SHORT ROTATION PLANTATIONS

Guidelines for efficient biomass production with the safe application of wastewater and sewage sludge

Developed with funding from the European Commission BIOPROS research project

BIOPROS

SIXTH FRAMEWORK PROGRAMME

HORIZONTAL ACTIVITIES INVOLVING SMES

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CONTENTS

1 INTRODUCTION

These guidelines were elaborated and published under the **EU-funded BIOPROS project**, where 25 partners from 11 European countries worked together for more than 3 years on approaches that can make wastewater and sewage sludge application in "Short Rotation Plantations (SRP)[1]" safer and more efficient. The main driving factor for starting the project were **previous experiences from Sweden, the UK, Estonia and Poland** that highlighted the potential to use willow plantations for a combination of high-yielding woody biomass production and associated wastewater purification.

Picture 1. SRP with willows [Photo by: S. Foellner, ttz Bremerhaven]

Picture 2. Harvested poplars (2 years old) [Photo by: A. Ramos Fernandez, ASAJA]

Within BIOPROS there was a particular focus on SRP with **willows and poplars** (Salix spp. and Populus spp.), because these are the two most common tree genera in Europe for woody biomass production with short rotation cycles. However, SRP should not be limited to only these two species, because eucalyptus, alders (Alnus spp.) and other species might also have a significant regional potential and therefore should be considered for SRP, as long as they guarantee **fast growth and high uptake rates for water and nutrients** to achieve the aimed wastewater and sewage sludge treatment performance.

The production of woody biomass from willow and poplars without application of wastewater or sewage sludge is very common in Europe and the reader should keep in mind that several guidelines for such plantations (e.g. Short Rotation Coppice–SRC) have been published elsewhere (see Annex). As the focus in BIOPROS was specifically on the safe reuse of human residues in SRPs, these guidelines contain a lot of specialized additional information about such practices.

[1] Further known under the term "Short Rotation Coppice" (SRC) or "Short Rotation Willow Coppice" (SRWC).

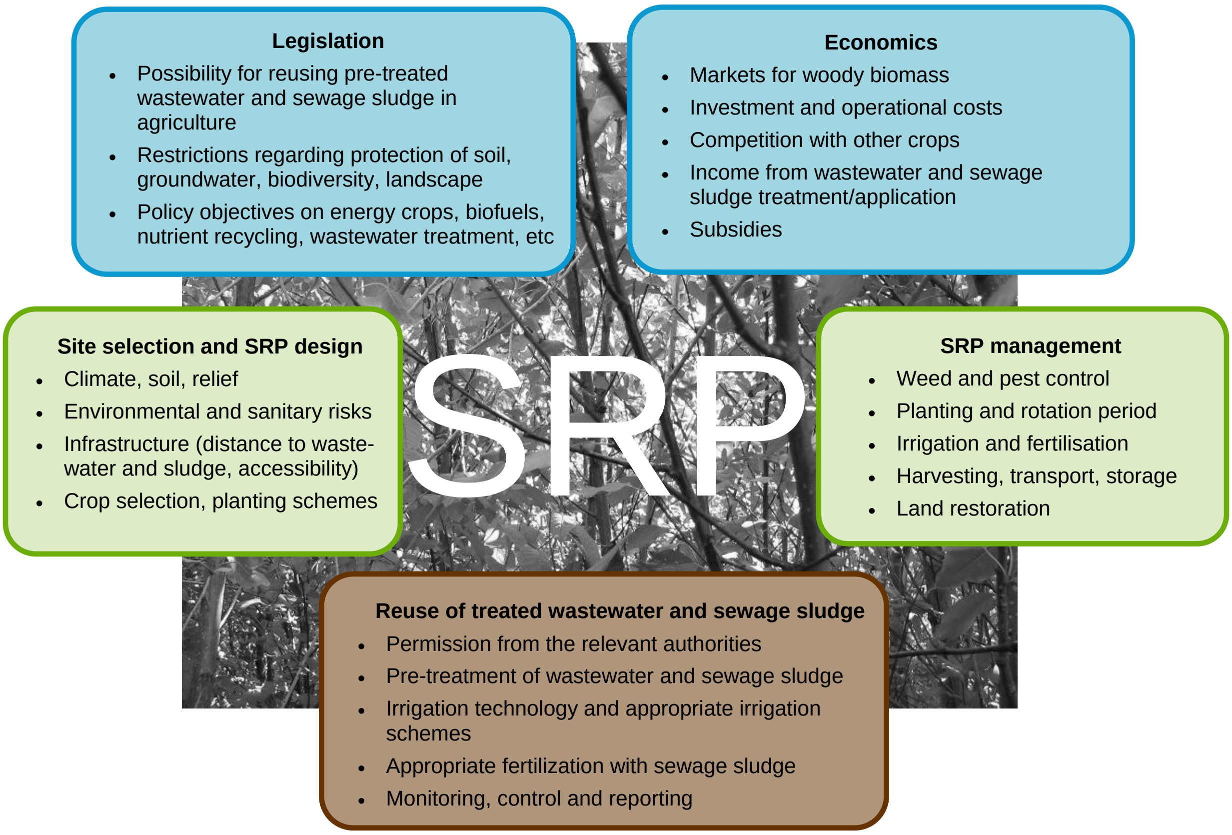
1.1 About the SRP guidelines

For guideline development the SRP potential has been assessed for **different European regions** taking into account different climate conditions, suitable tree species, local regulations and markets. Research activities were conducted in existing SRPs to analyse different impacts from wastewater and sludge application to soil, groundwater and plants. **Project results** show that the SRP potential for combined biomass production and wastewater and sewage sludge treatment strongly depends on the following practical aspects:

- legal possibility and permission to reuse pre-treated wastewater or sewage sludge for irrigation and fertilization (legal situation),
- local availability of suitable wastewater and/or sewage sludge and short transport distances to the SRP,
- public acceptance,
- markets for woody biomass,
- suitable local climate and soil conditions, and
- benefits from SRP operation and wastewater treatment for farmer, society and environment.

To **ensure sustainability** of the SRP approach and to protect population and environment from potentially negative impacts like groundwater or soil contamination, careful planning and management of SRP is essential. As the local conditions in Europe regarding legislation, climate, biomass market, etc. can vary significantly, each single SRP establishment requires a case-by-case decision and it is therefore recommended to **involve local experts and authorities** at an earliest stage. These **guidelines combine project results and pre-existing knowledge** to support SRP operators and decision makers in appropriate SRP planning and operation. Thus it contributes to ensure a safe and efficient reuse of wastewater and sewage sludge for high-efficient woody biomass production.

Picture 3 illustrates the main practical aspects to be considered for SRP implementation and the content of the following chapters. Within the guidelines you will find information about site selection (chapter 2), plantation design and establishment (chapter 3), crop management (chapter 5), economics of SRP (chapter 6) and instructions for safe reuse of wastewater and sewage sludge for irrigation and fertilization (chapter 4). Furthermore, you will find information about SRP success stories in Europe, specific national regulations for your country and contractual support.



Picture 3. Practical aspects to be considered for SRP implementation.

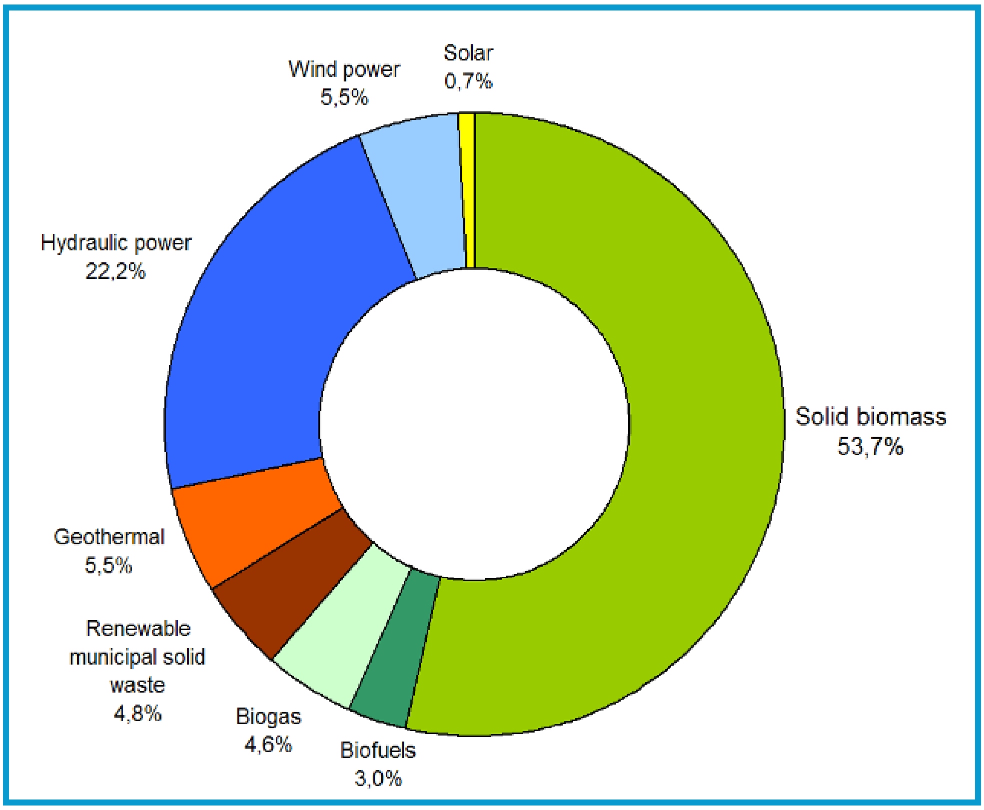
1.2 SRP BACKGROUND

Biomass from fast growing tree species cultivated in SRP or "energy forests" has the potential to substantially contribute to the achievement of ambitious EU and national goals of **reducing greenhouse gas emissions**. Heat, power and biofuels produced from biomass are CO_2-neutral. Only the amount of CO_2 that has been taken up by the plants from the atmosphere is re-emitted if biomass is converted into bioenergy[2]. Consequently, substitution of fossil fuels with biomass can contribute to a reduction in the concentration of greenhouse gases in the atmosphere and their impact on **climate change**. Furthermore, oil prices have almost quadruplicated since 2000 which proves that sole dependency upon fossil fuels threatens national economies, and a switch to **renewable energy sources** (RES) is urgently needed.

[2] Not included are emissions from plantation management (e.g. harvesting and planting machinery) and processing.

1.2.1 EU OBJECTIVES ON RENEWABLE ENERGIES

To achieve the **EU White Paper objectives for 2010** concerning renewable energies (COM [97] 599): a 12% share in total energy consumption, a 21% share in gross electricity consumption and a 5.75% share in vehicle fuel consumption, the biomass sector has an important role to play. Already today, more than 50% of total renewable energy generation comes from **solid biomass sources** such as wood, wood waste, straw, crop harvest residues, vegetal and animal waste. Specific objectives concerning the use of biomass have been defined in the 2005 **EU Biomass Action Plan**, aiming at an increase in the use of all biomass sources of 150 million tons oil equivalents (Mtoe) by 2010[3].



Picture 4. Share of RES in the EU primary energy generation (in 2005). [Source: Observ'ER 2006]

In 2005, about 58.7 Mtoe were produced from solid biomass compared to 13.6 Mtoe from other biomass sources such as biofuels, biogas and renewable municipal solid waste (Observ'ER 2006). Current trends suggest that a substitution of fossil fuels of 103.7 Mtoe seems realistic by 2010, with 78.6 Mtoe coming from solid biomass (Observ'ER 2006). Therefore, additional efforts

[3] 55 Mtoe intended for electricity production, 75 Mtoe intended for production of heat and 19 Mtoe intended for transport.

and incentives for more efficient production and use of biomass are required to fulfil the EU objectives for 2010.

EU-Targets for 2010:

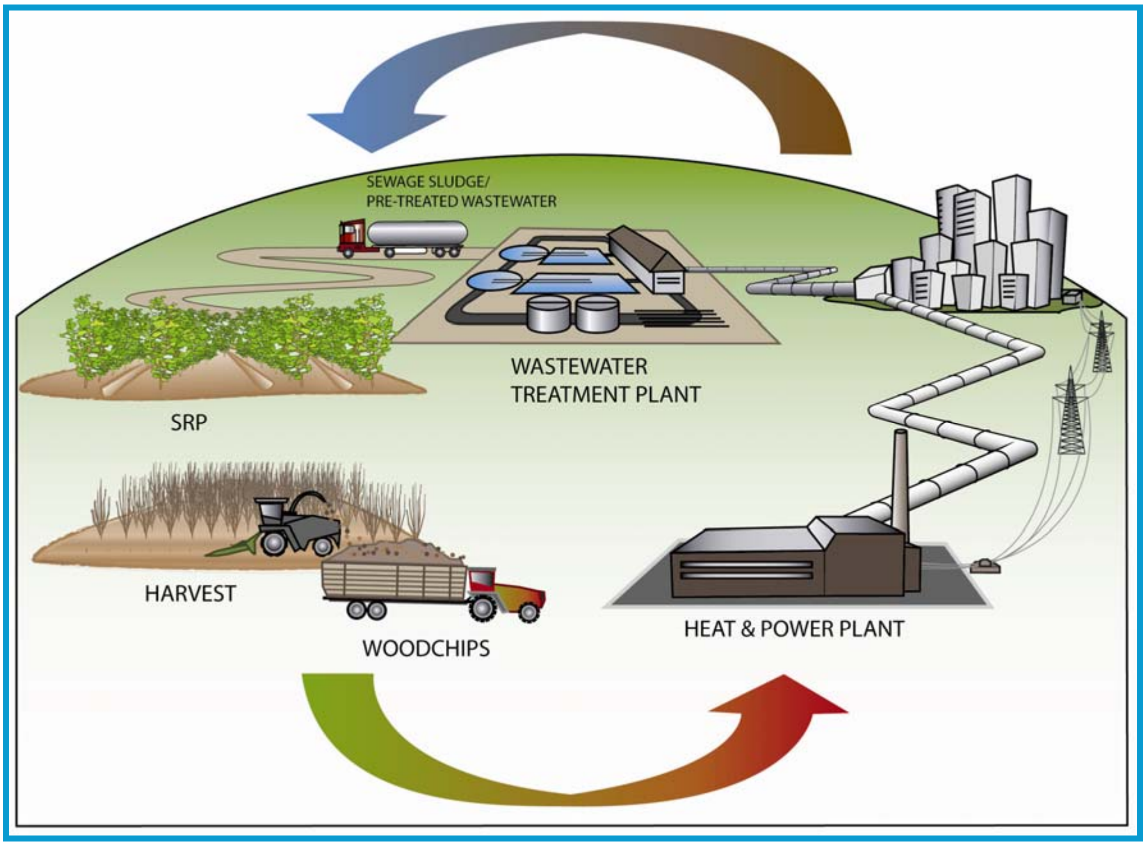
- 12% share of renewable energy in total energy consumption
- 21% share of renewable energy in gross electricity consumption
- 5.75% share of renewable energy in vehicle fuel consumption
- use of biomass sources up to 150 million tons oil equivalents (Mtoe)

Besides conventional forestry, a huge potential for solid biomass production is expected to come from high yielding, **coppiceable tree species** such as willows (*Salix spp.*) and poplars (*Populus spp.*), cultivated in plantations with dense stands and relatively short rotation harvesting cycles of 3-5 years. In order to meet the White Paper objectives it is estimated that about 4.5% of the EU total agricultural area (6.3 million ha) must be cultivated with such dedicated energy crops, but competition with food and fodder production must seriously be taken into account. Given the 2003 **Common Agricultural Policy** (CAP) reform, such energy plantations fit perfectly under new agricultural regulations which allow farmers to respond freely to changes in the market for agricultural products and an increasing demand for energy crops. The new support schemes include the possibility of using mandatory **set-aside land** for energy crop production, including SRP crops. Thus, in combination with an **increasing market for woody biomass** for district heating schemes and co-combustion in power plants, the current CAP strengthens the position of SRP for biomass production and creates new sources of income for European farmers in a growing market for bioenergy.

1.2.2 SUSTAINABLE NUTRIENT RECYCLING

For a broad SRP implementation sustainability of biomass production must be guaranteed. In addition to **economic aspects**, this implies consideration of specific **environmental and socio-economic aspects** before establishment and during operation. One interesting aspect of SRP is its potential to serve as a **multifunctional system** not only for biomass production but also as an alternative treatment system for low-polluted wastewater and sewage sludge. The potential results from the high demand of most fast growing tree species for water and nutrients that under normal conditions must be covered by irrigation with fresh water and mineral fertilizers. Both the latter are becoming increasingly scarce and more expensive. In Europe, climate change will probably lead on the one hand to longer dry periods during the summer and reduced available water resources, while on the other hand to an increasing demand for irrigation. Decreasing resources of mineral phosphorus worldwide will have a considerable influence on **fertilizer price increases** and may lead to a phosphorus deficit in the future given the growing demand for intensive food production and related fertilization.

Municipal wastewater[4] and **sewage sludge** contain large amounts of plant available nutrients such as nitrogen (N) and phosphorus (P), while associated levels of organic and inorganic pollutants (e.g. heavy metals) are normally low. Consequently these "human wastes" can be considered as an economically interesting resource for **unconventional irrigation and fertilization** especially for non-food/non-fodder SRP crops. The reuse approach in SRP supports **local recycling** of valuable nutrients, decreases demand for mineral fertilizer and fresh water for irrigation, and can increase biomass yields compared with conventional operated energy forests.



Picture 5. SRP recycling principle.

On the other hand the integration of SRP in an overall wastewater treatment concept can lower economic barriers for investing in proper treatment facilities. Even today a high number of smaller towns and communities, particularly in the new EU member states, have no or **inadequate treatment facilities** to meet EU quality requirements[5] for wastewater treatment before discharge. The use of SRP as a final purification step for municipal wastewater can contribute to a simple and efficient way to improve the overall treatment performance for such

[4] Mixture of domestic wastewater and rainwater, and excludes industrial discharges.

[5] Water Framework Directive 2000/60/EEC; Directive 91/271/EEC on Urban Waste Water Treatment (amending Directive 98/15/EEC).

communities by further reducing the amount of nutrients and pollutants currently being discharged into receiving natural water bodies. However, the pre-treatment or **“stabilisation” of wastewater** prior to its application in SRP is absolutely necessary because raw wastewater, even after primary mechanical treatment, still contains pathogens and large fractions of dissolved and undissolved matter unfavourable to crop survival, groundwater and soil fertility. For this purpose different options, almost identical to common wastewater treatment technologies, exist which may be adapted to particular SRP requirements.

Opportunities of SRPs with Wastewater and Sludge Application:

- Growing market and income opportunities for farmers
- Multifunctional system combining biomass production and alternative treatment
- Substitution of increasingly scarce fertilizers and irrigation water
- Interesting treatment option especially for small towns and communities

Minimize risks through:

- Careful site selection to avoid competition with food and fodder production
- Appropriate selection and pre-treatment of wastewater and sludge
- Careful planning, operation and monitoring for best environmental performance
- Compliance with EU directives and local regulations

If wastewater is treated in conventional treatment systems, **sewage sludge** is generated from sedimentation and activated sludge treatment in large amounts and must be disposed of in some way. Besides incineration, which is costly, agricultural application of stabilised sewage sludge is still a standard disposal practice in most European countries. Due to its high levels of organic matter, phosphorus and other nutrients, sludge application improves soil fertility and reduces the demand for mineral fertilizer. Despite these positive aspects, potentially harmful wastewater pollutants, such as **pathogens and heavy metals**, can concentrate in the sludge and if used in the fields may lead to contamination of soil and groundwater. To ensure environmental and hygienic safety, sewage sludge application on agricultural land is strictly regulated in the EU via thresholds for maximum nutrient levels (**Nitrates Directive 91/676/EEC**)[6] and pollutant levels (**Sewage Sludge Directive 86/278/EEC**)[7]. Potential risks for soil and groundwater protection require careful SRP planning and operation. In most cases permission by the relevant local authorities will be required to ensure fulfilment of existing legislation that may differ from EU Directives.

[6] Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources.

[7] Directive 86/278/EEC on the protection of the environment and in particular of the soil, when sewage sludge is used

2 PLANTATION SITE SELECTION

If farmers, landlords, tenants or other users of agricultural land consider introducing a new crop such as willows and poplars grown in SRP for energy, as with any other agricultural crop **proper site selection is essential**. In comparison to annual crops, the decision about establishing new SRP will affect land management and the economics of a farm for many years, given an expected life span of SRP in European conditions of around 25-30 years against costs which are largely concentrated in the plantation's first growing season. Therefore any mistake made in terms of selecting the appropriate site has an economic impact which is almost impossible to correct. **Several site selection factors** comprising natural, technical, infrastructural and geographical aspects are discussed further in this chapter.

Table 1. Factors determining site selection for SRP.

Conventional method of fertilization and management of SRP	Additional factors if wastewater and/or sewage sludge are applied
Local natural and geographic conditions	
• climate • soil • susceptibility to natural hazards • susceptibility to pest/disease attacks and damage by game • biodiversity issues	• groundwater level • relief, slope • distance to human settlements • distance to conservation areas, reservoirs and natural tributaries (esp. for wastewater reuse)
Infrastructural and technical aspects	
• distance to biomass customers • accessibility of SRP by roads for establishment and management • electric network wires • availability of appropriate planting and harvesting machinery	• power supply • availability of land for wastewater pre-treatment or storage • distance to outlet of collected wastewater or existing wastewater treatment facility • accessibility to wastewater • quality and quantity of available wastewater and sewage sludge (treatment level)

2.1 ECOLOGICAL ISSUES

Biomass production systems based on the growing of the shrub form of willow or poplar should be designed in order to achieve maximum biomass production, while at the same time maintaining soil productivity and ensuring an enhanced nutrient cycle.

Soil fertility: Proposed EU regulations[8] concerning environmental strategies for the protection and sustainable use of soil have as their main objectives the prevention of further degradation of soil and preservation of its functions and the restoration of degraded soil. They clearly state that "Member States would be required to ensure that land users whose actions might hamper significantly soil functions like biomass production, storing of nutrients and water, supporting biodiversity and acting as a carbon pool, take precautions to prevent or minimize the impact" (Art. 4 COM[2006]231).

While on one hand the application of wastewater and sewage sludge might be introduced as a practice to improve the economic viability of short-rotation plantations, on the other hand the application of wastes may bring potential environmental hazards. Therefore site selection must respect such limitations whilst acknowledging other important factors- among them the crucial role played by natural and climatic determinants.

Climatic conditions, snow and frost: It is generally accepted that genus Salix which can be considered as the best option for SRP for regions in Central and Northern Europe is very tolerant to a wide range of climatic and soil factors. A number of Salix species can grow near the Arctic and mountain snows making Salix the most climatic tolerant wood species in Europe. Climatic restrictions in the case of this species are therefore not so important.

Poplars seem to have different climatic and water demands, growing better in warmer climates and having lower water requirements. Poplar is far more susceptible than willow to frost, therefore its low winter hardiness limits its climatic range. Autumn and spring frosts can cause a lot of damage in poplar plantations. Even poplars originating from North America cannot grow well under conditions of North and Central Europe because they start their growth in early spring and are therefore susceptible to spring frosts. Climatic conditions therefore seem to limit the location of poplar plantations more than soil factors.

There are reports from Sweden that heavy wet snow can press down upon willow shoots and may result in plant breakage at the stump. Young stems are also vulnerable to ice cover in the winter under certain (relatively rare) weather conditions and may also experience breakage. Older stems are thick and therefore able to resist the advance of ice for a few days. Such risks therefore have to be taken into account when selecting SRP sites in areas where heavy snowfalls are common.

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[8] COM[2006]231 amending Directive 2004/35/EC

Water availability: It must be stressed that biomass production is limited by water availability even in the cool and wet climate of northern Europe. Willows therefore appear to be inherently sensitive to water stress. It is known that Salix is characterized by a very high evapotranspiration rate and by its ability to withstand seasonal flooding. On the other hand Salix roots cannot survive long periods of anaerobic conditions and hence permanently flooded sites cannot be taken into consideration as a site for SRP. Willow is able to give a substantially high biomass yield when precipitation is higher than 575 – 600 mm annually. If waste water irrigation is an option, then dryer sites may be selected because low rainfall will be compensated for, provided that a good supply of essential nutrients is forthcoming.

Groundwater: It is generally accepted that groundwater tables for maintaining high productivity of biomass cannot be lower than 120-150 cm. Therefore light sandy soils should be excluded as an appropriate SRP site. To some extent irrigation with wastewater facilitated the introduction of SRP on sites where the ground water table is deeper. Additionally, the growing of SRP on sites with a lower groundwater table can avoid the risk of groundwater pollution with nutrients originating from sewage sludge application. In many ways therefore the method of plantation management chosen will determine site selection.

Exclusion of peaty soils: Peaty or organic soils also prove restrictive in terms of site selection for fast growing willow or poplar species. Despite the fact that several willow species naturally grow on peaty soils, modern fast growing varieties are not able to develop strong enough root systems on such ground, resulting in poor plant structure exhibiting a tall and heavy stalk but with a weak root system. Organic (peaty) soils must also be excluded as an appropriate site for SRP given that heavy machinery cannot operate under such conditions. The natural process taking place in peaty soils often leads to anaerobic conditions which are very harmful for the developing roots of active growing plants.

2.2 Management issues

Topographical and geographical aspects: In many countries legislation prohibits the application of wastewater and sewage sludge close to conservation areas, reservoirs and natural tributaries. Therefore before making a final decision in terms of SRP establishment and the potential application of waste water and sewage sludge, the environmental protection policy of a given country must be taken into account.

Bearing in mind the aforementioned restrictions, the ideal site for SRP establishment represents mineral rich soils abundant in nutrients and organic matter, and flat land given that selecting fields which can be harvested economically is of critical importance. The best soils are loamy sand, light loamy clays i.e. soils of high agricultural quality with good aeration and moisture retention. Due to the fact that these soils are also ideal for food and fodder crop production means that compromises will have to be made.

