or sources of water supply.
 Applying the "right" mixture of fertilizers.
 Avoiding soil erosion.

The adaptation of harvesting technology:

Allowing cutting on market demand or extending rotation periods, if necessary, for environmental or marketing reasons.
 If market demand drops down SRC should be allowed to collect carbon and sun for another year. The diameters of the stems will increase at this time, therefore the harvesting technology has to be adapted or the harvesting needs to be done by hand.

The drying and storing technologies:

SRC are harvested in autumn or winter. For storage the woodchips need to be dried to an extent less than 15 per cent moisture content.

Adapted technologies to reduce environmental impacts:

Avoiding soil pressure.
 Supporting groundwater regeneration.
 Increasing bio-diversity.

Box 1:

Examples for technological change that may influence economy of SRC plantations

In this project (Dimitriou et al., 2009) we will distinguish two main clusters of technological aspects related to SRC:

1. New or adapted technology to optimise SRC woodchip production.
2. New technologies end-users will apply.

The first cluster of technologies deals with the development of machinery and innovations in management schemes along the production chain of SRC, whereas the second cluster focuses on the end-user industry, for example a shift from using woodchips in a CHP plant to the production of synthetic fuels.

Many of those technologies may be adapted from agricultural or forest technology and experience. All the processes invite stakeholders from almost all branches of research and business, for example scientists in basic and applied research, financial institutions, land owners, owners of workshops and farm industry.

The second cluster includes stakeholders that are interested in using woodchips as inputs to industries. Woodchips are used, for example, to produce fibreboards, compound products, pulp and paper, or energy. The various industries will compete for woodchips from forest or agricultural production.

This research project deals mainly with the energy market. One may divide the energy market into three submarkets that may increase the demand on woodchips:

1. The main market for woodchips from SRC plantings is the energy production in CHP plants (Dimitriou et al., 2009). CHP plants use woodchips as a co-fuel together with bark and sawdust from timber industry. Small and medium sized CHP plants produce power for the grid and heat for a district heating system. They operate seasonally or during the whole year. Pricing in the market for power effects the operational mode of the CHP plants. In Sweden the main focus of CHP industry is on heat production for district heating (ENA, 2009) whereas the focus in Germany is an all year long operation initiated by feed-in tariffs for electricity (BMU, 2009).
2. Large industrial power stations co-fire woodchips with fossil fuels to comply with (mainly sulphur) emission standards or to fulfil critical load regulations or to reduce obligations from carbon emission trading. The CHP as well as the coal fired large power stations use condensing power technology to heat water and convert steam into power. Heat is a by-product of this process. Some power companies operating large coal fired power stations are also involved in the coal mining business, for example Vattenfall in the Niederlausitz region.

They grow SRC re-cultivating soils after open mining (Hüttl, 2001).

3. A new technological option inducing an important increase in demand for timber is the biomass-to-liquid (BTL) technology. The conversion demands 4 kg of woodchips to produce 1 l of synthetic fuel. The energy content of 1 kg of timber is almost half the energy content of 1 l of synthetic fuel, i.e. the energy conversion rate is about 50 per cent (Köhn et al., 2009). Various pre-market studies see BTL technology as an economically feasible option to produce motor vehicle fuels (EJRC et al., 2007; DENA, 2006; BMU et al., 2007).

An analysis of the Agentur für erneuerbare Energien shows that planting SRC is the better option to produce biomass than growing annual energy crops (Pieprzyk, 2009).

7. Impacts of SRC on regional society

One aspect of SRC plantations is to produce as many goods locally or regionally as possible. The production of local energy – heat and power – in CHP plants or synthetic fuels may serve as such an option. If SRC are an environmentally sound and economically feasible option it may contribute to regional wealth. This section in the research project will analyse and evaluate those aspects.

European Joint Research Center (EJRC et al., 2007) analysed two scenarios for the BTL market. They compared global versus regional markets for biomass. Biomass contains less energy per ton than coal or oil, therefore transportation costs for biomass are substantially higher than for coal or oil. The consortium proposes to use biomass on a regional scale (EJRC et al., 2007). CHP plants connected to district heating systems fuelled with woodchips from SRC plantations are in line with those proposals.