Of the environmental benefits of SRP establishment, the most advantageous is their rapid growth rate and short rotations, so they can take up excess nitrogen and phosphorus runoff from many agricultural activities. Some of these nutrients are removed from the system at harvest, and the rapid coppice re-growth requires continued high rates of nutrient uptake which can be facilitated by the application of wastewater and sewage sludge.

Wild animals: In the spring, the young foliage of poplar and willow plantations may be browsed by wild animals, as the young leaves are soft and tasty. Losses made by animals (e.g. different deer species, elks, hares and other herbivorous animals) in the establishment phase of SRP, through the browsing and trampling of plants, can in some cases lead to the total destruction of the plantation. If SRP is intended to be planted close to forested land, then consultations with the local forestry administration and fencing of the plantation must be considered.

Infrastructure and vehicle access: Existing infrastructure is another factor which should be taken into account when selecting an SRP site, as in most countries profitable SRP cultivation requires the introduction of heavy machinery. This includes a road network enabling proper logistics throughout the whole SRP growth cycle starting from pre-planting site preparation, the delivery of cuttings, infrastructure for sewage sludge transportation, pipeline transportation of wastewater during the lifespan of the plantation, and ending with the harvesting and transportation of the harvested biomass. Consequently, spatial distribution of SRP will affect the economics of the whole system.

It is important not to have high tension electricity wires hanging lower than 6m above the ground surface, as poplar and willow plants when harvested in three to four year cycles can grow up to 8m.

Distance to end user: There are recommendations concerning the maximum distance between the SRP site and the end-user of biomass. This depends on many factors but among them the capacity of transportation units and the existing road system, as well as fuel price are crucial. A maximum distance of 40-80 km between the end biomass user and the SRP is generally recommended. Close proximity to a heat or power plant interested in purchasing biomass fuel would represent a very positive advantage for SRP establishment. Where wastewater and sewage sludge will be used to increase SRP productivity and to utilize wastes, site selection should aim to minimize the cost of transporting large amounts of waste substances as well as minimizing the cost of the transportable biomass produced.

Size of plantation: The issue of a minimum size of short-rotation plantation is often raised by potential growers and farmers associations. The answer cannot be easily found because it depends mainly on land availability and the existing market for biomass, but based on the system of subsidies, the area of 1 ha is considered the minimum.

2.3 Environmental and social issues

Landscape and biodiversity: The multifunctional character of SRP is that it has a high wildlife value, providing a rich habitat and food source for diverse organisms. There is evidence to suggest a rich insect fauna (ca. to 450 species) associated with willows. Numerous invertebrate herbivores from aphids to caterpillars feed on willows, and support a large food-web of higher trophic level organisms. Many animals depend on willows for food (mostly leaf, stem and bud tissue) and shelter; willows provide browse for deer, moose and livestock, and willow wood is a preferred food and building material for beavers.

Picture 6. Willow plantations in agricultural landscape. [Photos by: N.-E. Nordh, SLU]

By providing a habitat for numerous bird populations, SRP have been proposed as an alternative to intensively managed farmlands in order to halt the impoverishment of farmland biodiversity in Europe, as they enable a decrease in cultivation intensity and use of pesticides. Across the agricultural landscape, frequently there is a need for improved biodiversity and hence such factors should be taken into consideration while selecting sites for SRP.

It is important to consider that groupings of trees with shrubs of several species will look more natural and attractive than monoculture plantings. Perennial biomass crops will influence the ecological status of adjacent lands, as well as the sites on which they are planted. The extent of such influence is likely to be in proportion to the area planted to the new crop. This acreage would account for ca. 1% of the area in an 80 km transport radius surrounding the power plant. Several studies are ongoing or planned to consider this impact, including insect, avian and soil micro-arthropod diversity, and abundance and use of SRP. These impacts will be compared among species and clones with areas of native willow and other types of open/agricultural land, providing baseline information on the affect of willow crops on biodiversity and landscape ecology.

In order to maintain a high level of landscape biodiversity, it is suggested that the shape and size of the proposed plantation should also be taken into account when selecting the site. The results of numerous studies would suggest that the most biodiversity rich landscapes are border zones between SRP and open fields. Therefore to encourage higher biodiversity across agricultural landscapes one large area of SRP should be replaced by several smaller fields. So from this point of view 10 fields of 5 ha will create more habitats for wildlife that one big plantation of an area of 50 ha. Such site design may have to be compromised however, by the existing road network and the need to facilitate the effective use of heavy machinery introduced.

Soil erosion: Willows and poplars have diffuse and extensive perennial root systems which help prevent soil erosion. However, concerns were expressed about erosion on susceptible soils during the SRP establishment phase particularly when planted on sandy soils. During the lifespan of the SRP, an added benefit in terms of soil erosion protection relates to the fact that harvesting tends to be carried out during the winter months when the ground may be frozen. Moreover, harvesting is performed once every three to four growing seasons resulting in lower soil compaction and lower erosion threats compared to annual farm crops. However, during the first growing season willows and poplars cannot protect the soil against erosion, which when combined with the need for heavy vehicular access to the site, means that the slope of the land should be no more than 7% and never should it exceed 15%. Rules governing the operation of heavy machinery will determine the maximum slope where SRP can be established.

It must be kept in mind that in the first year of its establishment the SRP plantation is more similar to a field of cabbage than to a dense forest. This has led to research on alternative methods of site preparation. Results indicate that cover crops, like wheat or rye and changes in the timing of tillage practices can effectively be incorporated during the establishment of SRP without compromising, and in some cases increasing, above-ground biomass production. The approach to managing cover crops during the establishment of willow requires balancing three critical factors: aboveground biomass production, weed control and residue cover.

Social aspects: In addition to the natural and technical determinants which influence site selection for SRP, social factors also play an important role. It is assumed that biomass production in rural areas can create new jobs. According to Polish data, an area of 10,000 ha of SRP has the potential to create 3,000 new jobs. Even if this calculation may be true only for countries with relatively low labour costs, such information must be considered as part of the SRP site selection process, to avoid the potential barrier of an insufficient local labour supply. It is generally accepted that introducing SRP into agricultural land has a positive impact on rural development. Swedish studies revealed that willingness to grow SRP is highest among farmers with greater educational achievement and above average sized farm plots.

The selection of the SRP site and its determined acreage are processes which may be aided by **GIS** systems together with knowledge of the social and economic structure of the farm in question.

3 PLANTATION DESIGN AND PLANTING

This chapter is devoted to issues in the pre-planting phase as well as the establishment of the SRP site. The information is important in order to achieve a profitable and affordable system that fulfills the needs of biomass production for energy purposes and wastewater/sludge utilization if planned over a 20-25 year lifespan. Therefore all the issues under discussion should be considered and adapted to local conditions.

While considering different options for SRP design one has to take into account different criteria:

- the potential crop yield in a particular site,
- affordable investment to the SRP establishment,
- local support schemes and restrictions to different crops from the various species available in the market.

Such criteria vary from country to country and hence consultation with local farmers' organizations or respective companies is advised, which can be important partners and stakeholders in the process of establishing a SRP. Furthermore, the availability of both land and finance is strongly farm-dependent and therefore individual analysis is also required.

3.1 CHOICE OF PLANTING MATERIAL

From an economic point of view the most important factor when choosing plant material is the potential crop yield. However, one must also assess the microclimate of the proposed plantation area (soil moisture content, probability of late spring frosts etc.) before looking for **suitable planting material** from cuttings producers (see Table 2). When choosing suitable material, licensed plant nurseries should be the preferred source, as their planting material is a product of extensive breeding research programs and therefore of predictable characteristics and good quality. In general poplars are more drought resistant than willows, but suffer more often from frosts. Also different willow/poplar clones may have different frost, drought and disease resistance characteristics/tolerances. This is very important to bear in mind when choosing to establish a SRP with poplars or willows. The planting investment required is significant and therefore it is necessary that most of the plants survive not only during the first year but during subsequent harvesting cycles, to give a satisfactory wood yield for several years. Sometimes profit margins from biomass can be increased by energy crop subsidies available for particular species in some countries. Hence it is useful to be familiar with not only the availability, but the terms and conditions of such subsidy programs before SRP establishment. On the other hand, subsidy policy may change through time and should not be the main reason for entering into the bioenergy industry.

One option to reduce the risk of high plant mortality during the plantation lifespan is to use appropriate planting material for plantation establishment. The breeding programs of both willows and poplars continuously provide new clones and varieties with higher yield characteristics and improved tolerance to various risk factors. Typically they are compared in tests with some reference materials (see Table 2 and Table 3). Besides productivity, disease resistance and frost tolerance the **criteria for planting material choice** from particular genus should also include clone resprouting capacity after coppicing and typical crown shape. Tree-shaped clones have a higher wood/bark ratio and therefore a higher energetic value. On the other hand, large shoot diameters can cause a problem during harvesting for some specific harvesters if the plantation is planned to coppice less often.

Criteria for planting material choice:

- Species and clones (or combinations of species and clones) suitable for local site conditions
- Productivity and clone resprouting after coppicing
- Disease resistance and frost tolerance
- Typical crown shape
- Material from licensed nurseries

Farmers are sometimes encouraged to plant 4-8 clones into separate rows/blocks of a plantation in order to decrease the infection risks. For example, there is information available to suggest that in the **mixed-clone SRP**, the resistance of willows to the most common pathogen - leaf rust - is higher than in monoclonal stands. Furthermore, in the dense mixed-clone plantation, surviving plants are likely to quickly occupy the empty space left by clones vulnerable to disease attack, and hence increase plantation yield. On the other hand, given that clones may differ in their shape, shoot production capacity or average shoot diameter, mixed-clone plantations can be problematic when harvesting and one should consider the planting of different material of the same amount of clones in separate rows/plots. Farmers should therefore evaluate the probability of the various risks before planting.

Table 2. Examples of poplars with different resistance to various diseases and wind [Source: CRA-ISCI].

Species	Clone	Breeder	Resistance to		
			medium	high	very high
Populus x Canadensis Mönch	83.148.041	CRA-ISP	Discosporium populeum, Cytospora spp., Phomopsis spp., Dothichiza populea,		Venturia spp., Melampsora spp., Marssonina spp., PMV, Phloeomyzus passerinii (Sign.)
Populus x Canadensis Mönch	AF2	Franco Alasia, Cavallermaggiore (CN)	Discosporium populeum, Cytospora spp., Phomopsis spp., Dothichiza populea	Wind	Venturia spp., Melampsora spp., Marssonina spp., PMV, Phloeomyzus passerinii (Sign.)
Populus alba L.	Marte	DISAFRUS UNITUS Viterbo Franco Alasia, Cavallermaggiore (CN)		Wind	Venturia spp., Melampsora spp., Marssonina spp., PMV, Phloeomyzus passerinii (Sign.), Dothichiza populea, Cytospora spp., Phomopsis spp.
Populus L. spp.	Monviso	Franco Alasia, Cavallermaggiore (CN)	Wind	PMV, Phloeomyzus passerinii (Sign.)	Venturia spp., Melampsora spp., Marssonina spp., Discosporium populeum, Cytospora spp., Phomopsis spp.
Populus L. spp.	Pegaso	Franco Alasia, Cavallermaggiore (CN)	PMV, Phloeomyzus passerinii (Sign.)	Melampsora spp., wind	Venturia spp., Marssonina spp., Dothichiza populea, Discosporium populeum, Cytospora spp., Phomopsis spp.
Populus alba L.	Saturno	DISAFRUS UNITUS Viterbo Franco Alasia, Cavallermaggiore (CN)		Wind	Venturia spp., Melampsora spp., Marssonina spp., Dothichiza populea, Discosporium populeum, Cytospora spp., Phomopsis spp., PMV, Phloeomyzus passerinii
P.deltoides Bartr. X Populus x Canadensis Mönch	Sirio	Franco Alasia, Cavallermaggiore (CN)	Phloeomyzus passerinii (Sign.), wind	Dothichiza populea, Discosporium populeum, Cytospora spp., Phomopsis spp.	Venturia spp., Melampsora spp., Marssonina spp., PMV
Populus x generosa X Populus nigra	AF6	Franco Alasia, Cavallermaggiore (CN)	Melampsora spp.	Marssonina spp., Dothichiza populea, Discosporium populeum, Cytospora spp., Phomopsis spp., wind Phloeomyzus passerinii	Venturia spp., PMV
Populus x generosa	AF8	Franco Alasia, Cavallermaggiore (CN)		Melampsora spp., Marssonina spp., Dothichiza populea, Discosporium populeum, Cytospora spp., Phomopsis spp., Phloeomyzus passerinii	Venturia spp., PMV, wind

Table 3. Relative yield and resistance of selected willow clones (%) to some crucial factors [Source: Lantmännen Agroenergi].

Variety	Rel. yield	Leaf rust	Insects	Leaf beetles	Frost
L78183 (ref)	100	100	100	100	relative tolerant
Tora	157	0,3	45	111	medium
Torhild	123	2	87	107	relative tolerant
Sven	139	0,3	116	104	relative tolerant
Olof	143	12	44	106	relative tolerant
Gudrun	144	0	28	22	tolerant
Tordis	144	0	59	86	relative tolerant
Inger	144	0	59	86	relative tolerant
Sherwood 146	146	28	79	-	-
Doris	149	31	30	11	-
Karin	126	2	88	-	-

In order to maximize plantation yield, to increase the number of various crops or to have a more variable landscape one may decide to also use other perennial energy crops alongside willows or poplars. However, in such case one has to check for suitable species from local environmental offices, because numerous perennials currently promoted as energy crops in different countries are hybrids of non-native species and hence their importation or cultivation in another country may be prohibited.

3.2 Land preparation and weed control

Most of the **land preparation procedures** for SRP are common practices in agriculture. For example, the requirements for soil structure and tillage are similar to those for grain production. However, as both poplars and willows are perennial plants with quite poor aboveground growth during the first growing season, and their planting density in field is much lower than that of cereals; much more attention should be paid to weed control before planting. **Competition with weeds is the most typical problem** that influences SRP growth during the first vegetation period and it can cause poor growth, a higher rate of plant mortality and insufficient yield of the plantation during its lifespan. Even more devoted weed control is needed if wastewater or sewage sludge application is planned, because both additional irrigation and nutrients will also increase the growth rate of various weed species. Perennial weeds should be sprayed with a herbicide containing glyphosate during their active growth phase before ploughing in autumn. Depending on the previous land usage and management quality, a second application with the same chemical some weeks later may be necessary. In spring additional weed control should be carried out before planting with a seed herbicide (e.g. Stomp, Flexidor are valid in spring 2008), with no additional tillage then taking place.

Once the first buds emerge in the plantation, only contact chemicals or mechanical weed control between the rows is suggested, as there is no selective herbicide without serious influence on SRP growth in the market yet. In the early stage of SRP the area between the rows can be tilled with the same equipment used for weed control of vegetable crop fields. However, at a later stage this method may harm the fine root system of the plants, which spread rapidly in the upper 10 cm layer of the soil. In this case a grass cutter can be used for mechanical weed control. For **contact weed control**, special equipment including a glyphosate tank with hoses fixed to the width of the paths between rows could be applicable. If a significant weed problem occurs, glyphosate application during the early spring period of the second growing season will be an additional option if the one-year-old shoots of SRP are harvested before. If weed control has been successful during the first two growing seasons, canopy closure will suppress the less shade-tolerant weeds. Typically weed cover after the SRP harvest is already much less, because of the strong root system established and the rapid growth of new plant shoots during this stage. Some weeds remain in the SRP plantation during the whole rotation period without any influence on crop production, but help to maintain soil moisture content and prevent erosion. Moreover, the **ground cover vegetation** increases the biodiversity of the plantation and provides a natural habitat to various insects, small mammals and birds. Therefore diligent control of such ground cover flora does not give any economical nor ecological benefit (see Picture 7).

Picture 7. Accompanying ground vegetation does not limit SRP growth after a certain development phase. [Photo by K. Heinsoo, EAU]

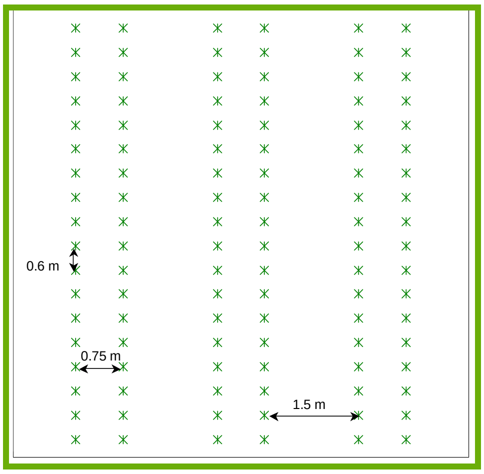
Before planting it is necessary to select a plantation design that will be compatible with the planned management and harvesting system to be adopted. For example, the required distances between the plant rows that allow for mechanical weed control and harvesting without damaging the plant stumps. For practical reasons it is also necessary to have

headlands of at least 8m in width to allow vehicle turning, otherwise both plant stumps and vehicle tires can be damaged. On the other hand, in an area of heavy soil with predictably high moisture content, during harvesting the root systems of SRP crop can perform additional carrying capacity. The maximum row length is limited by the harvesting technique off-load needs – for example for a harvester with an integrated trailer it should be kept to less than 200m. Headlands in the plantation help increase its biodiversity. However, wide headlands incorporating a significant area decrease the yield of the plantation per hectare. A large headland to SRP ratio can also reduce the possibilities for agricultural subsidies for energy crop production. Furthermore, the particular requirements and design of sludge or wastewater application equipment should be kept in mind during the plantation design phase. It is reasonable to use the headland area for an underground pipe system, such as that required for the transportation of wastewater to the SRP.

A further factor that must be considered during plantation design is the existence of **electric power lines** in the planned SRP area. Mature willows and poplars can grow up to 4-6m in height, and therefore it is prohibited to plant them under electric power lines. On the other hand, for farmers who propose to utilize wastewater for SRP irrigation, access to a power supply is required to operate the necessary pumping system. The width of the required security zone around power lines depends on the voltage of the actual line and should be specified in accordance with guidelines set by local authorities. The profitable plantation area can remain high if such security zones are planned to be used as headlands.

The **most typical SRP design** incorporates double rows 0.75m apart, with a 1.5m corridor between them. In this case the vehicle wheels operating in the large corridors between the plants do not harm the plant stems nor damage the pipe facilitating wastewater irrigation of the double row. The distance between plants within the rows is variable depending on a number of factors. Usually the planting density for poplars is lower than that for willows due to their more rapid height growth in favourable conditions. A denser plantation results in quicker canopy closure and maximisation of yield per ha. On the other hand, the wood/bark ratio in the case of a large number of thinner shoots is lower, resulting in an inferior heating value of the woodchip. The harvesting cycle in denser plantations should also be shorter to avoid dieback of crop plants in serious competition with each other. The relative planting cost depends significantly on the number of cuttings incorporated per area.

Considering all these factors, today it is suggested that one ha of SRP plantation should contain approximately 12 to 18 thousand willows, planted between 0.5 to 0.75m apart respectively, in a row. The suggested plant density for poplars is from 8 to 12 thousand plants per ha. Lower plant densities can help reduce planting costs, but are likely to result in more serious weed problems in the longer term. Furthermore, high biomass productivity per plantation hectare will only be achieved much later in this case. One possible planting scheme is illustrated on Picture 8. If the harvester that is planned to be used requires a different plantation layout (rows with equal distance, other distance between the rows etc.), an alternative planting scheme should be designed taking into account such factors as average plant density and the shelter area required for potential irrigation pipe establishment.



Picture 8. Typical willow SRP plantation layout where each plant is marked with an asterisk (A). Plantation design should allow for the harvesting machinery to operate in the areas between the plants (B). [Photo by: K. Heinsoo, EAU]

3.3 PLANTING PROCEDURES

In order to ensure the sustainability of the SRP over its lifespan, best practice must be observed for both cutting quality and planting techniques. The **quality of the cuttings** used is important, and planting material should only be bought from a reputable source. In some countries the planting material invoice is required for the reimbursement of investment costs under energy crop subsidy schemes. One must also bear in mind that planting material from varieties covered by Plant Variety Rights legislation may not be reproduced for planting or sale without permission from the original plant breeder.

The cuttings are usually produced in **plant nurseries** between December and March before the growing season. This timing ensures that the plant buds are fully dormant and the planting material is at its optimum quality. Once the buds have started to burst, the cuttings will not root easily and tend to loose a significant amount of water via transpiration through the buds. Planting of such material should be avoided. In order to obtain the **best quality planting material** in the required quantity and clonal diversity, it is necessary to order the material from the nursery in autumn or early winter well before the planned planting season.

If it is not possible to plant the cuttings immediately after delivery the planting material should be stored under refrigeration at a temperature of between -2 and -4 ºC, and at the appropriate humidity level. In order to avoid moisture loss in the cuttings they can also be packed in plastic bags. However, in this case they must be controlled from time to time to avoid mould growth. The cuttings must always be stored in their natural position in terms of the orientation of their upper and lower parts to prevent reallocation of different biologically active compounds responsible for root and shoot development. During transportation and before planting the cuttings should be kept in a cool environment and protected against direct sunlight.

Depending on the planting machinery to be adopted, the cuttings may be pre-cut to 15-25cm long sticks or delivered as 2-3m length rods. During planting these rods will be automatically made into **suitably length cuttings** as they go through the planting heads of the Step Planter. The diameter of the high-quality cutting ready for planting is 1-2cm at the midpoint. The poplar cuttings should have a healthy bud about 1cm below the top cut. Quality control can be performed by placing a number of delivered cuttings in water and by keeping them at room temperature and with access to daylight for 14 days. During that period healthy cuttings of both species should have root tips visible and some noticeable bud burst

Some days before planting it is useful to place the cuttings into a water filled container at room temperature or moisten them in other ways in order to promote early growth. It is important to check the correct orientation of the planting material in storage packages (see Picture 9). Some suppliers mark the top of the cuttings with a marker or paint to ensure their correct vertical orientation.

Picture 9. Planting material stored in a dug out ditch with water enables the water uptake necessary to promote rooting after planting in spring. [Photo by: K. Heinsoo, EAU]

Planting should be carried out in spring after the last phase of weed control and soil preparation, when the temperature is above +5 ºC necessary to enable the cuttings to start growing. The earlier planting is possible the better, to take advantage of moisture in the soil after snow melting. If a dry season is forecasted after the proposed planting phase, a longer period of storage of the cuttings in water before planting may be sensible. Treatment of the top area of the cutting with a special transpiration-protective chemical can also be preformed.

Picture 10. Use of chains for proper distant planting. [Photo by: A. Ramos Fernandez, ASAJA]

If a planting machine is used, planting should be carried out according to the manual supplied. When planting manually, a hole should be made into the appropriate position in the plantation with a sharp stick and the cutting should be pushed into the soil leaving the upper 1cm above ground level. For poplars the upper bud should remain above ground (see Picture 10).

Picture 11. For SRP planting different types of machinery can be used. The time and work load required for one hectare of short cuttings planting (A) is much larger than for long rod step-planting (B). [Photos by: T.Tilger, EAU; N.-E. Nordh, SLU respectively]

Different special **planting equipment** is available and therefore labour and time required for this activity depends largely on the technical characteristics of the unit employed (see Picture 11). Shorter cuttings may also be planted with the help of adapted horticultural planters. In smaller SRP fields planting may also be carried out manually. In many countries a specialist poplar and willow planting service provider is available. Before plantation establishment, farmers should analyse if it is economically more viable to use a professional provider for assistance, or to carry out all the planting procedures independently, in order to get a good quality SRP plantation with a high yield over its complete life span.

4 SAFE REUSE OF MUNICIPAL WASTEWATER AND SEWAGE SLUDGE FOR IRRIGATION AND FERTILIZATION

Considering current wood prices throughout Europe, conventional woodchip production in SRP offers economic profits that may not be as high as that of other conventional crops. Therefore, **residues from the local community** in the form of wastewater and sewage sludge from municipal wastewater treatment plants could be applied to SRP fields for fertilization, helping to reduce production **costs** and furthermore create **additional income-generating opportunities through** their biological treatment. Additionally, **increasing biomass growth, the recycling of nutrients** and the **reduction of pollution** in adjacent water bodies can be achieved, thereby enabling initiatives such as the Water Framework and Nitrates Directive to be met. Depending on local interests, such activity can also be **supported by local authorities** or companies responsible for wastewater treatment and sewage sludge management.

The application of wastewater or sewage sludge to SRPs, besides creating several economic and environmental benefits, can also cause problems, if not managed properly. This chapter discusses current issues and practices regarding the safe ecological and sanitary use of municipal waste water and sewage sludge on SRPs, in order to enhance opportunities whilst avoiding the potential risks associated with such activity.

The key stakeholders and partners involved in supporting the process of wastewater and sewage sludge application from municipal treatment plants on SRPs include **local authorities** and the **municipal institutions or private companies responsible for wastewater treatment and sewage sludge management**. Projects have proven to be most successful where constructive communication and cooperation links have been built up amongst the partners involved.

4.1 GENERAL REMARKS

SRPs with willows or poplars are in general considered appropriate for wastewater/sludge utilization. A range of features of such species have been shown to be advantageous for such practices compared with other crops.

Willows and poplars have:

- high water demands and high evapotranspiration rates,
- high nutrient-use efficiencies (particularly willow since it is a pioneer species),
- a shallow root system with a good ability to withstand anoxic conditions (especially willow),
- and an ability to take-up certain heavy metals (especially Cadmium - Cd).

As a **non-food non-fodder agricultural crop**, SRPs do not impose direct risks of heavy metal entrance into the food chain, and therefore in general threats to human health e.g. by heavy metals are limited. Moreover, it has been demonstrated that willows in particular can take up substantial amounts of certain heavy metals. Therefore, supply for example of Cd via sewage sludge is more than compensated by Cd uptake in the willow biomass shoots. Sanitary and odour problems are also not present after such practices, since sludge and wastewater pre-treatment prevents such problems occurring.

Wastewater irrigation and sewage sludge application to SRPs can be a cost effective and environmentally friendly way:

- to increase biomass production on poor soils, thus increasing farmer profit,
- to decrease energy demand for treatment of N, P and organic compounds thus reducing the costs of the entire wastewater treatment process,
- to recycle nutrients from human residues and contribute to sustainability, also with clear positive effects on the environment (less pollutant discharges into receiving water bodies), and
- to compensate for water needs of the crop (esp. in areas with scarce fresh water resources as in South and Middle Europe),
- to extract heavy metals from the food chain (esp. when heavy-metals are taken up by SRP crops and extracted and disposed of from ashes after burning the woodchip).

However, a sustainable practice of applying residual products to willow or poplar fields is only achievable if this reuse is performed in an environmental and hygienic safe way. Therefore, a farmer has to perform a series of careful actions before and after the establishment of SRPs to avoid environmental hazards. A range of factors for consideration related to the safe use of wastewater/sludge on SRPs is presented below. For safety reasons, it is **recommended to only use pre-treated wastewater and sludges**. Specific requirements for pre-treatment are usually regulated by local authorities, but if not regulated, EC directives and best practice should be taken into account throughout all activities.

4.2 Applications of Municipal Sludge

Sewage sludge results from wastewater treatment practices, the trend for which is increasing in almost all EU countries. The increasing number of wastewater treatment systems and the modernisation of existing plants also implies a need for handling sewage sludge in an environmentally sound way. As sewage sludge contains considerable amounts of plant nutrients, its reuse as fertilizer in agriculture is a somewhat common practice that supports recycling of nutrients from human residues as an overall accepted objective (Directive 86/278/EEC).

4.2.1 SLUDGE COMPOSITION

As sewage sludge generation is a result of different wastewater treatment steps (sedimentation, activated sludge etc), its composition depends very much on the quality of the incoming wastewater and the overall treatment process. Further, its applicability in SRP is influenced by the sludge treatment including biological, chemical or thermal processes (composting, liming, dewatering, etc).

In terms of plant nutrients, pretreated sewage sludge contains high levels of P for which optimism exists that it may be recycled in agriculture, some N (mainly organically bound) but very little K. Therefore, sewage sludge is not a balanced fertilizer and for soils with N and K deficiency**, additional fertilization is suggested** to reach local recommendations for these elements. Indicative concentrations of nutrient elements in municipal sewage sludge used in BIOPROS experiments in the different countries are presented in Table 4, showing vast country to country differences.

Table 4. Concentrations of different elements in sewage sludge (examples from sewage sludge used in BIOPROS experiments in different countries) [mg/kg DM]

	N	P	K	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Estonia	22700	20000	3000	2.50	190	190	0.71	53.00	51.00	720
Germany	23100	28200	510	0.94	24.00	699	0.27	15.00	16.00	478
Poland	30500	13250	NA	4.70	26.90	127	1.33	27.50	77.50	1124
Spain	45000	22485	NA	1.40	44.20	160	1.20	22.00	67.50	400

In addition to the useful nutrient elements, sewage sludge also contains quantities of various heavy metals and other unwanted substances, such as organic pollutants. Heavy metals in sewage sludge can emanate from domestic sources (discharge from households, corrosion of distribution material, detergents etc), commercial sources (industries, dental and healthcare etc), and from urban run-off. Usually, sludge quality from treatment plants with state-of-the-art technology is good and concentrations of heavy metals are low and within the suggested limits, and therefore appropriate for SRP application. In some cases however, heavy metals can be a hindrance to sustainability and therefore need to be taken into account. Usually, wastewater treatment plants with available pre-treated sewage sludge for external use provide both **quality and quantity certificates** that ensure the safe use of sludge in agricultural soils.

Before applying sewage sludge in a SRP site, the **related legislation** for such applications must be considered (limit values are presented for some countries in Annex 8.1). Legislation usually concerns:

- the quality of sludge applied (e.g. max. concentrations of hazardous compounds in sludge),
- the quantity of sludge applied (e.g. max. amounts of hazardous compounds supplied to the field), and
- the quality of soil after sludge application (e.g. max. concentrations in agricultural soil).

4.2.2 ASPECTS TO BE CONSIDERED FOR SEWAGE SLUDGE APPLICATION

- The wastewater treatment plant that produces and supplies the sewage sludge for SRP application should be responsible for the quality of the sludge delivered. There is usually a range of regulated substances related to sludge quality for agricultural applications. Typically, concentrations of organic pollutants and of heavy metals (usually for Cd, Cr, Hg, Ni, Pb, Zn) are regulated.
- EU recommendations such as the Sewage Sludge Directive 86/278/EEC are specified sometimes in terms of the national regulation standards applied in the respective countries (see Annex 8.1). In certain countries, the use of "fresh" untreated sludge is prohibited and there are regulations concerning the storage of sludge for certain periods of time prior to application. However, the responsibility for sludge of appropriate quality for agricultural applications must lie with the respective supplier, and farmers should be reassured by the local wastewater treatment plant for its safe use.
- In most European countries there is legislation limiting the quantity of **sludge applied based on** the amounts of **P, N, heavy metals** and other pollutants applied with it to the field. This is usually supplemented by **national legislation** related to the allowed maximum load for various elements, which may differ substantially across the various European countries (see Annex 8.2). These limits must be respected by the farmer when applying sewage sludge in the field, and hence **data resulting from sludge analyses** for heavy metals, N and P must be made available to the farmer in advance by the sludge provider. Sludge application should only be carried out once calculations regarding the quantity of wet sludge that may be applied are completed, which base themselves on the actual concentrations of the regulated compounds and which consider the most limiting factor in that particular case.

Picture 12. Application of sewage sludge in an SRP with Salix in Sweden. [Photo by: I. Dimitriou, SLU]

- In order to determine **soil quality** before and after sludge application, **analyses of top-soil** for heavy metal and nutrient (e.g. P, N and K) content should to be carried out at both pre- and post-application stage. **Analyses** prior to applications will determine the **P amounts** that can be applied in the field, since in most cases regulations vary for different soil contents. If legislation for maximum soil concentrations of **heavy metals** exists, it should be taken into account before and after sludge applications as well (see Annex 8.2).
- The **method** of sludge application should be considered well in advance. Sludge may be applied by existent farm machinery, e.g. equipment for spreading conventional fertilizer or manure (Picture 12). Sludge application should be performed every year for a balanced fertilization, but due to rapid SRP growth in most cases it is only technically possible after each harvest. **Additional fertilization** with conventional fertilizer for N and K **may be necessary** to balance the nutrients available for maximum growth (see above). These amounts should be decided considering the N or K amounts applied with sludge.

4.3 IRRIGATION AND FERTILIZATION WITH WASTEWATER

Wastewater irrigation of the SRP offers the farmer an alternative water supply where fresh water is scarce, as well as a reduction in fertilization costs and an additional income from wastewater treatment companies by using the SRP as a step in the wastewater treatment process. SRPs contribute to a reduction in pollution to neighbouring water bodies (via uptake of nutrients-in-excess) and to soil (via uptake of heavy metals). However, for successful use of SRP for biomass production and wastewater treatment, this open-system approach requires careful implementation and appropriate monitoring. In order to implement a safe and profitable SRP wastewater treatment system, a number of factors require consideration as per follows.

4.3.1 ASPECTS TO BE CONSIDERED FOR SAFE WASTEWATER IRRIGATION

- **Agreement with local authorities: Discussion with local authorities** is crucial in order to reach agreement **for** acquiring **permission** for wastewater irrigation; to agree how and by whom environmental **monitoring** will be carried out; and to discuss **economic** factors such as sharing costs. It is logical that for such issues, the wastewater treatment plant and the farmer will share responsibility. For example, the wastewater treatment plant can lead discussions with the relative authorities and take responsibility for compiling monitoring data from the field. The farmer can be responsible for more practical issues in the field concerning monitoring, e.g. collecting samples. For more information about things to consider with respect to contractual issues see Chapter 6 and 8.6).
- **Field appropriateness:** The location of the field is critical in considering whether wastewater irrigation of the SRP is appropriate. **Avoid** fields that can be sensitive to nitrate leaching, e.g. fields on **slopes** or with a **high groundwater** level. Also, close proximity to the **wastewater source** is obligatory in order to decrease transport costs. In cases where there is sufficient land available, the size of the area required to be cultivated with SRPs for sustainable use of wastewater will depend on local soil characteristics, the chosen plant species and the wastewater parameters. Examples are provided below (also see Chapter 2).

- **Wastewater appropriateness:** In warm and dry areas, **sufficient wastewater supply must be ensured** throughout the growing season to avoid drought of the SRP. Direct application of untreated "raw" municipal wastewater in SRP is generally not recommended since it contains large fractions of unfavourable dissolved and undissolved matters. For **further pre-treatment** or "stabilisation", almost identical to common wastewater treatment approaches low- and high-tech options exist, but such techniques differ in terms of quality. "Pre-treatment" for SRP generally aims at the reduction of unfavourable substances for SRP cultivation (high BOD, heavy metals, organic pollutants) and operation (suspended solids and pathogens), whilst simultaneously retaining plant nutrients in the water. The difficulty lies in the fact that during the pre-treatment process the biological-chemical-physical reactions to reduce pollutants imply a certain loss of plant available nutrients (esp. N). **If only untreated wastewater** is available, low-cost approaches like stabilisation pond systems, septic tanks or aerated rock filters should be considered in the first instance in order to maintain the economic viability of the overall treatment concept. The selected technology will be influenced by the quantity of wastewater that requires treatment (by means of connected households or person equivalents) and the land available for pre-treatment and SRP. The bigger the quantity, the higher the pollution and the smaller the available land, the more reasonable are advanced technologies like secondary treatment systems.
- **Environmentally safe wastewater load:** In order to justify wastewater application to SRPs, and to **decide appropriate irrigation rates,** the interactions of local climate, soil, plant age, and wastewater need to be taken into account. **Existing legislation** regarding general wastewater use, maximum fertilization rates, the quality of groundwater, drinking water and adjacent water body quality (e.g. of lakes, rivers and streams) must be taken into account. The legislative limits concerning various substances (e.g. BOD, N and P) are country and site specific and must be clarified with local environmental authorities in advance. In places **where legislation does not define the exact quantity of wastewater allowed** for irrigation, all local conditions, and their interactions, should be taken into account in order to choose the "right" application rates. A simple tool to assess the maximum irrigation loads is presented below in Table 5, taking into account all specific factors at a given location.

The specific steps for model calculations referring to Table 5:

1. You have to find the appropriate values for your planned SRP field for the following variables X1, X2, X3, X4, X5, X15
2. From the wastewater purification plant ask for X8 and X17
3. Evaluate if the assumptions are suitable for your case
4. Calculate variable X6, X10, X11, X12, X13, X14, X16, X18
5. Compare X11 and X18 to identify Maximum Annual Irrigation Load

Table 5. Calculation tool to assess the maximum irrigation loads and the resulting NO3-N concentration in drainage water. [Source: SLU, EAU]

CURRENT SITUATION	**Variable**	**Action**	**Example**
Annual average precipitation (mm)	X1	Find out	
Annual average drainage (mm)	X2	Find out	200
Soil type (e.g. clay, loam, sand)	X3	Find out	
Current cropping intensity[9] (medium or high)	X4	Find out	
Current annual nitrogen leaching (kg N/ha yr)	X5	Find out	50
Current average nitrate-nitrogen concentration in drainage water (mg NO_3-N/l)	X6	X6 = (X5 x 0.9) x 100/ X2	22,5
NITROGEN LOAD			
Increased evapotranspiration from SRP (%)[10]	X7	Find from previous SRP or Constant	35
Nitrogen concentration of irrigation water (mg tot-N/l)	X8	Find out	200
Acceptable Nitrogen leaching load (kg N/ha yr)[11]	X9	=X5	50
Maximum N-load via irrigation (kg N/ha yr)	X10	If X5>20, then = (X5+20)*5 If X5<20, then = X5*10	350
Maximum irrigation load based on nitrogen (mm/yr)	**X11**	**=(X10/X8)*100**	**175**
Resulting NO_3-N concentration in drainage water (mg NO_3-N/l)[12]	X12	=([(0.9 x X5) / (X11 + X2)] x (100 + X7)	16.2
Change in drainage water NO_3-N concentration (mg NO_3-N/l)[13]	X13	=X12 – X6	- 6.3
Resulting drainage (mm/yr)	X14	= (X2 / X7) + X11	323.15
PHOSPHORUS LOAD			
Annual average P-removal through SRP harvest (kg P/ha yr)[14]	X15	Find from previous SRP or Constant	7
Annual sustainable P-application through irrigation (kg P/ha yr)[15]	X16	=X15+1	8
Average P-concentration of the irrigation water (mg P/l)	X17	Find out	0.6
Maximum annual irrigation load based on P (mm/yr)	**X18**	**=(X15*100)*X17**	**420**
MAXIMUM ANNUAL IRRIGATION LOAD		**MINIMUM OF X11 AND X18**	**175**

[9] Crops as grain, maize and others with similar management are assumed to be of medium intensity; Crops as potatoes, vegetables, rapeseed etc. to be of high intensity
[10] The increased evapotranspiration value from SRP in % is assumed to be 35%
[11] N leaching concentrations are a result of current leaching divided by annual drainage
[12] We assume that 10% of N is leached when the N-load with irrigation is up to 200 kg/ha yr and 20% when the N-load with irrigation exceeds 200 kg/ha yr.
[13] Leached NO3-N corresponds to 90% of the total N leached in SRPs
[14] P-removal through stem harvest is 8 kg/ha yr
[15] 1 kg P is allowed to leach while sustainable wastewater irrigation in SRP occurs

- **Choice of irrigation system:** The selected irrigation system should minimize hygienic risks and should also achieve an even distribution of wastewater near the irrigation point and across the entire field. Therefore, close to surface methods should be promoted to avoid the spreading of diseases. Typically high-tech solutions are more expensive and therefore one has to consider the various pro and contra factors of the different options available (see Table 6 below). For even distribution, the drip irrigation system has proved effective in many cases, but the higher costs involved and the risk for root clogging should not be overlooked. Other tested systems for wastewater have been proved appropriate for wastewater irrigation in SRPs.

Table 6. Advantages and disadvantages of different irrigation systems (see Annex 8.7 for further explanations of the ratings in the Table).

	Drill hole in pipes	Drip pipe	Sprinkler	Free flow	Ditches
1. Health protection	+	+	---	-	-
2. Nutrients control	+	+	+	---	--
3. Even distribution	+	+	+	--	-
4. Investment cost	-	-	-	+++	+
5. Running cost	-	--	--	+	+
6. Harvesting friendly	+	+	--	+	---
7. Life length	+	-	-	++	++
8. SRP feasibility	++	+	---	---	---

- **Operation of irrigation system:** Wastewater irrigation must start in spring parallel with SRP growth and finish shortly before the end of the growing season. Irrigation must start one year after SRP establishment when the trees have developed a root system and leaching is negligible. It should be performed daily during the selected period but should cease when heavy rainfall occurs to avoid extensive nutrient leaching or washing out of the wastewater. This can be done either manually or by installing automatic precipitation control systems. To avoid water logging and irrigation overload and to achieve an even wastewater distribution with minimal risks, irrigation should be shifted throughout the day to different parts of the field for short periods of time. This should be done automatically to avoid high labour costs, but manual control is also an alternative if labour costs are reasonable.

- **Monitoring:** Simple monitoring to evaluate environmental hazards due to wastewater irrigation in SRPs should be conducted regularly. This should take account of local legislation relating to soil and water protection in agriculture as mentioned in subchapters 4.2.2 and 4.3.1, as well as the effects of wastewater on soil, groundwater and adjacent water bodies. Typically this means conducting periodical groundwater sampling for chemical analyses throughout the irrigation periods, and according to the agreed monitoring scheme with local environmental authorities. This will give an indication of the leaching risk of N and P due to wastewater irrigation and will allow for adjustment of irrigation rates in case of high concentrations of these compounds in the groundwater. Additionally, water samples from the SRP edge areas may be needed for comparison with the natural situation.

Picture 13. Examples of irrigation systems for SRP irrigation with wastewater. [Photos by: A) + B) I. Dimitriou, SLU C) C. Johston, RGL D) D. Rosenquist, Laqua Treatment AB]

- **Backup system in case of malfunction:** As wastewater inflow may vary greatly throughout the year (e.g. storm water inflow after heavy rains, seasonal peak numbers of persons in a summer resort area etc.), installation of a backup system will ensure environmental safety of the wastewater-irrigated SRP. Furthermore, a short-term break in the wastewater transport pipe from its originating point may seriously damage a long-term investment during a drought period. The best solutions respectively are of course to have slightly larger wastewater storage ponds corresponding to the expected average inflow and to establish a well close to the SRP site. During the planning stage more cost-effective options can be considered, including the establishment of a buffer zone of other non-food crops around the SRP and the availability of a transportable water tank should be mentioned.

5 PLANTATION - CROP MANAGEMENT

This chapter describes the main SRP management activities which aim at maximizing plantation productivity and minimizing any possible negative effects. Further practical suggestions for pest control, harvesting and storage are provided as well as for biomass transport and the restoration of the filed after SRP cultivation.

Picture 14. Willows SRP in North Ireland. [Photo by: J. Gilliland, UFU]

5.1 PEST CONTROL

Poplars and willows are susceptible hosts to a **wide range of different pests** such as fungal pathogens, leaf eating insects and, in a minor way, viruses. Fungal diseases are the most relevant pest for SRP, especially in wet climates, and in the last 20 years monoculture plantations of willows and poplars helped the spread of such threat.

5.1.1 LEAF RUST

Among the fungal diseases **leaf rust** is the most well known and hazardous and is caused by a number of fungi of the *Melampsora* genus. Up to 30 years ago *Melampsora spp.* (Poplar rusts) was not so widespread in Europe, since they were observed only in autumn and in nurseries where the density of plants was obviously higher. Furthermore, resistant clones seem to tolerate low fungal pressure efficiently. However, from the mid 1980s, new and more transmittable types *Melampsora spp.* (i.e. *M. larici-populina*) evolved, as larger plantations were being cultivated with less genetically divergent varieties of poplars. Similar evidence was observed for willows.

Picture 15. Willows affected by Leaf Rust. [Photo by: I. Dimitrou, SLU]

Leaf rust attacks the leaves and stems (see Picture 15 above); premature defoliation and consequently yield loss are evident consequences of this disease. Different species and clones of poplars and willows show different degrees of susceptibility to the various species and races of Melampsora. Resistance or tolerance to these fungi changes over time, and numerous are the observations of new specificity, particularly in the case of large blocks with a single plant variety.

Bearing in mind that SRP is likely to require minimal chemical inputs and that the use of fungicides will reduce the economic, practical and environmental benefits of the plantation, agronomy and breeding seem the best ways to help farmers and enhance SRP profitability. Experiences from Ireland show for example, that multi-clonal instead of mono-clonal willow stands improve their resistance against such diseases. The use of fungicides seems to be justified only in the nurseries, with different fungicides suggested throughout Europe.

5.1.2 Insects

A wide variety of insect species exists in SRP, and whereas most increase biodiversity, a few of them can severely attack poplar and willow trees and can cause serious damages to the plantation. Among them, Chrysomelides beetles are the most important **leaf eating insects** for willow and poplar.

Picture 16. Main leaf eating insects for poplars (Chrysomela populi adult and eggs). [Photo by: T. Baschieri, CRA-CIN]

Reduced leaf area and consequently crop growth is the most common result from such beetle attacks but other insects can cause breakages and infection sites which open pathways for the development of other diseases. A correct use of agronomical guidelines, particularly the **use of genetic divergent clones** may help to reduce the impact of these insects as well as promoting the development of natural control mechanisms. If possible the **presence of native birds and insectivorous mammals** should be supported by establishing typical habitats like hedgerows, and protecting any neighbouring forests already in existence.

There are also many **insecticides** available but their application is not practical in SRP after establishment, as it may be unprofitable and could damage many non-target and beneficial insects and therefore in most cases it is not suggested. Insecticide use could be suggested for young SRP, i.e. when trees are not too high, and only in the case of a serious attack, i.e. of 100 or more adult beetle adult insects per m^2 of ground surface.

Beetle populations also are fluctuate considerably from year to year. Attention should be given to the rotting wood around the plantation where insects over-winter. Insecticides were sometimes sprayed in the past to the borders of the SRP to establish a "protective net" against beetles when they tried to recolonise from their over-wintering sites in early spring.

For willows, the use of Chlorpyrifos (Durban) has been suggested to control leatherjackets, i.e. the larval stage of the Cranefly (Tipula) together with the pre-emergent herbicide treatment.

For older poplar cultivations treatments against Chryptorynchus lopethy with "Orbit" are suggested.

5.1.3 Other animals

Browsing animals such as rabbits and deers can damage the SRP, especially in the first year or after harvest re-growth, when crops are young and appetizing. Such mammals can exert considerable pressure on the SRP, and often **fencing** of the plantation is the only effective measure to protect the young plants from being eaten. Unfortunately fencing is a very expensive option and normally unsuitable for SRP profitability.

Picture 17. Shoots damaged by roe deer (left). [Photos by: K. Heinsoo, EAU]

5.2 Harvesting

According to different crop cultivation models (European or North American planting densities), species (willow or poplar), latitude (North or Mediterranean Europe) and final utilization of the product (woodchips, wood products, paper), harvesting is a process for which **different technologies and processes** have been developed. There are differences in cultivating 3-5 years willows SRPs in Northern and Middle Europe and 1-5 years poplar SRPs in Middle Europe and particularly the Mediterranean countries. Meanwhile willow SRPs appear to be a well established opportunity also in the Southern Europe.

Some practices are common for both species, for example in order to promote the development of multiple shoots it is sometimes recommended to cut each stem after the first winter, but in other cases specificities and procedures are well defined.

Picture 18. Nordic Biomass Stemster MK II harvesting in a willow SRP. [Photo by: Nordic Biomass]

5.2.1 WILLOW HARVESTING

Usually willows (Salix ssp.) have between a **2-5 years rotation cycle**, since this period offers the best option for biomass production under northern conditions. Here the critical parameter is the shoot diameter as the most common and efficient willow SRP harvesters are able to only cut shoots with a diameter of up to 8cm without problems. Harvesting is carried out **from November to March**, after leaf fall and before bud-burst, i.e. when the stools are in their dormant phase with most of the nutrients stored in the plant parts underground, and the moisture content of the wood is at its minimum level (ca. 50%).

The winter period undoubtedly offers a greater opportunity to farmers since this is usually a quiet time of the year in terms of workload but it is also during this period that soils are at their wettest (if not frozen) and it is possible that soil compaction and structure damage may be caused. **Specific harvesting machineries** with large tyres have been studied to avoid these undesirable effects. Delaying the harvest until the end of winter or the beginning of spring could be detrimental for the crop, since reserves stored in the roots and stems are mobilizing to the shoots. Their removal at this stage could be damaging, because the crop could lose energy, and therefore delay new shooting and lead to increased weed competition.

Critical criteria for the selection of harvesting time, equipment and methods:

- Shoot diameter not more than 8 cm,
- Suitable harvesting time in winter from November to March,
- Minimum moisture content of wood (ca. 50%),
- Soil compaction risks (i.e. on wet soils),
- Availability of drying facilities,
- Product and quality requirements of end-users.

Depending on end-user requirements, the available machinery and the availability of drying facilities, it is possible to harvest SRP wood as **chips, rods or billets** .

Manual cutting is also a wide-spread practice. However, manual harvesting is only economical and recommendable for small SRP area or where the cost of introducing expensive machinery is prohibitive and unaffordable.

5.2.2 WOODCHIPS

Direct chipping is the process where the crop is cut and chipped in a one step operation. The harvested "wet" materials needs to be further dried to avoid loss of its energetic value to microbial degradation. Machineries adapted to this operation consist of **modified cutting heads** fixed to standard harvesters (for example forage or sugar cane harvesters). Stems are cut, chipped and then moved into trailers. This operation is very time efficient but it requires subsequent treatment of the fresh chipped crop since its moisture content is still quite high (ca. 50%).

Picture 19. Chipping with CLAAS HS-2 (left) and KRONE Woodcut header (right). [Photo by: CLAAS, KRONE]

The **drying of biomass** is an energy costly and expensive action that requires dedicated facilities to avoid the fresh wood chips heating up to 60°C and initiating decomposition, and evidently losing their energy value (up to 30%). Prevention of this decomposition process, usually carried out by bacteria and fungi, with undesirable spore formation, needs to be considered. Different mechanical aeration systems have been positively tested and used, such as drying floors, grain driers, etc. However, their use is in most cases economically unfavourable. Natural air drying is also an option if it is not possible to use residual waste heat deriving from power plants or industrial processes.

These **harvesting machineries** (see Table 7) have a working capacity of up to 1 ha/hour and are usually operated by contractors or grower cooperatives because of the high capital investment required for their initial purchase. Smaller harvesting heads can be mounted on tractors for smaller harvesting operations on limited cultivation areas.