Large BTL plants need approximately 1 million tons of woodchips to produce about 200.000 tons of synthetic fuels. Choren Industries (2009) argues that those plants are the smallest feasible size based on technological and economic models. The production of 1 million tons of woodchips will cover an area of approximately 150.000 to 200.000 hectares. This calculation is based on the documentation of yields in poplar or willow SRC plantings (Boelcke, 2006; Gienapp, 2006; Agrobränsle, 2009). If 20 per cent of a region of one million hectares is planted with SRC only one BTL plant can be supported by fuel. Köhn et al (2009) show that small BTL plants are feasible both from the technological and business concept.

The market for woodchips is not as transparent as required for a complex economic analysis at present. It is impossible to apply Leontieff's input-output tables (1986) using the databases available today. Leontieff's methodol-

ogy, however, allows calculating direct and indirect effects a business causes on the regional or national economy.

The research project aims to generate a database to support such calculations. We assume, however, if SRC plantings will substitute for the production of annual crops on arable land only the overall impact on the agricultural and the agro-industrial market may tend to zero. This assumption bases on the idea that the earnings from annual crops and SRC woodchips in the long run will not differ substantially from the costs for labour, caring for the crop and harvesting.

However, the impact on the national economy will differ since the emission trading system as well as the generation of products from biomass instead of coal or oil will cause economic and environmental effects that need to be calculated in input-output tables.

The following impacts on the global economic and the global societal systems can be expected (examples only):

- In the fossil fuel and energy business. Climate change demands concerted action to mitigate carbon emissions. The emission trading system earmarks fossil fuels with an extra price making it more expensive in relation to renewable energy sources. This makes renewable energy more competitive in relation to fossil fuels. (EU) Policy intends to decrease the market share of fossil fuels. The shrinking market will, of course, effect the global market, for example, in total sales of fossil fuels, in need for global transportation, in substitution of technology (i.e. coal fired power stations), and in installation of better technologies to generate power and store energy. The impacts are expected to be seen in the annual gross domestic product reports on a national scale.
- In the forest and agricultural business. The "value" of forests and forest products is assumed to be a critical indicator. In addition, the creation of mosaic structures in landscapes with SRC may support coping with climate change, for example protecting or regenerating of groundwater in Central European regions like Brandenburg (INKA BB, 2009). The share of land planted with SRC is expected to grow substantially (Pieprzyk, 2009).
- In greening desert strategies. Several stakeholders (sciences and business, interviews 2007 – 2009) intend to grow jatropha trees using SRC experience to avoid further desertification in Africa. Another approach is to green deserts using sewer water to water those plantings (IfaS, 2009, interview). There is hope that such plantings will create new areas for the agricultural business, agro-forestry, and induce social wealth.
- In "terra preta" strategies. SRC may serve as an intermediate stage of cultivation enriching carbon in the

soil and improving soil productivity in the long-term. Those attempts are related to the "terra preta strategy" (Glaser et al., 2001; Heck, 2009) and to the demand of EU agricultural policy. EU demands returning carbon to arable land in a three year period depending on the crops planted (BMVEL, 2006).

- In people's awareness to climate change and in people's knowledge and acceptance of sustainability issues (Hardin, 1968).

8. Summary

The planting of SRC in order to produce woodchips is an emerging market. The reform of the EU agricultural policy and the introduction of the European emission trading system are seen as instruments to push the SRC woodchip market. It is expected that the market will substantially grow in the next few decades. Woodchips, as one source of renewable energy, may substitute for fossil fuels to generate heat, and power as well as motor vehicle fuels from biomass (EJRC et al., 2007).

The SRC market will interfere in the food and feed market because these markets compete for the same resource – arable land. Any competition on a scarce resource demands rethinking the modes of production and the cost benefit schemes of the stakeholders involved in those markets. Stakeholders have to decide whether to go for the new market or not. Examples from Sweden and Germany show how different stakeholders take chances and risks in an evolving market. Whereas the market has been institutionalised and mediated in Sweden, farmers in Germany experienced some pitfalls.

Biomass produced in SRC is assumed to be the better option to grow biomass for energy purposes compared with growing annual crops, for example corn or cereal (Pieprzyk, 2009). This assumption, however, lacks scientific evidence. The environmental impacts SRC plantings may have on the environment need to be analysed and evaluated in a regional context (Dimitriou et al., 2009). Those data may allow for an economic evaluation of costs and benefits in an environmental accounting system or in Life Cycle Analyses (LCA). LCAs, however, also have to take into account technologies that use and convert the energy stored in the biomass, which is produced in SRC. For this reason LCA compares concepts and technologies of businesses using woodchips from SRC, as well. The overall societal performance depends on the efficient use of resources and can be calculated on a regional, national or global scale using input-output tables (Leontieff, 1986).