Table 7. Cut-and-chip harvesters. [Source: ATB – Agrartechnik Bornim, 2006]

Company	**Austoft Ltd. (Australia)**	**Claas Harse-winkel**	**Hüttmann GmbH (Germany)**	**Lochner, Preuss GmbH (Germany)**
Model name	Austoft 7700/240	Salix-header HS-2	Woodcut 750	Model Goettingen
Type	Sugar cane harvester	Header	Header	Wood-chipper
Development status	Prototype	Small production	Prototype	Prototype
Deadweight (in kg)	12.500	1.300	2.000	1.200
Basic machine	Self-propelled	Claas chipper Jaguar	Krone chipper BIG X V8	Tractor
Basic machine power (in kW)	216	≥ 235	≥ 360	≥ 75
No. of rows	2	2	2	1
Distance between rows (in m)	0,75 + ≥ 1,4	0,75 + ≥ 1,5	0,75 + ≥ 1,5	≥ 0,9
Max. stem diameter (in mm)	< 70	< 70	< 70	< 120
Average cutting length (in mm)	> 80	5 - 40	5 - 30	50 - 100
Mass flow rate (t DM/ha)	10 - 25	10 - 30	20	5 - 10
Harvested area (in ha/h)	0,25 – 0,62	0,25 – 0,75	0,5	0,12 – 0,25
Costs, excl. VAT (in €)	175.000	100.000	-	< 30.000

Rods are full-length stems and their harvest is possible with a number of different machines (see Table 8). Rods are off-loaded on the headlands or in a particular part of the farm. Natural ventilation through the stacked rods prevents the deterioration of these materials and the initiation of decomposition processes. Using the spring and summer temperatures the natural drying process may reduce the moisture content down to 25-30%. After this practice, the chipping of the rods requires greater energy consumption because they are much harder to cut.

Together with a higher energy input the derived chips are less homogenous in shape. For this reason, chipping fresh material is often the chosen method where size and quality of the product is important. The former option seems affordable only for limited crop production.

Table 8. Whole rod harvesters. [Source: ATB – Agrartechnik Bornim, 2006]

Company	**Nordic Biomass (Denmark)**	**Bo Franzen (Sweden)**	**Sten Seegerslätt (Sweden)**	**Timberjack (US)**
Model name	Whole rod harvester	Fröbbesta 92	Empire 2000	TJ 720
Type	Cut-and-extra	Cut-and-extra	Cut-and-extra	Cut-only
Connection to prime mower	Towed	Towed	Self-propelled	Carried
Development status	Prototype	Prototype	Prototype	Small production
Deadweight (in kg)	< 3.000	3.100	9.800	340
Basic machine	Tractor	Tractor	Self-driving	Forest harvester
Basic machine power (in kW)	≥ 50	≥ 80	140	≥ 61
No. of rows	1	2	2	variable
Distance between rows (in m)	variable	0,75 + 1,50	0,75 + 1,25	variable
Max. stem diameter (in mm)	≤ 70	≤ 70	≤ 70	≤ 200
Mass flow rate (t/ha)	-	20	26	3 - 4
Harvested area (in ha/h)	-	0,45	0,77	0,07 - 0,1
Costs	-	50.000	134.000	27.000

The billet process is an intermediate option between chips and rod cuttings, because the stems are cut into small billets of 5-10cm in length. Also this process works very well with machineries developed for different purposes (e.g. for sugarcane production). Once cut, the billets are blown directly into an accompanying trailer for transport to the end-user or storage facility. As in the case of the natural drying process adopted for rods, during storage the billets have sufficient space between them so that they can be stored without decomposition losses. If necessary, a final chipping process could be carried out for the end-user.

5.2.3 POPLAR HARVESTING

Poplars may be cut in SRP **every 1-5 years** according to different planting densities, ranging from 10.000 to 14.000 plants/ha, 6.000 to 10.000 plants/ha and 1.000-1.500 plants/ha respectively (cultivation model from North America).

Harvesting **one-year rotation** poplar has been the preferred option, because at the end of the growing season a stem diameter of approx. 6 cm is nothing unusual. At the end of this first rotation cycle poplars' height can reach 3.5 – 4 m and from the second cycle the production should further increase to a stem height of more than 6 m.

Traditional modified harvesting machines (for example for maize or forage) are used to cut these young poplars. Unfortunately the harvesting machineries developed in the Northern Europe is often too heavy for lighter soils in Southern Europe and if used, may therefore damage the soil structure.

One-year rotation cycles have showed many disadvantages:

- the high investment costs of the plantation (number of planting materials and planting),
- the limited amount of stem wood compared to bark content, and further
- the economic life-span of the cultivation was shorter compared with other models.
- This cultivation model has been sidelined when it became clear that higher productivity and increased yields could be achieved with longer rotation cycles, e.g. after 2-5 years.

Picture 20. Poplars SRP at 2 years age. [Photo by: M. Di Candilo, CRA-CIN]

Two-years rotation cycles with single rows is a model with a lower density, i.e. from 6.000 to 10.000 plants/ha, which allows a better exploitation of lower plantation investment. Plants have more space to grow and produce a better wood-bark ratio. Additionally, harvesting machineries have a faster working capacity under such conditions (up to 8 km/h). After harvest, both options i.e. direct woodchips production or billet/rods production, are applicable models.

At the end of the first rotation cycle (after two years) poplar height is approx. 7-8 m. By the second cycle plant growth can show results of up to 10 m, with diameters ranging from 12-15 cm. Harvesting is possible by different machineries with cutting heads developed for forestry wood production.

Picture 21. Poplars SRP harvesting. [Photo by: M. Di Candilo, CRA-CIN]

The harvest of **longer rotation cycles** of poplars SRP (i.e. 5 years) has recently received interest since it requires less inputs, shows higher productivity and possibly more applications for the biomass produced incl. woodchips, pellets, etc.

Machineries are derived from forestry production because the average plant height during harvesting is between 12 - 15 m and diameters can be larger than 20 cm.

5.3 STORAGE

The **storage of harvested SRP biomass** should be done on farm or in off-farm storage facilities preferably close by the final end-user. Storage is important because energy production or industrial processes continuously require a certain amount of biomass throughout the year however harvesting occurs only once a year in winter time. Furthermore, the storage possibility of woody biomass is one of the main advantages of bioenergy compared to other renewable energy sources such as solar and wind.

Storage on farm could be carried out **outdoor or indoor**. The first option is common for rod or billet production, i.e. when stem pieces at the end of the cutting process are long enough to allow natural dehydration. Rods can be easily left in piles on the headland. Billets are usually stored in simple piles or containers.

The storage of woodchip is more complicated because this product requires carefully handling so as not to loose energy value through **microbial decomposition**. Different strategies and equipments are available to reduce the natural moisture content of the woodchip. Probably the best option is the use of waste heat coming from power plants or other industrial processes.

It must not be forgotten that biomass customers calculate the relative energy content of the biomass, and not the weight, because they are looking for the real energy output they can achieve from the product. Therefore, often samples of the material are taken and tested for their dry matter content prior to purchase.

5.4 TRANSPORT

The harvested SRP biomass needs to be transported to end-users, consequently **transportation costs affects the overall SRP economy** and need to be carefully calculated before investing in SRP.

In the case of short distances (3-5 km) the use of tractors with trailers may be acceptable, but with distances of 30-50 km trucks must be used for efficient loads. Transportation beyond 50 km may mean that such costs are too high to provide competitive biomass prices (see chapter 6).

Potentially **negative aspects from transport** could be avoided by considering the following aspects:

- creation of storage centres of wood production near the cultivated fields,
- study of traffic flow and delivery routes,
- accurate organization of harvesting, load and transportation throughout the whole biomass product chain, because optimising transport volume is both environmentally and economically sensible.

5.5 SITE RESTORATION

At the end of the of SRP life-span it is possible and necessary to **restore the field** for the following agricultural land use. Depending on the density of the SRP established, this could be carried out without difficulty by various machineries, both for poplar and willow.

Before removing the remaining stool a herbicide treatment is suggested in the spring following the final harvest. By using a rotovator or a forestry mulcher wood residues and soils will be admixed with positive aspects for the soil organic matter content. Another option, more appropriate for low density cultivation, is the mechanical removal of the whole stool. Furthermore, with this approach the root biomass can be used for further processing or direct application in burners, etc.

6 ECONOMICS OF SRP OPERATION

The decision pro or contra SRP will largely depend on how profitable the SRP will potentially be compared to other agricultural crops. This depends on various factors, such as yield, production costs, market prices as well as contractual obligations, possibilities for subsidies, etc. Before establishing a SRP, a business plan should be drawn up to estimate profitability according to local market conditions and circumstances. A sample business plan is shown in Annex Chapter 8.5.

This chapter gives some idea about income generating opportunities from SRPs, ranges of margins, production costs, labour requirements and contractual issues. It compares long-term SRP with short-term cereal cultivation and highlights the opportunity to gain extra income from becoming a partner of wastewater and sludge treatment works.

In addition to local authorities or private companies responsible for wastewater treatment and sewage sludge management, key stakeholders for a successful business case include (sub-) contractors for planting material, planting and harvesting equipment as well as energy supply/technology providers who could either act as clients or cooperative partners.

6.1 MARKETS AND MARGINS

The market for biomass for energy generation **is currently growing** in Europe and also in other parts of the world, but there are significant **differences between** the various **local markets**. Therefore, it is important for the SRP operator to establish good contacts within the biomass market and perhaps also to set up fixed long-term contracts with customers for the biomass produced. Another possibility may be to use the chips in a private boiler and sell the heat produced. A **further opportunity for income-generation** from SRP **includes wastewater and sewage sludge application**. With wastewater irrigation or sludge application, costs are reduced and biomass production is increased resulting in a higher yield per hectare, and a higher nutrient output. If the income derived from wastewater/sludge application is satisfactory, profits will be much higher as this in addition to income from a higher biomass yield.

Income opportunities:

- Selling biomass (wood chip, rods, etc.) to the local market,
- Establishing long-term contracts with local energy suppliers,
- Using chips in a private boiler or co-generation plant (and eventually selling the electricity and heat produced),
- Receiving fees for sludge and wastewater treatment/disposal

Table 9 illustrates the gross margins for SRP in Euro per hectare for a range of yields and wood **chip prices**. The results do not take account of subsidies nor land costs. All costs for machinery, labour, interest and overheads are included in the calculations. Examples of overhead costs are bookkeeping, telephone, road maintenance and others. The **calculations refer to current Swedish conditions**, since Sweden with an area of 15,000 hectares of SRP for energy purposes is a rather representative market. From Table 9 , it can be concluded that it is **very hard to find positive results for a low yield or low wood chip price** without the introduction of subsidy. An **exception is the case of SRPs fertilized with wastewater or sewage sludge**, if a large share of the total income is derived from their utilization. For example, as the table indicates, a yield of 9t DM/ha*yr, and a price of 5 Euro per GJ results in a gross margin of 103 Euro/ha*yr.

Table 9. Gross margin in EUR per hectare for a range of yields and wood chip prices (Swedish conditions, 1 MWh = 3.6 GJ, 1 t DM = 15.8 GJ). [Source: SLU]

Price (€/GJ)	Yield level (t DM / ha*yr)							
	5	6	7	8	9	10	11	12
2	-236	-234	-232	-231	-229	-228	-226	-224
3	-174	-160	-146	-132	-118	-105	-91	-77
4	-113	-86	-60	-34	-8	18	45	71
5	-51	-13	26	64	103	141	180	218
6	10	61	112	163	214	264	315	366
7	72	135	21	261	324	387	451	514

Production costs vary from country to country and from one grower to another due to differences in transport distances between the field and the biomass end-user, different field sizes and other factors. If sewage sludge or wastewater is used as fertilizer, production costs will decrease. Table 10 presents a range of production costs relating to different cost and yield levels. The line with 100% in cost level is calculated under the following assumptions: Swedish conditions, 30 km transport to district heating network, field size of 7 hectares under normal conditions for willow growing. Table 10 illustrates that for a farmer with a yield level of 9 t DM/ha*yr and with an assumed cost level of 90 % compared with a normal Swedish willow grower, production costs are 3.6 Euro per GJ.

Table 10. Current production costs in EUR per GJ related to different production cost levels and yield levels per hectare (Swedish cost level is 100%). [Source: SLU]

Cost Level (%)	Yield level (t DM / ha*yr)							
	5	6	7	8	9	10	11	12
60	3.4	3.0	2.7	2.5	2.4	2.3	2.1	2.1
70	4.0	3.6	3.2	3.0	2.8	2.6	2.5	2.4
80	4.6	4.1	3.7	3.4	3.2	3.0	2.9	2.8
90	5.2	4.6	4.2	3.9	3.6	3.4	3.3	3.1
100	5.8	5.2	4.7	4.3	4.1	3.9	3.7	3.5
110	6.5	5.7	5.2	4.8	4.5	4.3	4.1	3.9
120	7.1	6.3	5.7	5.3	4.9	4.7	4.5	4.3
130	7.7	6.9	6.2	5.8	5.4	5.1	4.9	4.7

In a start-up situation with a small area of established SRP, the **costs will be higher** compared to a situation with a large SRP area. Different regions also exhibit different cost levels: In Southern/Eastern Europe, a lot of the inputs for SRP cultivation are on a lower cost level, and probably will be much lower than the 100% shown in the table above.

6.2 BETTER CULTIVATE SRP OR OTHER CROPS ON MY LAND?

The most important question before deciding to establish a SRP on farmland is if it will give a higher income compared to the production of other "conventional" agricultural crops. **SRP is compared with cereals for a range of different prices and for land with a range of different yields**. Therefore Table 9 is compared with gross margins of winter wheat (see Table 11 and Table 12) to evaluate if winter wheat or SRP is more profitable. Table 11 shows the gross margin when all costs for machinery, labour, interest and overheads are included, but does not take account of land costs (e.g. tenancy) and subsidies. From this table, gross margins for a range of different yields and different grain prices can be evaluated. As an example, in Sweden a yield of 8t of wheat per hectare at a price of 120 Euro per ton will give a gross margin per hectare of 79 Euro.

Table 11. Gross margin in EUR per hectare per year for winter wheat with different price- and yield levels. [Source: SLU]

Price (€/t)	Yield level (t DM / ha*yr, 14% water content)							
	5	6	7	8	9	10	11	12
80	-281	-267	-254	-241	-228	-215	-201	-188
90	-231	-207	-184	-161	-138	-115	-91	-68
100	-181	-147	-114	-81	-48	-15	19	52
110	-131	-87	-44	-1	42	85	129	172
120	-81	-27	26	79	132	185	239	292
130	-31	33	96	159	222	285	349	412
140	19	93	166	239	312	385	459	532
150	69	153	236	319	402	485	569	652
160	119	213	306	399	492	585	679	772
170	169	273	376	479	582	685	789	892
180	219	333	446	559	672	785	899	1012
190	269	393	516	639	762	885	1009	1132
200	319	453	586	719	852	985	1119	1252

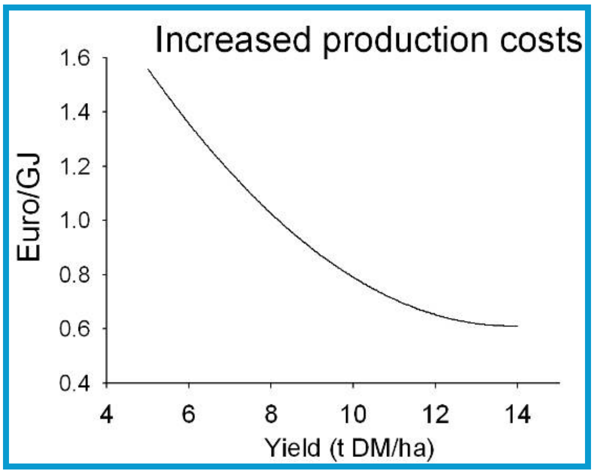
Table 11 includes all costs for machinery and labour. Most farmers have already obtained machinery for cereal production and in some cases have a low opportunity cost for their labour time, which will not be needed if the land will be planted with SRP. In this case for some farmers, it can sometimes be a low opportunity cost of resources like agricultural machinery and labour since a lower use of machinery is needed when SRP is grown. For this reason, it is **of interest to make a short-run calculation for cereal production and compare it with a long-run production for SRP**. This will probably show the situation of some farmers who already have resources for cereal production, but not for SRP production. In Table 12 costs for machinery, labour and overheads are taken at 50% of full costs. We can compare the gross margin in Table 12, which is a short-run gross margin in cereal production, with the long-run gross margin in willow production in Table 9. In the case where a farmer already has machinery for cereal production, it is possible that the farmer does not take account of full costs in the cereal calculations for machinery and possibly for his own time, especially in a short-run calculation. What percentage of the costs should be included in the calculation varies from case to case. In normal cases, **in the long-run calculation higher costs for machinery and labour should be included, compared with a short-run calculation**. If calculations are made for example, at 75% of the costs, the results will be in the middle of the table above the 100% cost level, and below the 50% cost level.

Table 12. Gross margin in EUR per hectare per year for winter wheat for a range of yields and prices. Cost reduction for machineries, workforce and overheads at 50% (short run calculation). [Source: SLU]

Price (€/t)	Yield level (t DM / ha*yr, 14% water content)							
	5	6	7	8	9	10	11	12
80	-80	-63	-46	-29	-11	6	23	40
90	-30	-3	24	51	79	106	133	160
100	20	57	94	131	169	206	243	280
110	70	117	164	211	259	306	353	400
120	120	177	234	291	349	406	463	520
130	170	237	304	371	439	506	573	640
140	220	297	374	451	529	606	683	760
150	270	357	444	531	619	706	793	880
160	320	417	514	611	709	806	903	1000
170	370	477	584	691	799	906	1013	1120
180	420	537	654	771	889	1006	1123	1240
190	470	597	724	851	979	1106	1233	1360
200	520	657	794	931	1069	1206	1343	1480

Table 12 only illustrates a short-run calculation and does not take into consideration all the costs in cereal production, making this table unsuitable to use for a long-run decision about which crop should be cultivated.

Picture 22 illustrates how an increased opportunity cost for land (from Table 10 and Table 11) increases the production costs for SRP. With higher cereal prices the opportunity cost will increase for using the land for SRP. As an example, 100 Euro in increased land costs increases the production cost by 1 Euro per GJ with a yield of 8 t DM/ha*yr.



Picture 22. Increased production costs in EUR per GJ per 100 EUR in increased opportunity value of land (see opportunity value with cereal production in Tables Table 11 and Table 12 with different yield levels for willow). [Source: SLU]

6.3 COST DISTRIBUTION IN SRP

Almost **half of all SRP costs are related to harvesting, transport and brokerage** (the brokerage cost is the cost for selling the crop. There can be differences between the price of what a large chip user pays and that price which the grower receives). A **higher yield gives higher costs connected to harvesting and also higher costs for fertilization.** For this reason, a **higher price received for the chips sold is much more important compared to a high yield level.**

*Table 13. Production cost breakdown in % for willow with 9 t DM/ha*yr in yield level, without wastewater and sludge (Swedish example). [Source: SLU]*

Cost categories	Cost distribution (%)
Establishment	17
Conventional fertilization	17
Road transports	17
Harvest	21
Field transports of chips	4
Brokerage (cost for selling the crop)	7
Weed control after harvest	1
Administration	4
Winding up (recovery field after SRP)	1
Overhead	9
Total direct production cost	**100**

6.4 Working hours in SRP production

Most of the work with SRP production will be carried out by contractors, as there are only a few farmers with large enough SRPs to justify possession of planting or harvesting machinery. As the SRP increases in size, a labour shift occurs from the farmer to work completed by contractors. Willow growing will also result in less work carried out by farmers when compared to grain production.

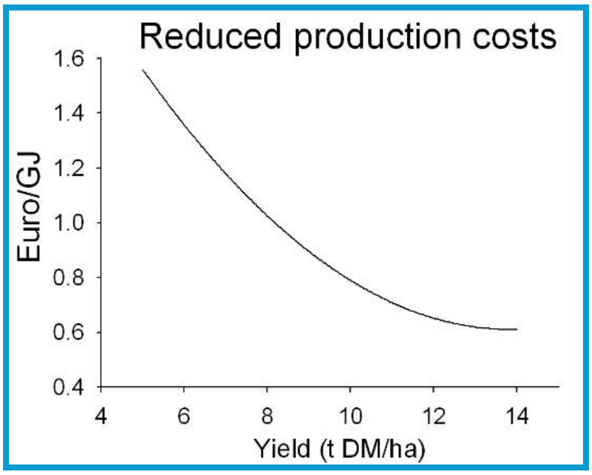
During the first year when plantation of the SRP takes place, the farmer's labour input will account for approx. 7 hours per hectare, compared to approx. 1 hour per hectare in the following years. Activities completed by others, for example contractors, will account for approx. 5 hours per hectare in the planting year. This will increase to approx. 9 hours per hectare in the first year of harvesting, and 11 hours per hectare for each subsequent year of harvest including all labour requirements up to delivery to the district heating network's gate.

For an average SRP lifespan of 22 years, the average labour input requirement per hectare is 5.1 hours per annum. Of this, the farmer labour input is approx. 1.4 hours compared to 3.7 hours for the contractor. All these calculations take account of high mechanization, a transport distance of 30km and with the wood chips delivered to a district heating network. The time needed to process the wood chips in the district heating system is not included in the calculations. By way of comparison, the labour requirement for winter wheat with reduced soil preparation and with high mechanization is 5.4 hours per hectare per season, and for spring barley with full soil preparation 6.0 hours per hectare per season.

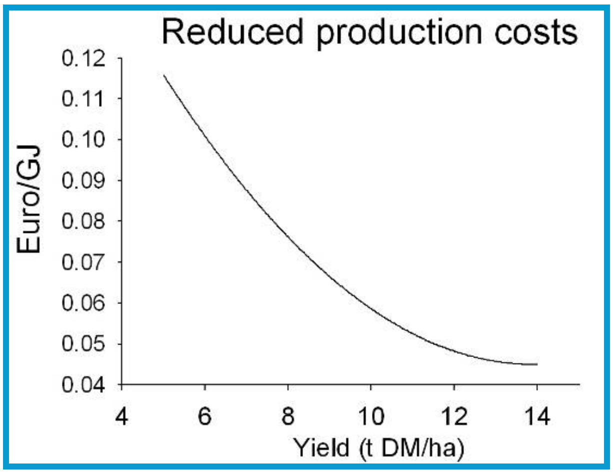
If wood chips are sold to many small customers instead of one large end-user, the need for labour will increase. The farmer can perform a lot of this work himself, using existing traditional farm equipment such as tractors and trailers.

6.5 Funding schemes

There are **usually two main funding systems for SRP**: Picture 23 illustrates an **investment or establishment subsidy** which may differ from country to country, but for some of which is approx. half of the planting cost; Picture 24 illustrates an **annual energy crop subsidy,** for which the availability and actual amount may vary from one country to another, and from one year to the next.



Picture 23. Reduced production costs per GJ assuming 100 EUR (Lower subsidy than 100 EUR in year 2008) in "annual hectare subsidy" with different yield levels for willow. [Source: SLU]



Picture 24. Reduced production costs per GJ assuming 100 EUR in "one-time hectare establishment subsidy" with different yield levels for willow. [Source: SLU]

Subsidies reduce the investment risks for SRP establishment as the actual investment for the new crop will be lower. The **establishment subsidy should be seen as a "safer" subsidy** in comparison to the annual energy crop subsidy, since annual subsidies are more susceptible to future changes and exhibit greater uncertainty.

6.6 COST REDUCTIONS WITH SLUDGE AND WASTEWATER AS FERTILIZER

Fertilization with sludge and wastewater increases SRP yields and saves costs on conventional chemical fertilizers. However, the **most important economic benefit from wastewater and sludge application relates to the cost reduction gained by the municipality or wastewater treatment company by subcontracting the treatment of such residues to SRPs, instead of using conventional treatment methods.** Costs for traditional wastewater treatment differ considerably but are in most cases about **10 times higher per kilo N** than it costs the farmer to buy a similar quantity of inorganic fertilizer. Due to this fact, it is therefore **important for the SRP farmer to negotiate** with wastewater treatment authorities the exact role he will play in any potential treatment process and the level of remuneration received for the service provided. Additionally, **a short distance between the treatment works and the SRP site saves costs** both in terms of pumping wastewater and transportation of sludge.

6.7 CONTRACTS AND AGREEMENTS

As for most other agricultural business activities, for efficient SRP operation it is equally important to develop quality and firm contracts with subcontractors and biomass customers. Contracts, subcontracts and specific agreements may be required throughout a number of stages of the SRP operation, especially whenever the SRP operator himself cannot guarantee high quality and cost efficient work, or when dealing directly with the customers.

In particular, contracts and agreements may include especially:

- Subcontractor for planting
- Subcontractor for harvesting
- Subcontractor for sludge application
- Biomass customer
- Sludge provider
- Responsible partner for wastewater treatment and/or wastewater irrigation

Planting and Harvesting: One important aspect for successful SRP operation is **high planting quality.** A 4-row planting machine plants approx. 1 hectare per hour whilst a 6-row planting machine plants more than 1 hectare per hour. A large SRP harvester harvests approx. 0.5 hectares per hour. With such capacities, a **large number of hectares are required per planting machine and harvester** to reach an adequate number of hours usage each year. Therefore, in most cases, **it is not economically feasible for a farmer to own such machinery** himself, but instead contractors may be hired to carry out such activities. One possible solution may be that the buyer of the wood chip organizes the planting and harvesting of the SRP. It may therefore be advisable that the farmer initiates contact with companies who plant and harvest SRP at the initial planning stage of the project. This will reduce the uncertainty of future costs. A model contract for the establishment and harvesting of SRP is provided in Annex 8.6.3.

Customer relations: With **more than one possible customer for wood chip,** the need to sell the chips directly after harvest reduces. In a situation where demand exceeds supply, the need to have a contract will be reduced, but even then it can be advantageous that a grower has a contract in advance. The degree of risk the SRP grower is willing to take also affects the need for a contract.

Sludge and wastewater application: When sludge will be spread on the field, it is important for the farmer to be aware of the alternatives the sludge producer has to dispose of this "waste". If the alternatives are more expensive than application in SRP, it provides the possibility for a good return for utilization of the sludge in the field, with benefits for both the sludge producer and the SRP farmer. How sludge application will be organised differs from case to case. However,. **in most cases specialist companies take on this role.** It is very important to draw up **a solid agreement** with the partner responsible for local wastewater treatment, if wastewater is to be used for irrigation and fertilization in the SRP. Apart from payment for providing final treatment for the wastewater, other important issues require attention. The **farmer should be insured against risks**, such as a die-off of part of the plantation, a closure of the wastewater treatment plant, reduction of the contract period and so on. It is also **important that the contract states which partner is responsible for the different costs, such as** analyses costs, investment costs, and maintenance costs for example. It is also helpful if the contract clarifies what will happen if the quality and quantity of wastewater will change. Licensing **requirements can also change as legislation is updated and it is therefore necessary to consider such eventuality.** Another factor requiring clarification in the contract relates to the termination of the contract by either party earlier than agreed. Model contracts for sewage sludge application are provided in Annex 8.6.

6.8 BUSINESS PLANS

Before starting a SRP business it is recommended to develop a business plan for the new agricultural practice of cultivating fast growing trees in combination with the application of wastewater and sewage/sludge in the field. High-quality SRP establishment, high yields, and available wastewater and sludge are not the only things necessary to achieve the best economy for the farmer. One of the first things to think about is **if the crop and the concept are suitable for the farm and the farmer**. For example, **labour requirements, adoption of machinery, change of landscape, the possibility to grow feed for animals, and other changes** must all be taken into account.

Some questions to consider before starting a SRP:

- How profitable are other business options?
- How suitable is the establishment of SRP in the farm both in the short- and long-term?
- Which resources, e.g. agricultural machinery and labour, are of less use for SRP and what is the opportunity cost for such resources previously employed in cereal production?
- What, how and where is the product to be sold?
- Should the biomass be sold as whole stems or harvested and delivered as chips?
- Should the chips be sold: unharvested on the field or as harvested and delivered as chips; dry or wet; delivered in bulk shortly after harvest or numerous deliveries throughout the year; and what are the storage costs involved?
- Which market possibilities exist: Selling the chips to a large broker, direct to a large user, to a small user or maybe in some other way?
- With which local company is it suitable to collaborate, and what manner of cooperation is possible? Is the specialist machinery required available and to what extent? Are the contractors fees reasonable?
- Strengths, Weaknesses, Opportunities and Threats (SWOT- analysis) of chosen business concept?
- Opportunities and risks for the company and the chosen business concept?
- What are the different requirements for various contracts?
- What potential changes can happen in the future and how will it affect the company and the chosen business concept?
- Which legislation, licensing requirements and regulations (particularly important for wastewater irrigation) require compliance?
- Which contracts are necessary to ensure "good quality waste water supply" (i.e. also including "risk prevention" if the SRP fails) a paragraph
- What reuse options are possible in the specific case?
- What is the level of public acceptance about using wastewater and sludge on the field?
- How does SRP affect my image as a farmer?

An example cost-benefit analysis is given in the Annex 8.5

7 SRP SUCCESS STORIES - CASE STUDIES IN EUROPE

Poplar and willow crops are two of the most extensively used woody SRPs in Europe. Some case studies are presented below in an effort to provide guidance for SRP implementation on new land.

The chapter focuses on a number of ways of managing SRP with no chemical fertilizer utilization through the recycling of waste products for crop fertilization, in line with the required monitoring and control procedures.

In general, the case study examples suggest that the most important constraints to obtaining a viable SRP, are the lack of legal support regarding subsidies, the difficulties obtaining permission for wastewater/sewage sludge application, as well as the actual acquirement of the most productive willow and poplar varieties

This chapter contains 5 case study examples of SRP:

- The **Swedish SRP** presents a successful case study where a willow plantation is used as a "green filter" for wastewater treatment. Biomass production provides heat and electricity for the municipality. Furthermore, no inorganic fertilizers are needed, the wastewater is not disposed into a water body and the municipality also benefits from bioenergy production.
- The **Spanish SRP case study** aims to demonstrate the effects of wastewater and sludge for increased productivity in a poplar plantation, as well as the implementation of wood biomass as an alternative source for energy production in Spain.
- **Brook Hall willow plantation in Northern Ireland**, presents a case study of recycling municipal sewage sludge for crop fertilization, and where associated bioenergy production brings profitability for the SRP site.
- The **Czech case study** is an experimental willow plantation for bioenergy production, where restrictive legislation does not facilitate the use of wastewater or sludge as fertilizers.
- Finally, the **Italian case study** is an example of poplar plantation fertilization through the combined use of mineral fertilizers with sludge from the wine industry in the Ferrara province. The obtained poplar biomass also aims to generate heat and facilitate electricity production

7.1 Case study 1 : Enköping Willow Plantation / Sweden

Enköping - the largest SRP in Europe irrigated with wastewater.

Picture 25. SRP wastewater system Enköping / Sweden. [Photo by: I. Dimitriou, SLU]

Backgound

In Enköping, a town in central Sweden with approx. 20,000 inhabitants, a novel system has been established. Supernatant water (from sludge dewatering rich in nitrogen) diluted with treated wastewater is recycled to fertigate 76ha of willow plantation. Thus, wastewater is treated before entering into the adjacent water body since the plantation acts as green filter. The produced wood fuel is purchased by the local district combined heat and energy plant for supplying part of the energy demand to the local community. Ashes from biomass combustion together with sewage sludge are also recycled back to other SRPs as fertilizer. The landowner is responsible for crop management and irrigation system maintenance.

GENERAL DATA

Location:	Enköping / Sweden
Area:	76 ha
Used plant species:	Salix spp. ("Tora" variety and other commercial Swedish clones)
Type of fertilization:	Mixture of supernatant (from sewage sludge dewatering) and treated wastewater
Date of planting and harvest cycle:	Spring 2000, harvest every two to three years
Climate:	Mean annual Temperature: 6.0◦C Precipitation: 521mm
Supported by:	Enköping's Municipality

OBJECTIVE AND MOTIVATION OF THE PLANTATION

- Energy supply via biomass from willow coppice
- Wastewater treatment (cost reduction)

LOCATION AND CONDITIONS

The crop is located on a plain, with less than 2m variation in elevation. The soil is fine clay. The mean annual temperature at the site is 6◦C. Frozen soil conditions usually occur during winter. The vegetation period starts in late April/early May and continues until late September/early October. The annual precipitation is 521mm.

SOURCE OF CUTTINGS

Willow cuttings were delivered by the company Agrobränsle.

SELECTED SPECIES/ VARIETIES

The field is planted with a range of commercially bred willow material from Sweden, with the clone "Tora" being predominant.

PLANTING SYSTEM, DENSITY AND HARVEST CYCLE

- Cuttings are planted with specially designed planting machines following the double-row planting system.
- The distance between double rows is 1.5 m and within the rows it is 0.75 m. Distance between plants in one row is approx. 60cm and the plantation density is approx. 15,000 plants/ha.
- The harvest cycle is every 2-3 years depending on the biomass growth.

FERTILIZERS ORIGIN, DISTANCE AND TRANSPORT

A mixture of supernatant water from the dewatering of sludge, and treated wastewater from the local wastewater treatment plant, is pumped into lined storage ponds during the winter and used for irrigating the SRP during summer (May to September). The distance between the wastewater treatment plant, the storage ponds and the fields is only 200-300 m. The pumping system drives the irrigation water from the treatment plant to the ponds.

PROCESS DESCRIPTION

Water from dewatering sewage sludge (supernatant) is stored in ponds during the winter period (solids settle and pathogens decrease). This water constitutes less than 1% of the total water flow in the treatment plant but contains approximately 25% of the nitrogen entering the plant with concentrations up to 800 mg N/l. From May to September, supernatant is diluted with treated wastewater effluent from the wastewater treatment plant and is irrigated to the 76ha of willow crop using a drip pipe system laid into every double-row. The irrigation load is approximately 300 mm/ha*yr equivalent to approximately 200-250 kg N and 7-10 kg P. The total volume of water applied for the entire plantation is 200,000 m^3/year (of which 20,000 is supernatant), being equivalent to 30 t nitrogen and 1t phosphorus that would otherwise have been deposited into the adjacent river.

Harvested wood is used by the local power station (Ena Energi plant) to fuel their boiler. The heat obtained is used to feed the district heating system supplying 55 MW of thermal energy. Additionally, the steam produced from the combustion process is used to produce electric power through the turbine-generator system supplying 22 MW of electricity.

The wood ashes resulting from combustion are mixed with digested sludge (provided by the wastewater treatment plant) and applied as fertiliser to Salix plantations located in other municipalities.

Picture 26. Wastewater pond in Enköping. [Photo by M. Lomas, BIOAZUL]

HARVEST SYSTEM

For harvesting, specially designed machines for SRP are used. The direct chip harvesting method is used giving the lowest costs, with the wood chips being blown into a tank trailer (also see Chapter 5.2).

BIOMASS PRODUCTION COMPARED TO TRADITIONAL SYSTEMS

Willow plantations irrigated with wastewater produce more biomass than non-irrigated plantations, and at the same time conventional inorganic fertilizers are not required reducing related costs. Thus, the advantages of wastewater/sludge utilization are clear.

From Ena Energi (www.enae.se/), 50% of the municipality's requirements (20,000 inhabitants) for electric power are covered, as well as 100% of its heat requirements (95% of the population being connected to this source), with 20% of total used biofuels coming from SRP willows.

ACTUAL BIOMASS USE

Biomass is used as fuel for the municipal district, for both heat and electricity generation.

COSTS AND BENEFITS

Costs include management of Salix plantation (see Chapter 6), wastewater/sludge transport, storage ponds, piping system, maintenance and monitoring. The municipality covered all costs for the establishment of the storage ponds and the irrigation system.

Benefits are based on higher biomass growth and improved availability of irrigation water.

Found difficulties

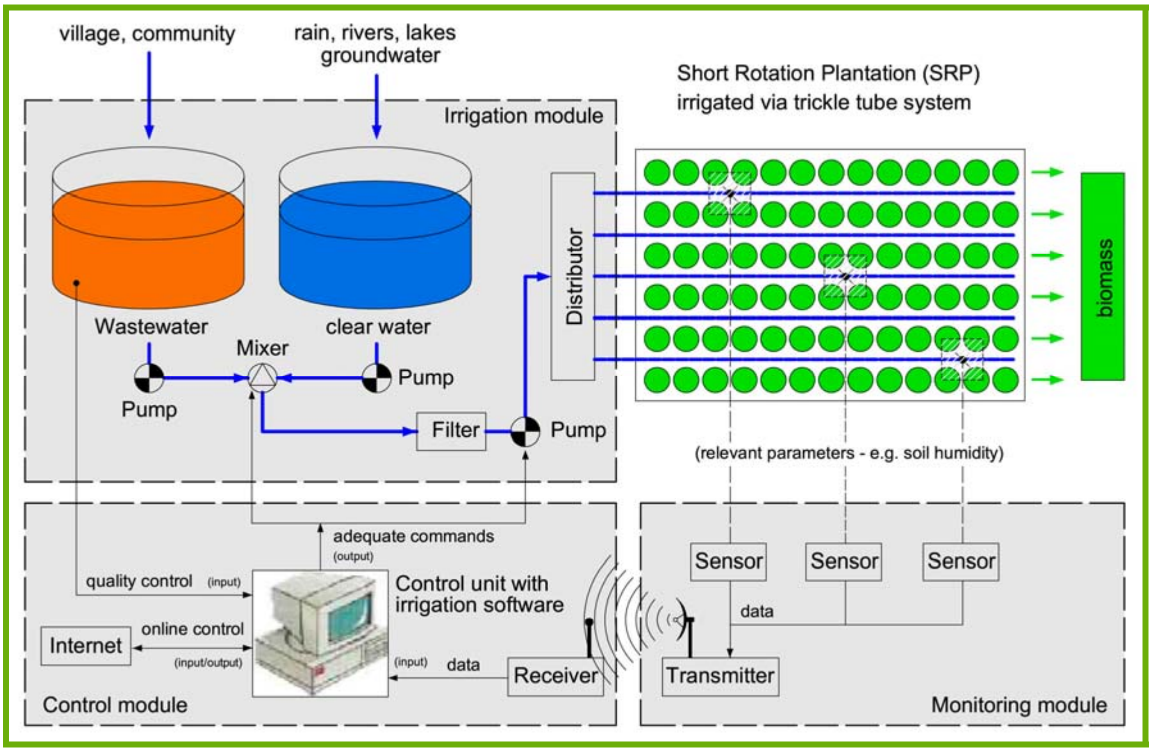
Field mice damaged some of the pipes.

Contacts and information

- Dr. Ioannis Dimitriou, Swedish University of Agricultural Sciences (SLU), www.slu.se
- Ena Energi Enköping power station, www.enae.se

7.2 Case study 2 : Granada Poplar Plantation / Spain

In Granada / Southern Spain a SRP research & test field with poplar trees (Populus spp.) has been established. It has been irrigated and fertilized with wastewater and sewage sludge.



Picture 27. Technological layout of local irrigation system. [Source: S. Foellner, ttz Bremerhaven]

Background

As part of the EU-funded cooperative research project WACOSYS, a research field was established in Santa Fe, in the municipality of Granada, in spring 2005. The landowner, Mr. Ramos, is a biomass farmer with expertise in poplar cultivation. With the support of two EU research projects, an irrigation prototype was established to conduct tests with wastewater irrigation and sewage sludge application.

Objective and motivation of the plantation

- To carry out trials with wastewater and sewage sludge application in order to test and demonstrate their effects on biomass production and nutrient uptake.

Location and conditions

The poplar plantation is located at 570m above sea level. The soil type is calcareous fluvisol with silt-sandy texture. The climate is continental-mediterranean with an average temperature of 16.1ºC in 2006. The temperatures are cool in winter, with abundant frosts, and hot in summer, frequently above 35ºC. The temperature oscillation is very high throughout the year, being frequently more than 20ºC in the same day. In 2006, annual precipitation was 343 mm. In general, rainfalls are scarce and concentrated in the coldest months with the region experiencing strong droughts in summer.

Picture 28. Plantation short after planting in April 2005. [Photo by: A. Ramos Fernandez, ASAJA]

Source of Cuttings

- From a nursery located in Valladolid, Spain
- From other local poplar plantations owned by Mr. Ramos

Selected species/ varieties

- Populus x euramericana clones: "B-1M", "I-214", "NNDv"
- Populus deltoides "Viriato" variety

Planting system, density and harvest cycle

- The poplar cuttings were planted by hand following the single row planting system.
- The distance between rows is 1m and between cuttings 0.4m. The plantation density is 25.000 plants/ha.
- The trees are harvested annually (January) due to their fast growth and high density).

Source of Fertilizer, distance and transport

Wastewater and sludge were obtained from the wastewater treatment plant Puente de los Vados (Granada). The transport distance to the plantation is 6 km. Pre-treated wastewater was transported in a 6 m3 PVC tank trailer and sewage sludge in a waterproof trailer.

Picture 29. Plantation in August 2005. [Photo by: A. Ramos Fernandez, ASAJA]

Process description

Prior to application, the wastewater was stored in a 35m^3 tank near the plantation allowing the suspended solids to settle. The total N concentration in wastewater after 1st treatment step was 64.8 mg/l and for P was 8.0 mg/l with a pH of 8.0.

The land was divided into several plots to facilitate different irrigation/fertilization regimes. Half of the area (0.25 ha) was irrigated with a mixture of wastewater (50%) and fresh water (50%), whilst the other half (0.25 ha.) was irrigated with clean water only. The wastewater was diluted according to quality analysis in order to avoid nutrient excess in the soil.

The poplars were irrigated by a drip irrigation system. The irrigation load for the 0.25 ha receiving wastewater was 17.5 m^3 of wastewater and the same volume of clean water once a week during a 2 month period (mid-March to mid-May). After that, the same volume was applied twice a week during a 4 month period (mid-May to mid-September). The remaining land was irrigated with the same amount of clean water only.

However, half of the plot which was irrigated with clean water was also fertilized with sewage sludge (0.125 ha). There was no requirement for a sludge storage system, since all the sludge was applied at the start of the growing season once purchased from the treatment plant. 25t of fresh sludge was applied by hand with a 21% dry matter content. Total concentration of N in sludge was 45,000 mg/kg and for P was 22,485 mg/kg. Thus, a total of 240kg/ha of N and 120kg/ha of P were applied on the plot for three years.

Note: All these data are from 2006.

HARVEST SYSTEM

Up to now, the poplars in this plantation have been harvested with a machine which cuts the shoots with disc-shaped blades, and which is a one-man operation. Mr. Ramos is currently researching more advanced harvesting methods using up-to-date technology.

Picture 30. Plantation during harvest in January 2007. [Photo by: A. Ramos Fernandez, ASAJA]

BIOMASS PRODUCTION COMPARED TO TRADITIONAL SYSTEMS

Biomass production on the 0.25 ha irrigated with wastewater mixed with clean water was 15.610 kg. Biomass production on the 0.25 ha irrigated with clean water was 13.690 kg. Consequently, a higher biomass growth was recorded in the plot irrigated with wastewater. Regarding the poplars fertilized with sludge, interestingly enough they did not show any improvement during the test period. In all probability, it is necessary to consider more than a one-year harvest cycle to evaluate the precise effects of the sludge application.

ACTUAL BIOMASS USE

The poplar SRP site aims to produce biomass for bioenergy, mainly electricity. Wood was transported to the Valoriza energy company which works with different bioenergy generation plants. Although, the power generation is still under development, the expected heat generation (thermal energy) and second generation biofuels production are currently under study.

COSTS AND BENEFITS

Costs include cuttings, wastewater transport, prototype and piping system design and installation, maintenance and monitoring. The costs of this research project have been financed by the EU applied research projects' resources (Project: WACOSYS). First year costs, including cuttings, planting, weed control and irrigation (piping system and labour) were approximately 3,000 €/ha. Second year costs including irrigation maintenance and pest control were approximately 1,100 €/ha. Harvesting costs were 1,400 €/ha. The adoption of new harvesting machinery is likely to reduce the costs of harvesting.

Benefits for the farmer are based on higher biomass growth (t/ha) and a potential service fee for treating the wastewater from the municipality. Also in Granada, irrigation water for agricultural purposes is scarce and using wastewater increases the total time period of irrigation and therefore biomass production. Last but not least, no chemical fertilizers have been applied to the test field site, with the required nutrients having been provided by the sludge and wastewater controlled application.

The price of the biomass is still being negotiated with the energy company since this is the first stage of biomass production for energy purposes in the region. Woodchip prices of approx. 80 €/t (20% water content) are envisaged. To date it is not possible to specify the net benefit since this study is still at a project experimental stage. Improvements in the planting/harvesting system adopted, and subsidy provision, could increase SRP feasibility in Spain.

DIFFICULTIES EXPERIENCED

It has proved very important to take into account the transport distance from the wastewater treatment plant to the plantation site since short distances and low transportation costs contribute to a more feasible approach. Also, vandalism can prove to be a serious threat for expensive equipment in remote fields.

CONTACTS AND INFORMATION

- Asociación Agraria de Jóvenes Agricultores, Spain: asaja-granada@asaja.com.es
- Antonio Ramos, president of Granada Association of Poplar Growers, Spain: asaja-granada@asaja.com.es
- Bioazul S.L., Spain: info@bioazul.com
- ttz Bremerhaven, Germany: sfoellner@ttz-bremerhaven.de

REFERENCES

- "Monitoring and Control System for Wastewater irrigated Energy Plantations" ("WACOSYS"). CRAFT Project supported by the European Union under the 6th Framework Programme (COOP-CT-2004-512877)
- "Solutions for the safe application of wastewater and sludge for high efficient biomass production in Short-Rotation-Plantation" ("BIOPROS"). Collective Research Project supported by the European Union under the 6th Framework Programme (COLL-CT-2005-012429)
- Meteorological Centre of Oriental Andalusia and Melilla, Spain

7.3 Case study 3 : Brook Hall Willow Plantation / Northern Ireland

In the Northern Ireland willow plantation case study, untreated municipal sludge is used as fertilizer.

Picture 31. Sewage Sludge being elevated into the injection trailer. [Photo by: UFU]

General data

Location:	Brook Hall Estate, Londonderry / Northern Ireland
Area:	320 ha
Plant species used:	Salix spp. ("Tora", "Sven", "Torhild", "Olof", "Tordis", "Ashton Stott", "Beagle", "Resolution", "Discovery", "Endeavour" and "Terra Nova")
Type of fertilization:	Municipal Sewage Sludge
Date of planting and harvest cycle:	Willow has been planted incrementally since 1996 2 year harvest cycle
Climate:	North Western Maritime 1,100 mm mean precipitation per annum
Supported by:	n/a

BACKGROUND

Brook Hall Estate is owned by David Gilliland and his son John. The 285 ha farm is situated on the West Bank of the River Foyle. David is now a retired solicitor and John manages the Estate. The farm has been in the Gilliland family for five generations.

Up until 1996 the Estate cropped 175ha of crops harvested by combine, 25 ha in set aside, 40 ha for potatoes, let 20 ha for grass and planted 15 ha of young forestry. In 1996, the first 8 ha of short rotation willow coppice were planted. This has risen year on year and there is now a total of 320 ha planted.

OBJECTIVE AND MOTIVATION OF THE PLANTATION

- The plantation is used to recycle approximately 5,000 t of sewage sludge.
- The willow chip is harvested, dried, graded and sold as wood fuel.

LOCATION AND CONDITIONS

The sites are low level, approximately 30 m above sea level, close to Lough Foyle. The fields are a mixture of pasture and land previously used for cereal crops. The soil is a mixture of sandy loam with some heavier clay and an average pH of 5.6. The climate is North Western Maritime, with 1,100 mm precipitation per annum.

SOURCE OF CUTTINGS

- Murray Carter, Ingerthorpe Hall Farm, Markington, Harrogate, North Yorkshire, England

SELECTED SPECIES/ VARIETIES

- Swedish Breeding Programme: "Tora", "Sven", "Torhild", "Olof", "Tordis"
- European Breeding Programme: "Ashton Stott", "Beagle", "Resolution", "Discovery", "Endeavour", "Terra Nova"

PLANTING SYSTEM, DENSITY AND HARVEST CYCLE

- Willows are planted using a Step Planter following the double-row planting system. Rows are planted parallel to the length of the field.
- Double rows are spaced 1.5 m apart, with cuttings planted at 0.75 m distance. The plants within a row are approximately 0.6 m apart. Planting density is approximately 1,500 pc/ha.
- The harvest cycle is generally now every 2 years.

Picture 32. Planting at Brook Hall Estate 2006. [Photo by: UFU]

SOURCE OF FERTILIZERS, DISTANCE AND TRANSPORT

The sludge is collected from Culmore municipal sewage treatment plant, which is situated approximately 3 km from the farm. It is transported by a tractor drawn covered trailer.

PROCESS DESCRIPTION

The sludge is transported from the sewage treatment works to the willow plantation. The trailer tips the sewage sludge cake into an auger which moves the sludge cake into the bespoke injector trailer. This is transported down the willow field and injected into the newly harvested willows. This process injects the sludge below the surface so no sewage sludge is left above ground.

Total concentration of N in sludge (dry matter) was 22,600 mg/kg and for P was 4,390 mg/kg.

HARVEST SYSTEM

Harvesting is carried out using a self-propelled Class 860 Jaguar Forage Harvester, with a modified cutting head. The willow is chipped inside the harvester and is then blown into high sided trailers. The trailers are pulled by tractors back to the farmyard, where the chip is dried on concrete floors using warm air.

Picture 33. Harvester at Brook Hall Estate 2007. [Photo by UFU]

Biomass Production

The willow coppice is returning yields of approximately 9 t DM / ha*yr (harvested at 2 year intervals with 18 t). This gives a good quality fuel, which is sized consistently.

Actual Biomass Use

Brook Hall Estate operates a wood fuel supply business delivering up to 1,500 t of willow chip annually. Biomass production is utilized for heat and power generation and customers include schools, hotels and swimming pools.

Costs and Benefits

Table 14 shows the impacts on economics per hectare and year depending on sale prices of wood chip, existence of a planting subsidy and sludge application.

Table 14. Sale prices of woodchip. [Source: Rural Generation Ltd.]

Sale price of woodchip	No planting grant	Planting grant	No planting grant 3 applications of sludge	Planting grant 3 applications of sludge
60 €/t	200 €	220 €	670 €	1.040 €
105 €/t	220 €	510 €	960 €	1.220 €
140 €/t	360 €	670 €	1.020 €	1.340 €

DIFFICULTIES EXPERIENCED

- Compliance with voluntary codes of practice which differ from European Legislation.
- Application of sludge during periods of exceptionally wet weather.

CONTACTS AND INFORMATION

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- Edel Kelly, Rural Generation, Ulster Farmers' Union (UFU), Northern Ireland. Edel@ruralgeneration.com
- http://www.feasta.org/documents/wells/contents.html?six/doran.html
- www.coford.ie/iopen24/pub/pub/Seminars/2005/Gilliland.pdf

7.4 CASE STUDY 4 : WILLOW SRP IN CHRAST U BREZNICE / CZECH REPUBLIC

Picture 34. Shredder mounted to tractor. [Photo by: J. Weger, VUKOZ]

GENERAL DATA

Location:	Chrast u Breznice / Czech Republic
Area:	2 ha
Plant species used:	Salix spp. ("Olof" and "Tora" varieties)
Type of fertilization:	n/a
Date of planting and harvest cycle:	March-April 2002, harvest every three years
Climate:	Semi-continental 600 mm mean precipitation per annum
Supported by:	n/a

BACKGROUND

In countries where very restrictive legislation does not facilitate wastewater or sewage/sludge reuse, other methods may be applied for improved SRP viability. This case study, from the Czech Republic, was selected in order to test the feasibility of a SRP plantation without fertilizer application, since legislative limitations discourage the application of recycled wastes.

A small-scale SRP area was established to verify the possibility of SRP tree cultivation and production. Part of the area is used as a garden-nursery to produce cuttings.

Objective and motivation of the plantation

- The SRP was set up by the mayor of the municipality as a private project with his own budget. Of the motivations behind the establishment of the SRP, productivity, education and promotion were the key influences.
- Potential income as a nursery.