In conclusion, socio-economics in SRC require transdisciplinary research integrating the fields of ecology, tech-

nology, business studies, and market economy with innovation, stakeholders' involvement and societal impacts (Funtowicz et al., 1993).

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Reference

- Abfallverzeichnis-Verordnung (AVV) (2007) Verordnung über das Europäische Abfallverzeichnis - Abfallverzeichnis-Verordnung – AVV vom 10. Dezember 2001 : Stand 01.02.2007, Änderungen BGBl. I S. 1623 vom 15.07.2006 sind eingearbeitet ; Nr. 100103: Filterstäube aus Torffeuerung und Feuerung mit (unbehandeltem) Holz [online]. Zu finden in <<http://www.proenvi.de/recht/AVV-20070201.pdf>> [zitiert am 24.09.2009]
- Agrobränse (2009) Weidensorten von Agrobränse AB [online]. Zu finden in <<http://www.agrobransle.com/index2,2.htm>> [zitiert am 24.09.2009]
- Amt für Landwirtschaft Bützow (2009) Flächen mit Kurzumtriebsplantagen im Amtsbereich und Auszahlungsmodi. Interview August 2008
- Baltic Sea Agro-Industrial Network (2004) Final report – BASAN [online]. Zu finden in <<http://www.baltic-network.de/index.php?page=22>> [zitiert am 25.09.2009]
- Baum C, Leinweber P, Weih M, Lamersdorf N, Dimitriou I (2009) Effects of short rotation coppice with willows and poplar on soil ecology. *Landbauforschung* 59(3):183-196
- Baumol WJ, Oates WE (1971) The use of standards and prices for protection of the environment. *Swed J Econ* 73:42-54
- Bishop RC, Champ PA, Mullarkey DJ (1995) Contingent valuation. In: Bromley DW (1995) *The handbook of environmental economics*. Oxford : Blackwell, pp 629-654, Blackwell Handbooks in Economics
- BMU/BMELV, VDA, MWV, IG, VDB, DBV (2007) Roadmap Biokraftstoffe : Stand 14.11.2007 [online]. Zu finden in <http://www.bmu.de/files/pdfs/allgemein/application/pdf/roadmap_biokraftstoffe.pdf> [zitiert am 24.09.2009]
- BMU (2009) Übersicht über die EEG-Vergütungsregelungen für 2009 gemäß Bundestagsbeschluss zum EEG Vergütung ct/kWh [online]. Zu finden in <http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/eeg_2009_verguetungen_bf.pdf> [zitiert am 24.09.2009]
- Bockstael NE (1995) Travel cost models. In: Bromley DW (1995) *The handbook of environmental economics*. Oxford : Blackwell, pp 655-671, Blackwell Handbooks in Economics
- Boelcke B, Bury M (2006) Die Bewertung des Ertrags schnell wachsender Baumarten im Nordosten Deutschlands. *Energia odnawialna* 2/3:113-117
- Bromley DW (1995) *The handbook of environmental economics*. Oxford : Blackwell, 705 p, Blackwell Handbooks in Economics
- Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2006) *Die EU-Agrarreform : Umsetzung in Deutschland ; Ausgabe 2006*. Berlin : BMELV, 118 p
- Carson R (1962) *Silent Spring*. Boston : Mifflin, 368 p
- Choren (2009) Kriterien für die Projektentwicklung [online]. Zu finden in <http://www.choren.com/de/energy_for_all/bt/standortentwicklung/> [zitiert am 24.09.2009]
- Costanza R (1991) *Ecological economics : the science and management of sustainability*. New York : Columbia Univ Press, 525 p
- Dales JH (1968) *Pollution, property, and prices : an essay in policy-making and economics*. Toronto : Univ Toronto Press, 111 p
- Deutsche Emissionshandelsstelle im Umweltbundesamt (DEHSt) (2008) Aufgaben der Deutschen Emissionshandelsstelle im Umweltbundesamt [online]. Zu finden in <http://www.dehst.de/clin_153/nn_476212/DE/DEHSt/Aufgaben/Aufgaben__node.html?__nnn=true> [zitiert am 24.09.2009]