Location and conditions

The site is located 450m above sea level. The SRP is established on an area with semi-sandy soils which are highly porous, and with a medium nutrient and organic matter content. Previously the site had been used as arable land. Several parts of the land become waterlogged every now and then, so suitable and permitted willow clones were used there.

Source of Cuttings

The cuttings were bought from the Silva Taroucy research institute, Prague, Czech Republic.

Selected species/ varieties

- "Olof" [Salix viminalis x (S. schwerinii x S. viminalis)]
- "Tora" [S. schwerinii x S. viminalis]

Planting system, density and harvest cycle

- The planting was carried out manually following the single-row planting system. Cuttings were approximately 20-30 cm in length and with a diameter of 1-2 cm. Nearly the whole cutting needed to be covered by the soil, with only the topping sprout showing approx. 3 cm above the ground.
- The distance between the rows is 2 m and the planting density is 10,000 plants/ha.
- The harvest cycle is once every three years, usually carried out in winter (January/February), when the soil is frozen. This is advantageous in two ways: frozen soil enables easier access of machinery and labour to the plantation and a lower moisture content in the harvested biomass.

Process description

Mechanical weeding was carried out in combination with pre-crop barley one year before inception, with autumn tillage carried out by tractor Zetor 160 HP, and leveling completed by harrow.

Willow cuttings were manually planted in early spring (March), when soil temperature exceeds +5°C.

The plantation was not irrigated.

Harvest system

Scrub cutter – manual shredder – using tractor engine.

Biomass production compared to traditional systems

Biomass production was approximately 30 tons of dry matter per ha per rotation period (equals 10 t/ha*yr).

SRP production with appropriate subsidies could be competitive with other energy crops.

In the Czech Republic, solid biofuels together with biogas and liquid biofuels constitute 85% of total renewable energy, which represents 4.3% of total energy production. Energy from willow biomass is small and as yet not significant enough to quantify.

Actual biomass use

Energy production: small-scale heating plants.

The plantation was primarily an experimental case study for scientific purposes. Potential further development may include meeting municipal energy requirements, such as the provision of heating for municipal buildings. If the viability of the plantation is confirmed, the SRP project site will be increased in an effort to meet such needs.

The biomass surplus is transformed into wood chips by small power or heat suppliers, optimally by cogeneration, within a radius of 50 km.

Costs and benefits

State assistance to establish SRP plantations for energy purposes includes subsidy programmes to help set-up the SRP site, including the purchase of cuttings, fencing materials, weed control, first planting, repeated planting etc.

SUBJECT OF STATE SUBSIDY

Note: according to Regulation NV 505/2000

PLANTING STOCK

- poplars and willows for plantation (additional planting): 1 pc cutting: 0.2 €
- poplars and willows for reproduction growth: 1 pc cutting: 0.12 €
- other timber species for plantation (additional planting): 1 pc cutting: 0.2 €

OTHER

- Fencing of reproduction growth: 2.4 €/m
- Protection of reproduction growth from weed infestation: 200 €/ha.
- Protection of reproduction growth from pests: 160 €/ha
- Conditions for obtaining the subsidy: It is necessary to reach a survival rate of 80% (maximum losses under 20%). Furthermore, the SRP must be operated for at least 15 years to obtain the subsidies.

REAL COSTS

- Costs of harvest and wood chip production: 32 €/t
- Costs of establishing the SRP: 3,200 – 3,600 €/ha.
- Ground lease can be: 28 – 40 €/ha/year

GENERAL SUBSIDIES

Note: see the state subsidy above

- Maximum subsidy for establishing reproduction plantation is 3,000 €/ha.
- Maximum subsidy for establishing production plantation is 2,400 €/ha.
- These subsidies decrease the final cost to the consumer to approximately 5.6 €/GJ (gigajoule).

DIFFICULTIES EXPERIENCED

The unstable subsidy schemes were too complicated a bureaucratic process for support. Productive varieties were not supported, varieties collected from nature were obviously not "good enough" in terms of productivity.

CONTACTS AND INFORMATION

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REFERENCES

- Czech Regulation NV 505/2000

7.5 Case study 5 : Ferrara Poplar SRP / Italy

Poplar SRP in Italy combining agro-industrial sludge with mineral fertilizer application.

Picture 35. Poplar plantation in February 2007, before harvesting. [Photo by: M. Caliceti, CONFAGRICOLTURA]

General data

Location:	Contrapò, Po di Volano, Ferrara / Italy
Area:	5 ha
Plant species used:	Populus spp. (“AF2”, “Monviso”, “Pegaso” varieties)
Type of fertilization:	Mineral fertilizer (ammonium nitrate 27%), before planting Urban and agro-industrial sludge
Date of planting and harvest cycle:	April 2005, rotation period every two years
Climate:	Continental Mediterranean
Supported by:	n/a

BACKGROUND

"La Bosca" farm is located approx. 10 km from the city of Ferrara. The owner is Nicola Gherardi, a 43 year old farmer, graduated in Agricultural Science and President of Confagricoltura Ferrara, which is one of the most important provinces in Italy from an agricultural point of view. The farm consists of approx. 240ha, made up of wheat, sugar beet, corn, sorghum, soybean and a pear orchard. The application of urban and agro-industrial sludges was started almost 6 years ago on various crops because of the positive results in terms of productivity, improvements in soil structure (soils are sandy-loam) and therefore reduced production costs. Five hectares of poplar SRP with different clones (F2, Monviso and Pegaso) were fertilized with sludge in accordance with local legislation. The biomass produced is sold to Biomasse Europa (http://www.biomasseuropa.com), a company involved in renewable energy services which supplies the Argenta biomass heating and energy plant.

Picture 36. Poplar plantation in February 2007. [Photo by: M. Caliceti, CONFAGRICOLTURA]

OBJECTIVE AND MOTIVATION OF THE PLANTATION

- To test poplar SRP for potential expansion in the Ferrara province, which traditionally has been devoted to arable crops.
- To confirm the beneficial effects of sludge application for increased productivity and improved soil structure.

LOCATION AND CONDITIONS

The site is a typical alluvial soil of the Po river basin, the largest Italian basin. Farm soils (sample analysis of the SRP field) are rich in silt (silt 71%, clay 25%, and sand 4%), and have a low organic matter content (2%); a pH of 8.4 and a cationic exchange capacity of 16.7 meq/100 gr. Mean annual temperature from 2005 to 2007 was between 12 and 14°C and in the same 3 years annual precipitation was approx. 500-600 mm.

SOURCE OF CUTTINGS

The clones were bought from "Franco Alasia" nursery, Savigliano (Cuneo, Italy) (http://www.alasiafranco.it/).

SELECTED SPECIES/ VARIETIES

- **AF2** is a male clone of Populus x Canadensis, derived from a cross between P. deltoides 145-86 (Illinois - USA) and P. nigra 40 (Piemonte - Italy). It is tolerant to Venturia sp., Melampsora sp., Marssonina sp., Dothichiza populea and some viruses such as PopMV.
- **Monviso** is a female clone of Populus x generosa 103-86 [P. deltoides 583 (Iowa - USA) x P. trichocarpa 196 (Oregon -U.S.A.)] X Populus nigra 715-86 [P. nigra 12 (Piemonte -Italia-) x P. nigra 7 (Umbria – Italy)]. It is very tolerant to Venturia sp., Melampsora sp., Marssonina sp., Dothichiza populea and some viruses such as PopMV.
- **Pegaso** is a male clone [P. deltoides 80-16 Iowa x P. trichocarpa 84-119 Oregon] X P. nigra 4, (Piemonte - Italy).). It is very tolerant to Venturia sp., Melampsora sp., Marssonina sp., Dothichiza populea and sufficiently tolerant to PopMV.

Picture 37. Poplar plantation in February 2007. [Photo by: M. Caliceti, CONFAGRICOLTURA]

PLANTING SYSTEM, DENSITY AND HARVEST CYCLE

- Plantation of the SRP site was carried out with a Spapperi transplanting machine (http://www.spapperi.it/) specifically designed for poplar (http://www.agricoltura.regione.lombardia.it/admin/rla_Documenti/1-3221/spapperi_trapiantatrice.pdf), following the single-row plantation system, parallel to the length of the field.
- Planting density is approximately 6,600 plants/ha with a 3m distance between rows and 0.5 m from plant to plant within the rows.
- The harvest cycle is biennial.

SOURCE OF FERTILIZER, DISTANCE AND TRANSPORT

Agro-industrial sludge was brought from the Caviro wine industry purification plant in Faenza (www.caviro.it), which is situated approximately 100 km from the farm. The company Ter.Am.Ec.srl, which is devoted to environmental services (in particular urban and agro-industrial sludge treatment) was in charge of the transportation of the sludge.

PROCESS DESCRIPTION

Prior to planting, an initial chemical fertilization was applied of 120 units/ha (4.5 q/ha of ammonium nitrate 27%). After the first biomass harvest, 200 q/ha of agro-industrial sludge (organic dehydrated sludge) was added according to the EU Nitrate Directive (see the sample chemical analysis in the table below). Total concentration of N in sludge (dry matter) was 220 mg/kg while for P was 230 mg/kg. Sludge was distributed by a sludge/manure Bossini spreader (www.fbbossini.com/) and then buried after 24 hours with disc harrow.

With respect to weed control, one herbicide treatment after plantation was carried out with Goal (Oxifluorfen) and Stomp (Pendimetalin) and later on, only during the first growing year, 2-3 superficial mechanical weed controls were completed.

Table 15. Sludge composition. [Source: University of Chemistry of Ferrara, Italy]

Sludge sample chemical analysis			max value (Regional Decree) 285/2005
pH	-	8,09	-
residue at 105°C	%	25,2	-
ash at 600°C	%	10,0	-
salt content	meq/100gr	32,3	50
SAR index	-	-	20
humification ratio	%	27,7	60
cadmium	mg/kg dm	1,6	20
chrome tot.	mg/kg dm	50,3	1000
mercury	mg/kg dm	0,4	10
nichel	mg/kg dm	19,3	300
lead	mg/kg dm	55,1	750
potassium tot	% dm	0,65	-
copper	mg/kg dm	248,8	1000
zinc	mg/kg dm	494,5	2500
arsenic	mg/kg dm	1,5	10
organic carbon	% dm	24,3	>20
nitrogen tot.	% dm	2,2	>1,5
phosphorus tot	% dm	2,3	>0,4
salmonella	MPN/g	absent	1000

Harvest system and biomass production

Biomass was harvested with a combined Class chopping harvester. Five hectares were harvested in one day with 48t/ha of wet biomass with an average moisture content of 50%. 6.8 MJ/kg was the quantity of energy obtained from this poplar wood chip.

Actual biomass use

Biomass production as wood chip, was sold to Biomasse Europa, a company involved in renewable energy services which supply the collected biomass to customers like Argenta biomass heating and electricity plant, owned by the San Marco Energie company (http://www.sanmarcoenergia.com/) and wood panel industry.

Costs and benefits

Costs for the first year were 1,800 €/ha for cuttings and planting machinery, 80 €/ha for seedbed preparation, 60 €/ha for weed control and 120 €/ha for fertilization before planting. Sludge transport, distribution and disc harrowing on the field costs are the responsibility of Ter.Am.Ec.srl with no cost to the farmer. Biomass harvest costs (18 €/t) and transport costs (6 €/t within 30km, for distances greater than 30km the cost is 6 €/t + 0.11 €/t per km) are paid by the biomass collector (Biomasse Europa). The final income for the total biomass production for the first harvesting cycle, was approximately 6,000 € (dry matter 60%, 20-35 €/t depending on the final product, only electricity or both electricity and heat).

DIFFICULTIES EXPERIENCED

No agronomical difficulties were observed, poplar SRP grew very well and fast. The SRP site showed a tolerance to attacks from spring insects. Bureaucracy and chemical analysis proved challenging, as it took almost 45 days to obtain Environmental Protection Agency authorization, the latter of which is carried out by the sludge supplier. Due to the Nitrate Directive, sludge applications are forbidden from October till March.

CONTACTS AND INFORMATION

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8 ANNEX

The Annex contains some general but also more country specific information for the UK and other BIOPROS regions.

8.1 SUMMARY OF COUNTRY SPECIFIC LEGISLATION

Table 16. Summary of BIOPROS partner countries specific legislations

UK and Northern Ireland			
Ref no	Title and Date of Application	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	The Sludge (Use in Agriculture) Northern Ireland) Regulations SR 1990/245 1990	Parliament	It regulates the use of sewage sludge in agriculture in Northern Ireland '*to prevent the harmful effects on soil, vegetation, animals and man, thereby encouraging the correct use of such sludge*'. As the use of sewage sludge is a major part of the BIOPROS project, the key points of this piece of legislation must be adhered to. Trace metal concentrations and nutrient budgets must be a known factor for the application of the sludge to the land. Regular monitoring of sewage sludge trace metal concentrations and regular assessment of nutrient budgets may be required to satisfy the government regulators.
2	Protection of Water Against Agricultural Nitrate Pollution Regulations (Northern Ireland) SR 2004/419 2004	Parliament	It seeks to curb water pollution caused by nitrate coming in the main from agricultural use of fertilisers and manure in Northern Ireland. Nitrate vulnerable zones (NVZ's) are to be identified where concentrations of nitrate in groundwater exceed or is approaching 50 mg/l. The application of sewage sludge to land will ultimately fall under these regulations whereby the concentration of nitrates from the sludge will limit its application to land under the codes of practise. This will mean that no winter application of sludge will be allowed and that weather conditions will determine suitable periods of application.

3	The Groundwater Regulations (Northern Ireland) SR 1998/401 1998	Parliament	It was established to protect groundwater from pollution and to reduce current pollution by prohibiting the discharge of dangerous substances. This regulation adopts two lists of prescribed substances from the parent Directive, which are to be controlled. As sewage sludge and wastewater will be indirectly discharged onto the receiving area some levels of both List I & II may be present in the sludge and water. This means that authorisation from the regulators will be required and may result in limited application of sludge or water. This problem may be resolved by some form of removal of certain contaminates from sludge or water prior to discharge.
4	The Surface Waters (Fishlife) (Classification) (Northern Ireland) Regulations SR 1997/488 1997	Parliament	It is intended to control water pollution in waters capable of supporting freshwater fish. Watercourses have been identified as being suitable for salmonids and cypinids. The aim of this regulation is to assess chemical water quality and achieve water quality standards in accordance with mandatory and guide values laid down. Run-off from land treated with sewage sludge and wastewater may be of concern if watercourses are in close proximity to the land being treated. This runoff may contain elevated levels of chemical parameters, which may prove harmful to fish. Application of sewage sludge and wastewater may be restricted therefore to proximity to a watercourse to minimise any potential effects.
5	The Urban Wastewater Treatment Regulations (Northern Ireland) SR 1995/12 1995	Parliament	They are concerned with the collection, treatment and discharge of urban wastewater. It provides the guidelines for operators by setting out the minimum standards for treatment of urban wastewater. Both treated wastewater and sewage sludge arising from wastewater treatment must be re-used wherever appropriate. However, these disposal routes are to minimise the effects on the environment. As a requirement of this regulation is the waste generated from urban wastewater treatment (sewage sludge and wastewater) is to be reused where appropriate.
6	Water Environment (Water Framework Directive) Regulations (Northern Ireland) SR 2003/544 2003	Parliament	They were designed to protect inland surface water, estuaries, coastal and groundwater. This legislation should be brought into full effect by 2013. At present the regulators (EHS) have began the process of implementing this legislation in Northern Ireland. Although at present this legislation is not fully implemented, it will supersede the following legislation: SR2004/419, SR1998/401 and SR 1997/488. As a result in the long term this legislation will govern the disposal of sewage sludge and wastewater on agricultural land.

7	Environmental Impact Assessment (Uncultivated Land and Semi-Natural Areas) Regulations (Northern Ireland) SR 2001/435 2001	Parliament	It is set up to minimise the environmental impact caused by large-scale development on Uncultivated land and Semi Natural Areas. Therefore an environmental impact assessment must be carried out on any large-scale development planned for the BIOPROS project in Northern Ireland. This legislation will be indirectly applied to BIOPROS whereby it only applies if large-scale development work is required for any aspect of the project. If this is the case then an environmental impact assessment is required and will need to be approved by the regulators.
8	Environmental Assessment of Plans and Programmes Regulations (Northern Ireland) SR 2004/280 2004	Parliament	It provides a high level of environmental protection and also contributes to the adoption and preparation of plans and programmes which will promote sustainable development. This is achieved through environmental assessment. The environmental effects of plans or programmes must be monitored to identify any potential adverse effects and carry out appropriate remedies. This legislation in effect may require participants of the BIOPROS project to gather supporting data, which may require significant time to accumulate such as long-term studies of environmental impacts.
9	Environmental Energy Act 2004 2004	Parliament	It applies to the whole of the UK, so is therefore relevant to Northern Ireland. The act requires that the UK cuts it carbon emissions and promotes competitive energy markets. This is to be achieved in the UK by developing and brining into use any energy sources or technologies. The energy sources and technologies referred to include biomass fuel.
10	The Conservation (Nature Habitats, etc.) Regulations (Northern Ireland) SR 1995/380 1995	Parliament	-

Italy			
Ref no	Title and Date of Application	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	Ministry of the Environment an Territory Decree 3/11/2004: Financing of cogeneration pilot plant 13/04/2005 (GU n.85)	Ministero dell'Ambiente e della tutela del territorio Italian Ministry of the Environment and Territory	It promotes high yield cogeneration pilot plants, with an installed capacity of less than 5 MWe, exploiting the produced heat for the cogeneration system. Among the priorities agricultural and forestry sector is foreseen and beneficiaries are also agricultural and forestry enterprises
2	Law n. 448, 23/12/1198: Public financial measures for the stabilization and development GU n. 302 del 29/12/1998	Legge dello Stato Italiano Law of the Italian State	It sets compensative measures to stimulate the reduction of polluting emissions, increase energy efficiency and use of renewable energy as well as the management of heating network systems with biomass energy resources.
3	Rural development plan (2000-2006), measure h (2.8), Lombardia Region: "Afforestation of agricultural land" Decree of the Regional Government. n° 19416 del 19.11.2004	Regione Lombardia Lombardia Region	Implements mechanisms that provide grants for planting of trees for biomass production with a minimum duration of 15 years and extension of at least of 1 hectare and at least 1.100 plants per hectare. Single farmers or an association, cooperative, consortium etc.,local administration or any other private law person are eligible.
4	Discipline of the combustible characteristics with relevance for the atmospheric pollution and technical characteristics of combustion plants 12/03/2002	Decreto del Presidente del Consiglio dei Ministri Decree of the Ministry Council President	It introduces biomass among the other combustibles for industrial and civil purposes. Dedicated vegetable materials are considered as biomass combustibles.
5	Recommandation CTI SC9: Biocombustible specifications and classification April 2003	Comitato Termotecnico Italiano Italian Termotechnical Committee	It provides a classification of solid and liquid biofuels from a technical and commodity point of view.
6	Resolution n.173/98 of the Inter-ministerial Committee for the Economic Programming (CIPE): Guide lines for national politics and measures towards green house gases emissions reduction 19 /11/1998	Comitato Interministeriale per la Programmazione Economica Inter-ministerial Committee for the Economic Programming	It approves the national greenhouse gas emission reduction targets at 95-112 MtoeCO2, in the years 2008-2012. Among other things it foresees the production of dedicated biomass and foresees the "National Program for the development of agricultural and forestry biomass". It sets important objectives like protection and extension of forests for CO2 absorption, sustainable agricultural and forestry schemes, etc. No specific financial source for the emission reduction had been implemented and short rotation forestry had not been promoted.

7	Resolution n.217/99 of the Inter-ministerial Committee for the Economic Programming (CIPE): "National Program for the development of agricultural and forestry biomass" 21/12/99	Comitato Interministeriale per la Programmazione Economica. Inter-ministerial Committee for the Economic Programming	It approves the "National Program for the development of agricultural and forestry biomass", which indicates the main actions to carry out in order to stimulate the production and the utilisation of biomass for energy purposes.
8	Resolution n.217/99 of the Inter-ministerial Committee for the Economic Programming (CIPE): Amendment of the guidelines for national politics and measures towards green house gases emissions reduction 19/12/2002	Comitato Interministeriale per la Programmazione Economica. Inter-ministerial Committee for the Economic Programming	It underlines the need to introduce new afforestation measures to reach the objectives of GHG emission reduction. It foresees a recognition and reorganisation of the legislation on forestry for this purpose. The resolution is a national plan for emissions reduction; it shows the limits of the emission that must be respected.
9	Law n. 10/91: regulation for the National Energy Plan implementation for the energy rational use and saving and the development of renewable energy sources G.U. n. 13 del 16/01/1991	Legge dello Stato Italiano Law of the Italian State	It was designed to improve the energy transformation processes, reduce energy consumption and improve the environmental compatibility conditions of energy use. The use of renewable energy sources is among the norms prescribed by the law.
10	Decree 11/09/1999 n. 401: Regulation for the accomplishment of art.1, paragraph 3 and 4, legislative decree 30/04/98 n.173 for the granting of aids in favour of the agricultural sector for the production and utilization of renewable energy sources. GU n. 260 del 5-11-1999	Governo Italiano Italian Government	It provides an aid scheme for farms for energy cost reduction and incentives for renewable energy sources utilisation. It promotes biomass plants but it could also promote systems that reuse wastewater and sewage sludge.
11	Legislative decree 16/03/1999 n.79: Implementation of the Directive 96/92/CE on common rules for the internal electricity market Gazzetta Ufficiale n. 75 del 31-03-1999	Governo Italiano Italian Government	It obliges all energy users or producers to insert, by the year 2002, into the national circuits at least 2% of the total amount of energy used the previous year in the form of renewable energy. In order to meet this annual threshold, interested operators are required to file Green Certificates.
12	Legislative Decree D.Lgs 387/03: Implementation of the 2001/77/CE Directive on the promotion of electricity production from renewable energy sources inside the internal electricity market Gazzetta Ufficiale n. 25 del 31 gennaio 2004	Governo Italiano Italian Government	It aims to foster the renewable energy sources contribution for the electricity production at Italian and community market level.

13	Law 23/08/2004 n. 239: Reorganization of the energy sector as well as proxy statement to the Government for energy legislation readjustment. G.U. n. 215 del 13 settembre 2004	Governo Italiano Italian Government	-
14	Ban for the presentation of contribution applications in reference to the CE Regulation 1257/99, Rural Development Plan (2000-2006), H Measure, Afforestation of agricultural lands	Regione Molise Molise Region	Describes strategies for afforestation in the Molise Region
15	Law n. 266/2005 Italian budget law for 2006	Legge dello Stato Italiano Law of the Italian State	Financial law 2006: Production and commercialization of electricity and heat from renewable agricultural sources operated by farmers are considered connected activities according to the Civil Code, article 2135, and they produce farm income. This means that the involvement of farmers in the energy production can benefit of the farmer special tax scheme regulations.
16	Decree 159/2007 implemented by Law n. 222/2007	Governo Italiano Italian Government	The electricity production of plants fuelled by biomass or biogas, either agricultural or animal, of a short chain supply, ie, supplied within a range of 70 km from the site plant, having a capacity higher than 1MW is granted with the issuance of Green Certificates, for a period of 15 years. Plants with an electrical capacity not higher than 1 MW, are entitled to receive, as an alternative to Green Certificates, upon producer's request, a sole tariff which is equal to 0.30 eurocents/kWh, for a period of 15 years. The plants above shall be entitled to receive Green Certificates equal to the net output multiplied by 1.8.
17	Regional Law n. 14, 2/05/2003: Agri-forestry interventions for biomass production 2/05/2003, n. 14 (BUR n. 45/2003)	Regione Veneto Veneto Region	It promotes and fosters the agro-forestry-energy production chain by providing specific contributions for wooden plantation for energy purposes, or for dedicated biomass plantation within a range of minimum 0.3 and maximum 4 hectares.
18	Law Proposal n°35: Initiatives for the support of production and of wood biomasses for energy production 21/07/05 (draft date)	Regione Veneto Veneto Region	

19	Legislative Decree 11/05/1999 n.152: Arrangement on water protection against pollution and implementation of Directives 91/676/CEE and 91/271/CEE concerning the treatment of urban wastewater and the protection of water pollution caused by farming nitrates Gazzetta Ufficiale n. 246 del 20 ottobre 2000	Governo Italiano Italian Government	It assigns to the Regions a central role in water protection policies by means of the enactment of regional Water Protection Plans. This decree has been conceived in order to adopt into Italian legislation the European Directives 91/271 on urban wastewater treatment and 91/676 on protection of water from agricultural pollution. The treated water can be used for irrigation, civil (street washing, cooling or heating plants feeding) or industrial purposes (process water). The decree states the minimum requirement for some chemical-physical and microbiological parameters.
20	Law n.36, 05/01/1994: Dispositions on water resources 05/01/1994	Governo Italiano Italian Government	The so-called "Galli Law" contains "new provisions relating to water resources". Through this legal framework, the Italian Parliament approved new regulations concerning water resources, bringing about a move from a fragmented and uncoordinated system to one based on market principles (Integrated system). There is a brief explanation of the general procedures for the use of refluent water but in technical terms and without stressing the role of the agricultural sector. Later on it is explained that the regions have to adapt programmes for the of water by means of incentives and facilities for companies needing equipments for the reuse and recycling of treated refluent water.
21	Decree 12/06/2003 n. 185: Regulation on technical norms for wastewater reuse in accomplishment of art. 26, paragraph 2, legislative decree 11/05/1999 n. 152 Gazzetta Ufficiale del 23 luglio 2003, n.169	Ministero dell'Ambiente e della tutela del territorio Italian Ministry of the Environment and Territory	It regards the reuse of purified wastewater, which aims to reduce the pollution of water bodies due to discharges. It contains measure regulating the technical standards for the reutilisation of wastewater. Interesting for the project is the use of wastewater for the irrigation of food and non-food crops. This decree indicates that sludge fertilizers from wastewater purification processes can be used if they have the right characteristics.
22	Decree 6/11/2003 n. 367: Regulation on water environment quality standard concerning hazardous substances, according to art. 3, paragraph 4, of legislative decree 11/05/1999 n. 152 Gazzetta Ufficiale N. 5 del 8 Gennaio 2004	Ministero dell'Ambiente e della tutela del territorio Italian Ministry of the Environment and Territory	

23	Legislative Decree n. 99, 27/01/1992, Gazz. Uff. n. 38,: Accomplishment of the Directive (CEE) 278/86, concerning del 15 febbraio 1992 environment protection, in particular soil protection with reference to water treatment sludge utilization in agriculture	Governo Italiano Italian Government	It implements Directive 86/278/EEC and regulates treated sludge utilisation in agriculture. It sets the rules and conditions for the correct use of purification sludge in order to avoid harmful consequences for the land, the vegetation, the animals and human beings.