- Deutsche Energie-Agentur (Dena) (2007) Biomass to liquid : BtL-Realisierungsstudie. Agra-Europe / Dtsche Ausgabe 48(3)1-12
- Deutscher Bundestag (1990) Bericht der Enquete Kommission Vorsorge zum Schutz der Erdatmosphäre. Verhandlungen des Deutschen Bundestages : Drucksachen, 11. Wahlperiode (8030)
- Dimitriou I, Baum C, Baum S, Busch G, Schulz U, Köhn J, Lamersdorf N, Leinweber P, Aronsson P, Weih M, Berndes G, Bolte A (2009) Short Rotation Coppice (SRC) cultivation and local impact on the environment. *Landbau-forschung* 59(3)159-162
- Drewes J (2009) In einem Pilotprojekt erprobt Landwirt Gernot Schaack in Kasow den Anbau von Weiden für die Produktion von BtL-Kraftstoff [online]. Zu finden in <<http://www.bauernzeitung.de/?redid=330435>> [zitiert am 24.09.2009]
- Ena Energi AB (2009) History [online]. Zu finden in <<http://www.ena.se/default2.asp?h=0&m=123&u=133>> [zitiert am 24.09.2009]
- European Commission (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [online]. Zu finden in <<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:NOT>> [zitiert am 24.09.2009]
- Europäische Union (2003) Richtlinie 2003/87/EG des Europäischen Parlaments und des Rates vom 13. Oktober 2003 über ein System für den Handel mit Treibhausgasemissionszertifikaten in der Gemeinschaft und zur Änderung der Richtlinie 96/61/EG des Rates [online]. Zu finden in <<http://www.metalleproklima.de/hintergrund/europaeisches-emissionshandelssystem/EU-Emissionshandelsrichtlinie.pdf>> [zitiert am 24.09.2009]
- Europäische Union (2004) Richtlinie 2004/35/EG des Europäischen Parlaments und des Rates vom 21. April 2004 über Umwelthaftung zur Vermeidung und Sanierung von Umweltschäden, Amtsbl Europ Union, L 143:56-73
- Lonza L, Mahieu V, Edwards R (2007) Well-to-wheels analysis of future automotive fuels and power-trains [online]. Zu finden in <<http://ies.jrc.ec.europa.eu/our-activities/support-for-eu-policies/well-to-wheels-analysis.html>> [zitiert am 24.09.2009]
- Factor 10 Institute (2008) The Factor 10 Institute 2008 [online]. Zu finden in <http://www.factor10-institute.org/pages/factor_10_institute_2008.htm> [zitiert am 24.09.2009]
- Fischer DH (1996) *The great wave : price revolutions and the rhythm of history*. New York : Oxford Univ Press, 536 p
- Freeman III AM (1995) Hedonic pricing methods. In: Bromley DW (1995) *The handbook of environmental economics*. Oxford : Blackwell, pp 672-686, Blackwell Handbooks in Economics
- Funtowicz S, Ravetz J (1993) Science and the post-normal age. *Futures* 25(7):739-755
- Georgescu-Roegen N (1971) The entropy law and the economic problem. In: Daly HE (ed) *Toward a steady-state economy*. San Francisco : Freeman, pp 61-81
- Gesellschaft für Erneuerbare Energien (2008) Wirtschaftlichkeits- und Effizienzbetrachtungen. Consultancy request August 2008
- Gienapp C (2006) Der Landwirt als Energiewirt – Chancen und Perspektiven. *Energia odnawialna* 5:89-94
- Glaser B, Haumeier L, Guggenberger G, Zech W (2001) The „Terra Preta“ phenomenon : a model for sustainable agriculture in the humid tropics. *Naturwiss* 88:37-41
- Goodland R (1995) The concept of environmental sustainability. *Ann Rev Ecol Syst* 26:1-24
- Goren-Inbar N, Alperson N, Kislev ME, Simchoni O, Melamed Y, Ben-Nun A, Werker E (2004) Evidence of hominin control of fire at Geshel Benot Ya'aqov, Israel. *Science* 304(5671):725-727
- Gren IM, Söderqvist T, Wulff F, Langaas S, Sandström M, Folke C (1996) Reduced nutrient loads to the Baltic Sea : ecological consequences, costs and benefits. *Beijer Inst Discuss Paper Ser* 83
- Hammond AL (ed) (1994) *People and the environment : resource consumption, population growth, women*. New York : Oxford Univ Press, 400 p
- Hardin G (1978) The tragedy of the commons. *Science* 162(3859):1243-1248
- Heck P (2007) Energieeffizienz und Nutzung erneuerbarer Energien in Rheinland-Pfalz. Trier : Inst angew Stoffstrommanagement, Umweltcampus Birkenfeld, pp1-14
- Helynen S (2007) The effect of emission trade on biofuels markets in the Baltic Sea region [online]. Zu finden in <<http://www.docstoc.com/docs/10460979/The-Effect-of-Emission-Trade-on-Biofuels-Markets-in-the-Baltic-Sea-Region>> [zitiert am 25.09.2009]
- Hüttl RF (2001) Rekultivierung im Braunkohlentagebau : Fallbeispiel Niederlausitzer Bergbaufolgelandschaft, *Akademie-Journal* 1:7-12
- Innovationsnetzwerk Klimaanpassung Brandenburg Berlin (INKA BB) (2009) Das Innovationsnetzwerk Klimaanpassung Brandenburg Berlin [online]. Zu finden in <[http://www.klimzug.de/_media/INKA_BB_\(Knierim\).pdf](http://www.klimzug.de/_media/INKA_BB_(Knierim).pdf)> [zitiert am 24.09.2009]
- Institut für angewandtes Stoffstrommanagement (2009) Carbonisation strategies. Interview Juni 2009
- IPCC Houghton JT (1995) *Climate change 1994 : radiative forcing of climate change and an evaluation of the IPCC IS92 emission scenarios*. Cambridge : Cambridge Univ Press, 339 p
- IPCC Bruce JP (1996) *Climate change 1995 : economic and social dimensions of climate change*. Cambridge : Cambridge Univ Press, 448 p
- Köhn J, Kropshofer BL (2009) Klein, aber fein. BTL-Anlagen für dezentralen Einsatz. *Energiepflanzen* 13(1):39-40
- Leontieff W (1986) *Input-output economics*. New York : Oxford Univ Press, 436 p
- Michel-Kim H, Köhn J (1998) Bioenergiewirtschaft in Mecklenburg-Vorpommern : Potentiale und Chancen. *Beitr Innovations- Bildungszentr Hohen Luckow* 6:29-47
- North DC (1984) Transaction costs institutions and economic history. *J Institutional Theoret Econ* 140:7-17
- Pieprzyk B (2009) Globale Bioenergienutzung – Potenziale und Nutzungspfade : Analyse des WBGU-Gutachtens „Welt im Wandel: Zukunftsfähige Bioenergie und nachhaltige Landnutzung“ [online]. Zu finden in <http://www.unendlich-viel-energie.de/uploads/media/AEE_Globale_Bioenergienutzung_Kurzstudie_jun09_01.pdf> [zitiert am 24.09.2009]
- Pigou AC (1920) *The economics of welfare*. London : MacMillan, 976 p
- Pulm H (2001) Eco-performance evaluation. In: Köhn J (ed) *Sustainability in action : sectoral and regional case studies*. Cheltenham : Elgar, pp 61-77
- Raiffa H (1968) *Decision analysis : introductory lectures on choices under uncertainty*. New York : Random House, 309 p
- Rees WE, Wackernagel M (1994) Ecological footprints and appropriate carrying capacity. In: Jansson AM (ed) *Investing in natural capital : the ecological economics approach to sustainability*. Washington : Island Press, pp 362-390
- Schaack G (2008) Kurzumtriebsplantage Schwaan-Sandgarten. Interview Juni 2008
- Slater SF, Mohr JJ (2006) Successful development and commercialization of technological innovation : insights based on strategy type. *J Prod Innov Manag* 23:26-33
- Stiglitz JE (1997) *Economics*. New York : Norton, 997 p
- Tack D (2001) Arbeitsplätze durch nachhaltige Wirtschaftsentwicklung im Landkreis Güstrow. Zusammenfassung. Güstrow : Wirtschaftsförderges
- Tietenberg TH (1995) Transferable discharge permits and global warming. In: Bromley DW (1995) *The handbook of environmental economics*. Oxford : Blackwell, pp 317-352, Blackwell Handbooks in Economics
- Weeber KW (1990) *Smog über Attika : Umweltverhalten im Altertum*. Zürich : Artemis, 223 p
- WestLB (2008) Installation of SRC poplar plantings in Lithuania. Consultancy request