Spain			
Ref no	Title and Date of Application	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	Plan for Renewable Energies Promotion in Spain 2005-2010 Date of approval: 26-Aug-05	Ministerio de Industria, Turismo y Comercio Ministry of Industry, Tourism and Trade	The Plan for Renewable Energies Promotion in Spain, encourages the practice promoted by BIOPROS by stimulating the renewable energy use. the biomass use as a renewable energy source is strongly encouraged
2	Energetic Plan of the region of Madrid 2004-2012	Consejería de Economía e Innovación Tecnolológica (Dirección General de Indusria, Energía y Minas) Regional Ministry of Economy and Technological Innovation (General Agency of Industry, Energy and Mines	It is the Energetic plan for the region of Madrid. One of the basis of the energetic policy is the promotion of the use of renewable energy sources, duplicating the energy generated by renewable sources and then representing the 3.4% of the total energy consumption. In order to achieve the mentioned aim the plan foresees actions on several renewable sources: biomass, wind, solid residues, solar photovoltaic energy and solar thermal. For biomass, the energetic plan purposes a research and technological development programme focused in the three main exploitation branches: direct thermal use, biofuels and agrarian electricity.
3	Decree 86/2003 of 1st of April, which approves the Energetic Plan of Andalusia 2003-2006 29-May-2003 (B.O.J.A. * number 101	Consejería de Empleo y Desarrollo Tecnológico Regional Ministry of Employment and Technological Development)	The Energetic plan for Andalusia, shows that biomass covers around 90% of the total renewable energies in Andalusia
4	Order of 18th of July 2005 in which the basis of subsidies for the sustainable develop in Andalusia and their call in 2005-2006 are established. 23-Aug-2005 (B.O.J.A. 164)	Consejería de Innovación, Ciencia y Empresa Regional Ministry of Innovation, Science and Enterprises.	It is based on the European Directive (86/278/CEE) and establishes that only treated sludge can be used. The decree also outlines conditions that need to be met. Apart from this, the Decree establishes the necessity to accompany every sludge load with the corresponding documents certifying its origin, composition and other information. . It is not stated the sludge use as for agricultural uses, but in any case, the mentioned requirement must be fulfilled by the soil and the sludge
5	Royal legislative Decree 1302/1986 of 28th June, of Environmental Impact Assessment 30-Jun-1986 (B.O.E. ** 155)	Ministerio de Obras Públicas y Urbanismo Ministry of Public Works and Town Planning	It states that only the projects regarding water resources management for the agriculture, which affect a larger area than 100 Hectares, must develop an environmental impact assessment and projects affecting an area of 10 Hectares or more are obliged to the assessment only in case the corresponding environmental body decides it. Regional regulations can demand an assessment of a project not included in the mentioned groups.

6	Act 7/1994, of 14th May, of the Environmental Protection in region of Andalusia 31-May-94) (B.O.J.A. 79)	Consejería de Cultura y Medio Ambiente Regional Ministry of Culture and Environment	It exempts the same projects as the national regulation from the environmental impact assessment, but adds two more possibilities of reporting the environmental effects of the project: environmental report and environmental qualification.
7	Royal Decree 1310/1990, of 29th of October, which regulates the Sludge Utilisation in the Agrarian Sector 1-Nov-1990 (B.O.E. 162)	Ministerio de Agricultura, Pesca y Alimentación Ministry of Agriculture, Fishery and Food	-
8	Royal Decree-Law 11/1995 of 28th of December which establishes the Norms Applicable to the Urban Wastewater Treatment 30-Dec-1995 (B.O.E. 312)	Ministerio de Industria, Turismo y Comercio Ministry of Industry, Tourism and Trade	It transposes the Directive 91/676/EEC, determining the kind of treatment that must be applied to the urban wastewater before the discharge, according to the area (sensitive or not).
9	Royal Decree 509/1996 of 15th of March, on the development of the Royal Decree-Act 11/1995 of 28th of December, which establishes the Norms Applicable to the Urban Wastewater Treatment 29-Mar-1996 (B.O.E. . 77)	El Ministro de Obras Públicas, Transportes y Medio Ambiente Ministry of Public Works, Transports and Environment	It develops what is determined in Reference 8 by establishing the requirements that must be met for discharges of treated wastewater.
10	Royal Decree 2116/1998 of 2nd of October as the last modification of the Royal Decree 509/1996 on the development of the Royal Decree-Law 11/1995, which establishes the Norms Applicable to the Urban Wastewater Treatment 20-Oct-1998 (B.O.E. 251)	Ministrerio de Medio Ambiente Ministry of Environment	-
11	Water Act 29/1985 of 2nd of August 8-Aug-1985 (B.O.E. 189)	Jefatura del Estado Central State	It imposes that the authorisations of actions affecting the public hydraulic domain and involving risks for the environment require an assessment of its effects. Thus, every project or action consisting in the realisation of works, facilities or any other activity that could affect the environment, must develop the mentioned assessment. It states that reuse of wastewaters was considered in the original and the rewritten texts of the Water Act and in the Regulation of the Public Hydraulic Domain, which establishes the basis for a later development on the issue of urban wastewaters reuse. It is also laid down that in order to be able to reuse wastewaters, the following authorisations are required: Health Report (Health Department of the Regional Government), Discharge Permission (Basin authority) and Administrative Permission (River Basin authority).

12	Royal legislative Decree 1/2001 of 20th of June, which approves the rewritten text of the Water Act 24-Jul-01 (B.O.E . 176)	Ministerio de Medio Ambiente Ministry of Environment	The Government will establish the basic conditions for the reuse of water, describing the required quality of the treated water on the basis of the foreseen use, but such guidelines have not been developed yet.
13	Royal Decree 849/1986 of 11th of April, which approves the Regulation of the Public Hydraulic Domain, that develops the Preliminary Title and the Titles I, IV, V and VIII of the Water Act 30-Apr-1986 (B.O.E. 103) 29/1985 of of August, as amended 2nd 606/2003 by Royal Decree	Ministerio de Obras Públicas y Urbanismo Ministry of Public Works and Town Planning	It determines that the discharges of wastewaters to the public hydraulic domain (including surface and groundwater, rivers and streams, lakes and ponds) are subjected to the concession of an authorisation and to emission limits established based on the receiving media and its sensitivity (therefore, submitted to the decision by local or autonomic authorities).
14	Royal Decree 606/2003 of 23th of May that amends the Royal Decree 849/1986 of 11th of April that approves the Regulations of the Public Hydraulic Domain that develops the Preliminary Title and the Titles I, IV, V and VIII of the Water Act 29/1985 of 2nd of August. 6-June-2003 (B.O.E. 135)	Ministerio de Medio Ambiente Ministry of Environment	It includes amendments to reference 5 and 13.
15	Resolution of 28th of April 1995, in which the National Plan of the Drainage and Wastewater Treatment is approved 1995-2005 12-May-1995 (B.O.E. 113)	Ministerio de Obras Públicas, Trasnportes y Medio Ambiente Ministry of Public Works, Transports and Environment	It is the resolution approving the National Plan of the Drainage and Wastewater Treatment for 1995-2005. The basic objective of this plan is to guarantee the quality of the treatment and the discharging of the urban wastewater according to the European criteria by promoting the finalization of the wastewater infrastructures according to the European Directive 91/271 and reutilisation of wastewater. Additionally it promotes the sludge reutilisation and tries to minimize the environmental impact of the sludge treatment or deposit. Although a specific use for wastewater and sewage sludge is not determined, the reuse of both is one of the objectives of the public Hydraulic Domain management.
16	Royal Decree-Law 2/2004 of 18th of June that modifies the Law 10/2001, 5th June of National Hydrological Plan. 19-June-04 (B.O.E. 148)	Jefatura del Estado Central State	It modifies the former Act 10/2001 about the National Hydrological Plan, modifying the National plan itself and promoting the wastewater reuse coming from the wastewater treatment plants in order to increase the availability of water in Spain. Although it is not specifically determined in the text, one of the uses of the treated wastewater could be the irrigation of energy crops,

17	Decree 13/1992, 13th February, that regulates the discharge of the liquids coming from urban wastewater treatment plants. 7-March-1992 (B.O.I.B.*** 29)	Gobierno de la comunidad de las Islas Baleares Balearic Islands government	It refers to a decree published by the government of the Balearic Islands, regulating the use of treated urban wastewaters for irrigation. This decree divides the reuse irrigation applications in two categories: "restricted" and "unrestricted". Whereas for restricted applications a microbiological limit is established, for unrestricted applications no limits are set.
18	Plan of drainage and treatment of the wastewaters of the region of Madrid (1995-2005)	Consejería de Medio Ambiente y Ordenación del Territorio Regional Ministry of Environment and Territory Management	It is the plan of drainage and treatment of wastewaters of the region of Madrid and explains that the huge amount of treated wastewater generated by the plants in Madrid and the scarce of water resources have led to the consideration of wastewater reuse as a feasible option. The use of sludge for agricultural ends is also considered an important alternative. Due to the lack of legislation and the economic importance of the subject, the Hydrographical Confederation of Tajo developed a survey about this issue in 1990 that proposes basic rules for a regulation on water reuse. At the moment, the mentioned survey is the most reliable document regarding water reuse. It divides the kind of irrigations into three (general, controlled and restricted) and identifies three types of crops.
19	Decree 193/1998 of 20th November. AGRICULTURE. It regulates the use of sewage sludge. 3-Dec-1998 B.O.C.M****. 287	Gobierno Regional de la comunidad de Madrid Regional Government of Madrid	It regulates the Sludge Utilisation in the Agrarian Sector, and states the norms about the information to be received by the central government from the controls carried out by the autonomous regions regarding the monitoring of the reuse of sewage sludge for agriculture and the National Register of Sewage sludge. Regarding the reuse of sludge, Madrid presents special characteristics that justify the auto-regulation of the region. According to this Decree, the high sludge generation coming from the urban wastewater in Madrid is a brilliant opportunity to enrich the agricultural soil, always avoiding affecting the soil with an inadequate dosage and keeping the conditions of public health.
20	Resolution of 7th July 2005 of the General Agency of Industrial Development, which publishes the list of UNE norms approved by ANEOR (Spanish Association of Standardization and Certification) during May 2005 5-Jul-2005 B.O.E. 159	Dirección General de Desarrollo Industrial Industrial General Agency Development	-

21	Royal Decree 1618/2005, of 30 December, on the application of a single payment scheme, and other direct aid schemes for agriculture and livestock 31-12-2005 B.O.E. nº 313	Ministerio de Agricultura, Pesca y Alimentación Ministry of Agriculture, Fishery and Food.	It states that the surface area that forms the object of an application for aid for energy crops is not eligible to justify withdrawal rights under the single payment scheme. It lays down compatibilities for aid to energy crops provided in EC Regulation CE 1782/2003 and states that the minimum surface area per application shall be 0.3 hectares. It also lays down criteria for sales contracts for energy crop production.
22	Royal Decree 2353/2004, de 23 de December, regarding certain EC aid schemes for agriculture for the 2005-2006 campaign, and for livestock for 2005. 24-12-2005 B.O.E. nº 309	Ministerio de Agricultura, Pesca y Alimentación Ministry of Agriculture, Fishery and Food.	It states that the surface area that forms the object of an application for aid for energy crops is not eligible to fulfil the obligation to withdraw land. The compatibilities between the application for aid for energy crops and payment of arable crops are also presented.
23	ORDER of 28 January 2005, that governs certain EC aid schemes for agriculture for the 2005-2006 campaign, EC aid schemes for livestock, the dairy premium, and additional payments for 2005, compensation in certain disadvantaged zones for 2005, surface area declarations for tobacco, cotton and dried fodder, and also crop declarations for the purpose of applying for agricultural-environmental aid. 07-02-2005 B.O.J.A. nº 26	Consejería de Agricultura y Pesca. Junta de Andalucía Regional Ministry of Agriculture and Fishery. Andalusian Government.	It governs aid to energy crops in Andalusia.
24	Mountain Law 43/2003, of 21 November. 22-11-2003 B.O.E. nº 280	Jefatura de Estado Head of State	It offers guidelines for the management of forestry mass and crops, plant quality used in reforestation, forestry-usable waste, etc, but makes no specific mention of energy crops.
25	Order of 6 September 1999 that informs of the publication of the details of the legislative contents of Southern Basin Hydrological Plan18, approved by virtue of Royal Decree 1664/1998, of 24 July. 17-09-1999 B.O.E. nº 223	Ministerio de Medio Ambiente Ministry of Environment	It permits the use of wastewater in forestry plantations and industrial crops(minimum treatment: primary sedimentation), adopting protective measures for workers and to avoid the water coming into contact with the population.
26	Order of 13 August 1999 that informs of the publication of the details of the legislative contents of Iberus (Ebro) Basin Hydrological Plan, approved by virtue of Royal Decree 1664/1998, of 24 July. 16-09-1999 B.O.E. nº 222	Ministerio de Medio Ambiente Ministry of Environment	It considers the use of wastewater in the creation of forestry masses in urban settings,

27	Order of 13 August 1999 that informs of the publication of the details of the legislative contents of Tagus (Tajo) Basin Hydrological Plan, approved by virtue of Royal Decree 1664/1998, of 24 July. 30-08-1999 B.O.E. nº 207	Ministerio de Medio Ambiente Ministry of Environment	It stresses that the use of waste water for irrigation purposes and waste water supply pipes should be marked by means of signs.
28	Royal Decree 2666/1998, of 11 December, that lays down the selection criteria to encourage improved conditions in the transformation and marketing of agricultural products, fishing, aquaculture and foods. 30-12-1998 B.O.E. nº 312	Ministerio de Agricultura, Pesca y Alimentación Ministry of Agriculture, Fishery and Food.	It lists the subsidies for making briquettes and pellets for energy purposes.

Poland			
Ref no	**Title and Date of Application**	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	Regulation of the Ministry of Agriculture and Rural Development dated of 7 April 2004 concerning the minimal demands of farm lands maintenance in a good agricultural culture Official Journal 16.04.2004 No 65, pos. 600	Minister Rolnictwa i Rozwoju Wsi Minister of Agriculture and Rural Development	It states that all farmlands should be kept in good agricultural care. Arable lands used for perennial plantations should be treated in a specific way. The Regulation contains the information that farm lands cannot be planted with trees and bushes, except for bushes and trees protected against cutting, with influence on the protection of the water and ground, having no influence on the plant production, as well as lands with established plantations of basket willows (Salix sp.) used for weaving.
2	Regulation of the Ministry of Economy, Jobs and Social Welfare dated of 30 May 2004 concerning detailed extent of obligation of purchasing heat and power from renewable sources and power produced in CHP installations Official Journal 13.06.2003 No 104, pos. 971 – abolished 1.01.2005	Minister Gospodarki, Pracy i Polityki Minister of Economy, Jobs and Social Welfare	-
3	Regulation of the Ministry of Economy and Employment dated of 9 December 2004 concerning detailed extent of obligation of purchasing heat and power from renewable sources Official Journal 17.12.2004 No 267, pos. 2656	Ministerstwo Gospodarki i Pracy Ministry of Economy and Employment	It provides different types of renewable energy sources, technical and technological standards of renewable sources, demands for specific parameters, registrations, amounts of energy or heat obligatory in renewable sources, a way and amount of energy that is obligatory to be purchased by the energy industries in the following 10 years and a way of including in the costs of energy and heat (based on tariffs) the costs of purchasing and generation.
4	Act from 10 April 1997 – Energy Law Official Journal 10.04.1997 No 54, pos. 48	Sejm Parliament	It is the most important energy act in Poland. It provides the rules of energy policy in Poland, the rules of energy, fuels, heat generation and supply, the institutions responsible for this policy, different types of concessions and tariffs. It describes also the definition of renewable energy sources.
5	Resolution of the Sejm (Parliament) of the Republic of Poland from 8 July 1999 concerning the growth of utilization energy from the renewable sources Monitor Polski 8.07.1999 No 25, pos. 365	Sejm Parliament	It defines the main aim that the growth of utilisation of energy from renewable sources should be an integral part of sustainable development of the country. It describes the targets in the energy policy of Poland for the nearest future.

6	Act of the Sejm of the Republic of Poland dated of 9 November 1990 concerning the rules of energy policy of Poland until the 2010 Monitor Polski 9.11.1990 No 43, pos. 332	Sejm Parliament	It describes the main aims of the Polish energy policy for next twenty years.
7	Proclamation of the Ministry of Economy and Employment dated of 1 July 2005 concerning the national energy policy until the 202512 Monitor Polski 22.07.2005 No 42, pos. 562	Ministerstwo Gospodarki i Pracy Ministry of Economy and Employment	It summarises all previous acts concerning the Polish energy policy from the beginning of 1989. It also provides the rules of future energy policy in Poland with respect to energy security, long-term general activities (until 2025) and executives activities (until 2008) in the energy sector, as well as the growth of the renewable energy sources, like biomass
8	Proclamation of the Ministry of Economy and Employment dated of 31 August 2005 concerning the promulgation of the report on the extent of shares of energy from renewable sources in the territory of the Republic of Poland, in national consumption of energy in 2005-2014 Monitor Polski 15.09.2005 No 53, pos. 731	Ministerstwo Gospodarki i Pracy Ministry of Economy and Employment	It gives recommendations for the next 10 years. In Poland the amount of renewable energy sources in total balance of energy generation in 1999/2000 was 2.35 TWh (1.6%). The target for 2010 is 7.5%. It is also planned to implement the subsidies to the willows plantations (Salix sp.) and roses (Rosa multiphlora var.) like as in the other European Union Member States (EU-15), which may be useful for BIOPROS.
9	Act dated of 18 July 2001. Water law Official Journal 2001 no 115 pos. 1229 2002-01-01	SEJM =National Parliament	It is one of the basic legislations on water quality protection. The act concerns water management according to the rule of sustainable development, particularly protection of water environment, use of water and water resources management . The act implements several EU directives. T
10	Act dated of 3 June 2005 about the change in the act of Water law and changes in the other acts. It was worked out on the basis of Official Journal no 130, pos. 1087 June 2005	SEJM Parliament	It provides some changes and integrations to the former Water Law.
11	Act dated of 27 April 2001 Law of Environmental Protection Official Journal 2005 no 62 pos. 552 2001-10-01	SEJM Parliament	It is one the basic legislations on Environmental protection. Most important to what regards BIOPROS, is that the owner of a contaminated land is obliged to rehabilitate the soil/water polluted. Standards of water/soil quality are determined by the content of some substances in soil/water,beneath of which, any of the soil/water functions cannot be fulfilled.

12	Act dated of 26 July 2000 on waste materials 2004-07-25 Official Journal 2001 no 62 pos. 628	SEJM Parliament	The Act on waste materials, defines the rules for managing waste materials. Article 43 concerns municipal sludge. Municipal sludge may be used when stabilized and prepared suitably towards elimination any hazard for human health and environmental conditions. Before usage, both municipal sludge and the ground on which the sludge is going to be used, have to be examined. The areas where the use of municipal sludge is forbidden are also listed as well as categories of sludge.
13	Act dated of 27 March 2003 on Spatial Planning and Management 2003-07-11 Official Journal 2003 no 80 pos. 717	SEJM Parliament	-
14	Act dated of 3 Feb 2003 concerning arable lands and forest protection Official Journal 1997 no 80. pos. 505 1995-03-24	SEJM Parliament	It regulates principles of arable and forest areas protection as well as their rehabilitation and improving of soil utility.
15	Act dated of 26 July 2000 r on Fertilizers and Fertilizing Official Journal 2000 no 89 pos. 991 2001-01-25	SEJM Parliament	It regulates the fertilisers' turnover and application;
16	Regulation of Ministry of Environment dated of 8 July2004 concerning conditions to be fulfilled when wastewater is discharged to water or ground and substances particularly harmful to water environment Official Journal 2004 no 168 pos. 1768 2004-07-28	Minister +rodowiska Minister of Environment	It states the requirements for the agricultural use of wastewater. The place and frequency of uptake of wastewater samples as well as reference methods of analyses and assessment are also defined. Harmful substances for the water environment are also defined.
17	Regulation of the Ministry of Agriculture and Rural Development dated of 30 Dec. 2004 concerning the method of water, reclamation devices and reclaimed ground records Official Journal 2005 no 7 pos. 55 2005-01-28	Minister Rolnictwa i Rozwoju Wsi Minister of Agriculture and Rural Development	It is the regulation of the Ministry of Agriculture and Rural Development, concerns the method of water, reclamation devices and reclaimed ground records. The regulation seems to be useful in case of willow irrigation with treated wastewater. When the land is irrigated with wastewater and the soil properties may change, and especially when "water-law" permission is required, the local authorities keep a record of the area.
18	Regulation of the Ministry of Environment dated of 11 Feb. 2004 concerning the classification for presenting quantity and quality of surface and ground water, methods of monitoring performance and methods of the results interpretation and presentation Official Journal 2004 no 32 pos. 284 February 2004 is not binding any more	Minister +rodowiska Minister of Environment	It concerns the classification for presenting quantity and quality of surface and ground water, methods of monitoring performance and methods of the results interpretation and presentation. The main value of the regulation – although it is already expired– is 5-degree surface water classification.

19	Regulation of the Ministry of Environment dated of 1 August 2002 concerning municipal sludge Official Journal 2002 no 134 pos. 1140 August 2002	Minister +rodowiska Minister of Environment	It is the regulation of the Ministry of Environment concerning municipal sludge is one of the most important legislation for the purpose of the BIOPROS project. The regulation determines the conditions to be fulfilled when the sludge is going to be used. It states the doses of sludge that may be applied to the soil and contains the range, frequency and methods of the reference research sludge and ground on which the sludge is going to be used.
20	Regulation of the Ministry of Agriculture and Rural Development dated of 7 April 2004 concerning the minimal demands of farm lands maintenance in a good agricultural culture Official Journal 16.04.2004 No 65, pos. 600	Minister Rolnictwa i Rozwoju Wsi Minister of Agriculture and Rural Development	It states that all farmlands should be kept in good agricultural care. Arable lands used for perennial plantations should be treated in a specific way. The Regulation contains the information that farm lands cannot be planted with trees and bushes, except for bushes and trees protected against cutting, with influence on the protection of the water and ground, having no influence on the plant production, as well as lands with established plantations of basket willows (Salix sp.) used for weaving.
21	Regulation of the Ministry of Economy, Jobs and Social Welfare dated of 30 May 2004 concerning detailed extent of obligation of purchasing heat and power from renewable sources and power produced in CHP installations Official Journal 13.06.2003 No 104, pos. 971 – abolished 1.01.2005	Minister Gospodarki, Pracy i Polityki Minister of Economy, Jobs and Social Welfare	-
22	Regulation of the Ministry of Economy and Employment dated of 9 December 2004 concerning detailed extent of obligation of purchasing heat and power from renewable sources Official Journal 17.12.2004 No 267, pos. 2656	Ministerstwo Gospodarki i Pracy Ministry of Economy and Employment	It provides different types of renewable energy sources, technical and technological standards of renewable sources, demands for specific parameters, registrations, amounts of energy or heat obligatory in renewable sources, a way and amount of energy that is obligatory to be purchased by the energy industries in the following 10 years and a way of including in the costs of energy and heat (based on tariffs) the costs of purchasing and generation.
23	Act from 10 April 1997 – Energy Law Official Journal 10.04.1997 No 54, pos. 48	Sejm Parliament	It is the most important energy act in Poland. It provides the rules of energy policy in Poland, the rules of energy, fuels, heat generation and supply, the institutions responsible for this policy, different types of concessions and tariffs. It describes also the definition of renewable energy sources.

Estonia			
Ref no	Title and Date of Application	Author or Organisation publishing the legislation; Original name & English translation	Comments
1	Land Improvement Act 22.01.2003	Riigikogu Parliament of Estonia	The Act gives the rules for management of land improvement systems. By the meaning of this act the land improvement is drainage, irrigation, and double water regime regulation, also liming of acid soils and agromeliorative, agrotechnical and other works for management of land improvement systems for increasing the value for cropping and use or for environmental protection.
2	Land Reform Act 17.10.1991	Riigikogu Parliament of Estonia	Backround: almost half of the Estonian cultivation area is still state land and this land is supplied by the land reform act to be used as agricultural land by using usufruct. The Act defines a 10-year use period for usufruct on agricultural land. Since the lifetime of SRP can be up to 25 years, willow plantations are not allowed on the land by usufruct.
3	Nature Conservation Act 21.04.2004	Riigikogu Parliament of Estonia	The Act states that it is forbidden to plant foreign species in Estonia. The only native poplar is the Populus tremula. Thus there is one type of SRP species that is allowed to be used for afforestation; the Populus tremula x P tremoloides
4	Temporary restrictions on Natura 2000 areas, which are beyond nature protection areas 22.04.2004	keskkonnaminister Ministry of Environment	It specifies the possible areas for farmer's test site in BIOPROS.
5	Water Act 11.05.1994	Riigikogu Parliament of Estonia	The Act sets requirements for using fertilisers, limitations on spreading wastewater etc, as well as limitations on crop demands and on regions. A special licence for water usage is needed for wastewater purification systems. This Act and also the Waste Act are the base for the Requirements for reuse of sludge in agriculture, greenery and recultivation (date of application 30.12.2002), which is marked in this table by number 10.
6	Regime of wastewater disposal to natural waterbody or ground 31.07.2001	Vabariigi Valitsus Estonian Government	It sets quality requirements for wastewater leading to ground or water bodies that are also specified in the licence for water usage.
7	Requirements for sewerage constructions 15.05.2001	Vabariigi Valitsus Estonian Government	It states that any wastewater treatment plant has to be built for at least 15 years. Biomembran has to be used on areas where groundwater is endangered. These limitations should be kept in mind while disseminating the idea of vegetation filters with SRP's among local authorities and farmers.

8	Fertilisers Act 11.06.2003	Riigikogu Parliament of Estonia	This Act is not regulating the usage of sludge, but regulating the usage of other fertilisers.
9	Waste Act 28.01.2004	Riigikogu Parliament of Estonia	States that sludge is regarded as a waste. This Act and also the Water Act are the base for the Requirements for reuse of sludge in agriculture, greenery and recultivation (date of application 30.12.2002), which is marked in this table by number 10.
10	Requirements for reuse of sludge in agriculture, greenery and recultivation 30.12.2002, Regulation nr 78	keskkonnaminister Ministry of Environment	Reuse of untreated sludge is not allowed. Reuse of pre-treated sludge in SRP's is possible under certain conditions.
11	Ambient Air Protection Act 05.05.2004	Riigikogu Parliament of Estonia	The possessors of sources of pollution shall take additional measures to reduce the emission evels of carbon dioxide and other greenhouse gases.
12	Certification of long-term development plan of fuel and energy economy until 2015 15.12.2004	Riigikogu Parliament of Estonia	This indicates that 5,1 % of electricity should be renewable in 2010. About 2.6% of that is predicted to be based on biomass, but the type of biomass is not specified.
13	Water protection requirements for storages of fertilizers, manure and for storage of silage and requirements for using and storage of manure, liquid of silage and other fertilizers, Regulation nr 288	Vabariigi Valitsus Estonian Government	In the regulation annex there is a list of amonts of nitrogen aloud to use per ha of cultivated area with mineral fertilisers by agricultural crops and yield planned.

Slovakia			
Ref no	Title and Date of Application	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	Act on the power sector No. 6 56/2004 Coll., Act on the heat power sector No. 657/2004 Coll. and Act No. 658/2004 on the regulation in network industries (regulatory office of network industries) 01/01/2005 (entered into force -EIF)	Narodna rada Slovenskej republiky National Council of the Slovak Republic	The legislations described are the only ones regulating in some way the use of energy from renewables. Reference to energy crops is missing, which could be seen as limiting for the BIOPROS project. Currently, a discussion is ongoing in Slovakia regarding if this should be implemented by revising the current acts or if a new separate act dealing only with Renewable energy systems should be elaborated
2	Act No. 188/2003 on the application of sewage sludge and bottom sediments into ground 01/01/2004 EIF	Narodna rada SR National Council of the SR	It regulates the conditions of the use of sewage sludge and bottom sediments for soil applications. There are conditions for the amount of sludge used and their application. On agricultural lands, or on forest soils, it is forbidden to apply sludge, from septic tanks and from other similar equipments aimed at wastewater and sludge treatment from sewage treatment plant, which treats industrial wastewater. Only wastewater from households or communal wastewater is allowed to be used. It also describes in details the conditions under which sludge and sediments can be used for application to the soil, e.g. only treated, with minimum 18 % content of dry matters. Sludge with lower content can be used only from water treatment plant under 5000 inhabitants, soil characteristics, where application is forbidden, etc
3	Regulation No. 707/20 04 which sets the details on project content and process of certification on sewage sludge and bottom sediments application into agricultural or forest land 01/01/2005 EIF	Ministerstvo p odohospodarstva SR Ministry of Agriculture of the SR	It sets the details on the project content and process of certification on sewage sludge and bottom sediments application into agricultural or forest land.
4	Fertilisers Act No. 136/2000 01/01/2001	Narodna rada SR National Council of the SR	Wastewater is not defined as fertiliser and using it for such purpose has not been taken into account nor regulated.

5	Regulation No. 338/2005 which sets the details on the soil sampling process, the way and scope of agrochemical soil testing and soil characteristics analysing in forest land, on soil fertilising registration and on plant nutrition status on agricultural and forest land 01/08/2005 EIF	Ministerstvo podohospodarstva SR Ministry of Agriculture of the SR	It formulates details on soil sampling, testing, characteristics, on agriculture plot and record keeping of fertilisers use and disposal and on the way of annual balance comparison of nutrients and soil organic mass on agriculture land. It concerns also energy coppice, whereby the basic parameters are analyzed regularly, at least every 4 years.
6	Regulation No. 392/2004 on provision of the program of agricultural activities in defined vulnerable areas. 15/07/2004 EIF	Ministerstvo podohospodarstva SR Ministry of Agriculture of the SR	Restrictions on fertilisers' application with nitrogen content (among them also sewage sludge and bottom sediments) in vulnerable areas are regulated.
7	Act No. 543/2002 on nature protection 01/01/2003 EIF	Narodna rada SR National Council of the SR	It regulates the case of land afforestation of protected areas, changes in the land use and the need for afforestation of land that is not suitable for agricultural practices and unused soil etc.
8	Act No. 307/1992 on agricultural land resources protection 29/04/1992 EIF	Narodna rada SR National Council of the SR	It regulates the case of land afforestation of protected areas, changes in the land use and the need for afforestation of land that is not suitable for agricultural practices and unused soil etc.
9	Conception of the forest policy up to 2005 2000 EIF	Vlada Slovenskej republiky Government of the Slovak Republic	It regulates the case of land afforestation of protected areas, changes in the land use and the need for afforestation of land that is not suitable for agricultural practices and unused soil etc.
10	Sectoral operational program Agriculture and rural development 2004 -2006 2004 EIF	Vlada Slovenskej republiky Government of the Slovak Republic	It aims to afforest 1700 ha of agricultural lands (in long term, the aim within the state conception is 23 000 ha) and on 10 % of afforested land to realise short rotation coppice (SRC). The conditions for obtaining grants for afforestation are also outlined.
11	Act No. 220/2004 on protection and exploitation of agricultural land 01/05/2004 EIF	Narodna rada SR National Council of the SR	
12	Act No. 229/1991 on land and other agricultural property ownership Act No. 504/2003 on the tenancy of agricultural land, enterprises and forest land Act No. 180/1995 on some provision for land property settlements 21/05/1991 EIF 01/01/2004 EIF 01/09/1995 EIF	Narodna rada SR National Council of the SR	It regards permission for afforestation of agricultural land.
13	Act No. 217/2004 on forest reproductive material 01/05/2004 EIF	Narodna rada SR National Council of the SR	It regards the disposal of land of unknown owners.

14	Water Act No. 364/2004 01/06/2002	Narodna rada SR National Council of the SR	The Water Act, has indirect relation through Reference 2 (Act No. 364/2004 Coll. on water and on amendment and supplement to act No. 372/1990 Coll. delicts in wording of later regulations (Water act)
15	Act No. 617/2004 on sensitive and vulnerable areas designation 01.01.2005	Narodna rada SR National Council of the SR	Ordinance of the Government of the Slovak Republic No 617/2004 on sensitive and vulnerable areas designation
16	Act No. 242/1993 on permissible pollution index of water 12/10/1993	Original name: Vlada Slov. R. Government of the Slovak Republic	Ordinance of the Government of the Slovak Republic No. 242/1993 Coll. setting up permissible pollution index of water in wording of the Ordinance of Government of the Slovak Rep. No. 491/2002 Coll.
17	Act No. 287/1994 Coll. on protection of nature and landscape in wording of the Act No. 222/1996 Coll. and the Act No. 211/2000 Coll.	Narodna rada SR National Council of the SR	Dealing with protection of nature and landscape.
18	Act No. 409/206 Coll. on wastes and on amendment and supplement to some acts ... as well to act No. 188/2003 Coll. on the application of sewage sludge and bottom sediments into ground	Narodna rada SR National Council of the SR	Dealing with wastes and on amendment and supplement to some acts ... as well to act No. 188/2003 Coll. on the application of sewage sludge and bottom sediments into ground.
19	Act No. 326/2005 Coll. on Forests	Narodna rada SR National Council of the SR	The Forest Act aims at the maintenance, enhancement and protection of forests.
20	Act No. 217/2004 Coll. on Forest reproduction sources	Narodna rada SR National Council of the SR	Dealing with condition for import of forest reproduction sources.
21	Act No. 543/2005 Coll. On protection of nature and landscape	Narodna rada SR National Council of the SR	Dealing with protection of nature and landscape in wording of the Acts No. 525/2003 Coll., No. 205/2004 Coll. and No. 364/2004 Coll.)

Czech Republic			
Ref no	Title and Date of Application	**Author or Organisation publishing the legislation; Original name & English translation**	**Comments**
1	Act No. 185/2001 Coll., on waste, as subsequently amanded Acts No. 477/2001, 76/2002, 275/2002, 320/2002, 356/2003, 167/2004, 188/2004, 317/2004, 7/2005 Coll., 1.1. 2002	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	The Act on Waste applies to all kind of wastes, including sludge, whereas wastewater is covered by the Act on Water. Sludge from municipal wastewater treatment plants belongs to the category of waste. According to Czech law sludge is defined as waste Only treated sludge can be applied taking into account the nutritional requirements of plants. The Act on Waste also defines the areas in which the use of sludge is prohibited.
2	Act No. 254/ 2001 Coll., on water with amendments to other laws, 1.1. 2002	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	It further defines the term of „wastewater" and forbids the use of contaminated wastewater.
3	Act No. 156/1998 Coll., on fertilizers, auxiliary soil substances, auxiliary plant agents and substrates and the agrochemical testing of agricultural soil (Act on fertilisers), as subsequently amanded Acts No. 308/2000, 147/2002, 317/2004 Coll., 1.9.1998	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	It defines conditions for the use of sludge and cases, where sludge is prohibited to use. The Act also defines the obligation to register the use of sludge. Whether the registration will concern SRP will depend on if land with SRP will be classified as agricultural land or not. Furthermore it defines the methodology for carrying out soil sample analysis.
4	Ordinance No. 381/2001 Coll., which defines the Catalogue of Waste, Register of dangerous wastes, and Registers of waste and countries for the purpose of export, import and transit of wastes, as subsequently amanded Ords. No. 503/2000, 168/2007 Coll., 19.7.2007	Ministerstvo zivotniho prostredi, MZP Ministry of Environment	It defines the catalogue of wastes. If sludge from wastewater treatment plants is classified as dangerous waste, it may not be applied on agricultural land.

5	Ordinance No. 382/2001 Coll., on the requirements of the use of treated sludge on agricultural soil, as subsequently amanded Ord. No. 504/2004 Coll., 1.10. 2004	Ministerstvo zivotniho prostredi, MZP Ministry of Environment	It defines the technical requirements/conditions for the use of treated sludge on agricultural soil including the allowed amount and the way of application, the concentration limits in the soil etc. Furthermore the methodology for taking sludge and soil samples and carrying out analysis of soil and sludge is defined. Note that Reference 5 deals with the use of sludge on agricultural land. If SRP's are not cultivated on agricultural land then this ordinance is not relevant anymore. In that case "normal" environmental law that prohibits the pollution of the environment deals with the use of sludge. If on such land sludge is applied, this needs to be approved by the district authority, which it self establishes the maximum pollution limits. The use of sludge is therefore possible, but there is no unified standard or procedure for the approval of such use, and the application of the regulations seem to vary from case to case
6	Ordinance No. 383/2001 Coll., on details of waste treatment, as subsequently amanded Ords. No. 41/2005, 294/2005, 353/2005 Coll., 15.9.2005	Ministerstvo zivotniho prostredi, MZP Ministry of Environment	-
7	Ordinance No. 376/2001 Coll., on the evaluation of danger of waste, as subsequently amanded Ord. No. 502/2004 Coll., 1.1.2002	Ministerstvo zivotniho prostredi, MZP, Ministerstvo zemedelstvi, MZe Ministry of Environment, Ministry of Agriculture	-
8	Ordinance No. 294/2005 Coll., on the conditions of waste storage on landfills and their use on land surface and the change of ordinance No. 383/2001 Coll., on specifications of waste treatment, 26.7.2005	Ministerstvo zivotniho prostredi, MZP Ministry of Environment	It defines the technical requirements and conditions for the usage of waste on surface territory. Biological degradable wastes as carrier of nutrients must be proven to be treated (removal of dangerous substances etc.) before application. If sludge from WTP fulfils the requirements defined in this ordinance, the sludge could be used on recultivation land, which can be used for the cultivation of SRC.
9	Ordinance No. 274/1998 Coll., on the storage and usage of fertilisers, as subsequently amanded Ords. No. 476/2000, 473/2002, 399/2004 Coll., 12.11.1998	Ministerstvo zemedelstvi, MZe Ministry of Agriculture	-

10	Ordinance No. 275/1998 Coll., on the agrotechnical testing of agricultural ground and the ensuring of the quality of forest area with amendments to other laws, 1.1.1999	Ministerstvo zemedelstvi, MZe Ministry of Agriculture	It defines the chemical characteristics of agricultural land and the methodology for collecting samples. chemical analysis needs to be applied for all agricultural lands and the amount of nutrients (Nitrogen , Phosphorus and Potash) must be determined before applying sludge. This will also be relevant to SRP.
11	Ordinance No. 474/2000 Coll., on the defenition of requirements on fertilisers, as subsequently amanded Ord. No. 401/2004 Coll., 1.1.2001	Ministerstvo zemedelstvi, MZe Ministry of Agriculture	It refers to sludge from wastewater treatment plants, which are used to produce industrial compost. This indirect use of sludge might be applicable for SRP on land of worse quality.
12	Government Order No. 197/2003 Coll., on the Waste Management Plan of the Czech Republic, 1.7.2003	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	It defines measures that prevent and limit the production of waste, and defines measures for the removal of dangerous substances from waste. This means that the use of sludge on agricultural land or as compost is preferred to other ways of disposing sludge and might therefore support the use of sludge on SRP.
13	Government Order No. 103/2003 Coll., on the definition of vulnarable areas and on the usage and storage of ferilisers, the rotation of plants and the realisation of erosion-preventing measures in these areas 1.1.2004 (section III) otherwise 3.3.2003	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	-
14	Act No. 180/2005 Coll., on the promotion of electricity from renewable energy sources with amendments to other laws 01.08.2005	Vlada (Ministerstvo zivotniho prostredi, MZP, Ministerstvo prumyslu a obchodu, MPO) Government (Ministry of Environment, Ministry of Industry and Trade)	It was designed to create appropriate framework conditions for the Czech Republic to fulfil its indicative target of providing 8% of its electricity (gross consumption) from renewable energy sources by 2010. It provides support in two ways and if SRP wood is used for the production of electricity, it benefits from this financial support.
15	Ordinance No. 482/2005 Coll., which stipulating the types, means of utilization and parameters of biomass to promote the production of electricity from biomass, as subsequently amanded Ord. No. 5/2007 Coll., 2.12.2005	Ministerstvo zivotniho prostredi, MZP Ministry of Environment	It defines the type of biomass and the way biomass can be used (refering to the Act on the promotion of electricity from renewable energy sources)

16	Price Decision No. 7/2007, which support electricity generation from renewable energy sources, combined heat & power, and secondary energy sources, 26.11.2007	Energeticky regulacni urad, ERU Energy Regulatory Office	Ordinance on technical and economic parameters of the support of electricity from renewable energy sources
17	Act No. 185/2001 Coll., on waste, as subsequently amanded Acts No. 477/2001, 76/2002, 275/2002, 320/2002, 356/2003, 167/2004, 188/2004, 317/2004, 7/2005 Coll., 1.1. 2002	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	The Act on Waste applies to all kind of wastes, including sludge, whereas wastewater is covered by the Act on Water. Sludge from municipal wastewater treatment plants belongs to the category of waste. According to Czech law sludge is defined as waste Only treated sludge can be applied taking into account the nutritional requirements of plants. The Act on Waste also defines the areas in which the use of sludge is prohibited.
18	Act No. 254/ 2001 Coll., on water with amendments to other laws, 1.1. 2002	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	It further defines the term of „wastewater" and forbids the use of contaminated wastewater.
19	Act No. 156/1998 Coll., on fertilizers, auxiliary soil substances, auxiliary plant agents and substrates and the agrochemical testing of agricultural soil (Act on fertilisers), as subsequently amanded Acts No. 308/2000, 147/2002, 317/2004 Coll., 1.9.1998	Vlada (Ministerstvo zivotniho prostredi, MZP) Government (Ministry of Environment)	It defines conditions for the use of sludge and cases, where sludge is prohibited to use. The Act also defines the obligation to register the use of sludge. Whether the registration will concern SRP will depend on if land with SRP will be classified as agricultural land or not. Furthermore it defines the methodology for carrying out soil sample analysis.

8.2 LIMIT VALUES FOR SEWAGE SLUDGE APPLICATION IN DIFFERENT EU COUNTRIES

Table 17. Limit values for heavy metal concentrations in sludge for use in agriculture in different EU countries (mg/kg sludge DM) - state: 2007

Country		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
86/278/EEC	6 < pH < 7	-	20 - 40	-	1000 - 1750	16 - 25	300 - 400	750 - 1200	2500 - 4000
Spain *1	pH < 7	-	20	1000	1000	16	300	750	2500
	pH > 7	-	40	1500	1750	25	400	1200	4000
Bulgaria *2		25	30	500	1600	16	350	800	3000
UK *3		-	10	1000	1000	10	300	750	2500
Poland *4	Food production	-	10	500	800	5	100	500	2500
	Non-food, non-fodder production	-	50	2500	2000	25	500	1500	5000
Estonia *5		-	20	1000	1000	16	300	750	2500
Czech Republic *6		30	5	200	500	4	100	200	2500
Slovakia *7		20	10	1000	1000	10	300	750	2500
Germany *9	5 < pH < 6	-	5	900	800	8	200	900	2000
	pH > 6	-	10	900	800	8	200	900	2500
Sweden *10		-	2	100	600	2.5	50	100	800

*Table 18. Limit values for amounts of heavy metals which may be added annually to agricultural land, based on a 10 year average in different EU countries (kg/ha*yr) - state: 2007*

Country	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
86/278/EEC	-	0.15	-	12	0.1	3	15	30
Spain *1	-	0.15	3	12	0.1	3	15	30
UK *3	0.7	0.15	15	7.5	0.1	3	15	15
Poland *4	-	0.2	10	16	0.1	2	10	50
Estonia *5	-	0.15	4.5	12	0.1	3	15	30
Slovakia *7	0.06	0.03	3	3	0.03	0.9	2.25	7.5
Sweden *10	-	0.00075	0.040	0.3	0.0015	0.025	0.025	0.6

Table 19. Limit values for concentrations of heavy metals in soil in different EU countries when sewage sludge can be applied (mg/kg soil DM) - state: 2007

Country		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
86/278/EEC	6 < pH < 7	-	1 - 3	-	50 - 140	1 - 1.5	30 - 75	50 - 300	150 - 300
Spain *1	pH < 7	-	1	100	50	1	30	50	150
	pH > 7	-	3	150	210	1.5	112	300	450
Bulgaria *2	pH 6 - 7.4	25	2	200	100	1	60	80	250
	pH > 7.4	25	3	200	140	1	75	100	300
UK *3	pH 5 < 5.5	50	3	400	80	1	50	300	200
	pH 5.5 < 6	50	3	400	100	1	60	300	250
	pH 6 - 7	50	3	400	135	1	75	300	300
	pH > 7	50	3	400	200	1	110	300	450
Poland *4	light textured soils	-	3	100	50	1	30	50	150
	medium textured soils	-	4	150	75	1.5	45	75	220
	clay soils	-	5	200	110	2	60	100	300
Estonia *5	pH > 5	-	3	100	50	1.5	50	100	300
Italy *8		-	1.5	-	100	1	75	100	300
Czech Republic *6	Sands	15	0.4	55	45	0.3	45	55	105
	Common soil	20	0.5	90	60	0.3	50	60	120
Slovakia *7	pH ≤ 6	15	0.5	30	20	0.1	15	70	60
	pH > 6	20	1	60	50	0.5	50	70	150
Germany *9	5 < pH < 6	-	1	100	60	1	50	100	150
	pH > 6	-	1.5	100	60	1	50	100	200
Sweden *10		-	0.4	60	40	0.3	30	40	100

*1 Real Decreto 1310/1990, Ministerio de Agricultura, Pesca y Alimentacion
*2 Ordinance N 339/14 - OJ 112/23 December 2004
*3 DEFRA, the Department of the Environment Food and Rural Affairs
*4 Regulation No 02.134.1140 from 27.08.2002 of the Minister of Environment
*5 Regulation no. 78 from 30.12.2002 of the Minister of Environment
*6 Ordinance No. 382/2001 Coll.
*7 Act No. 188/2003
*8 Legislative Decree 99/1992
*9 Ordinance on sewage sludge application in agriculture (AbfKlärV) from 15. April 1992
*10 Swedish Board of Agriculture (Jordbruksverket), 2008

8.3 Suppliers of equipments, plant materials and services in Europe

Company	Country	Profile
Lantmännen Agroenergi www.agrobransle.se	Sweden	Lantmännen Agroenergi in Örebro works with planting and marketing of Short Rotation Coppice Willow varieties, and the harvesting and marketing of SRC Willow chips. It is also active for the application of sludge to the SRC willow plantations and develop machinery and systems for planting, growing, harvesting and transportation of the harvested product to heating plants. [Source: www.agrobransle.se]
Nordic Biomass www.nordicbiomass.dk	Denmark	Nordic Biomass focuses on the cultivation of and applications for new crops for energy and industry. Production, propagation, crop husbandry, harvesting and consultancy in relation to new crops such as willow and elephant grass. Development and production of technical equipment and logistics. Establishment and crop husbandry for plantations, including energy crops, windbreak planting and afforestation, and landscaping. Supplier of first grade living and dried willow for further processing in industry and handicrafts. Development of new environmental solutions, including sludge conversion in willow crops, recultivation of garbage dumps, and plantations for wastewater treatment plants, biogas plants and in-situ soil remediation. [Source: www.nordicbiomass.com]
Renewable Fuels Ltd www.renewablefuels.co.uk	United Kingdom	Renewable Fuels Ltd is a British biomass fuel supply company committed to reducing CO2 emissions by providing realistic alternatives to fossil fuels, interfacing with energy producers and primary fuel producers to provide logistics and specification fuel for renewable energy production. its portfolio of fuels comprises processed energy crops, wood pellets, heat logs as well as forestry, sawmill and olive residue, used for a variety of applications including co-firing with coal in power stations, small scale commercial and domestic use. Core to its business is the long term establishment of energy crops in the UK in the form of short rotation coppice willow and the company provides a full range of services to growers, from land preparation to end-user contracts. [Source: www.renewablefuelsco.uk]
BICAL www.bical.net	United Kingdom	BICAL is the leader in the successful production and continued development of Miscanthus, the multipurpose crop for energy and industry. In the UK Miscanthus is recognised and supported by DEFRA, significant areas of Miscanthus are required to supply biomass into the renewable energy market. Established once, the crop yields for over 10 years, without replanting. BICAL have developed efficient and profitable systems for all aspects of crop production and onward processing. [Source: www.bical.net]

CHEVIOT TREES www.cheviot-trees.co.uk	United Kingdom	Suppliers of native trees, (broadleaves & conifers) shrubs, reedbeds, grasses & marginal plants to the Forestry, Woodland, Landscape, Amenity and Hedging sectors. Specialising in native British tree species and UK seed origins. [Source: www.cheviot-trees.o.uk]
BIOENERGY WEST MIDLANDS www.bioenergywm.co.uk	United Kingdom	Bioenergy West Midlands has been established by Advantage West Midlands, Harper Adams University College, Defra, and the Government Office for the West Midlands to assist in the development of a dedicated regional bioenergy supply chain. Its main activities are: Help to bring together bioenergy producers, processors, end users, consultants, manufacturers and local authorities across the region Provide stakeholders with information on funding Provide a unified voice to policy makers Facilitate networking opportunities Co-ordinate conferences, seminars, knowledge forums and practical demonstration events [Source:www.bioenergywm.co.uk]
Coppice Resources Ltd www.coppiceresources.com	United Kingdom	Coppice Resources Ltd is a British company for planting, managing and harvesting short rotation coppice (SRC), the primary energy crop for use in biomass heat and/or power plants and boilers. Specialists in all commercial aspects of SRC production including supply of willow cuttings, crop establishment, harvesting and its associated logistics, R&D and the development and supply of dedicated machinery. [Source: www.coppiceresources.com]
CNER (National Consortium for Renewable Energies)	Italy	CNER has the purpose of promoting bioenergy through the use of energy crops, especially short rotation coppice of poplar and robinia. CNER provides assistance the following fields: implementation of bioenergy projects in the agricultural field; development of regional and local energy projects; Energy provision and heat supply contracts with public and private bodies; Research and development projects. CNER can offer cultivation contract for the production of short rotation coppice all over Italy, managing harvest, logistic and purchase of woodfuel. CNER activities can be developed at large scale (provision of biomass to large power generation facilities) as well as medium scale projects aimed at setting up local supply chains. [Source: www.cner.it]

BIOMASSE EUROPA www.biomasseeuropa.com	Italy	Biomasse Europa is a founding member of CNER and operated since 2001 in the supply of services and materials for the implementation of short rotation plantations and bioenergy projects. In 2007 Biomasse Europa planted more than 1700 Ha of short rotation poplar in northern Italy. Source: [Source: www.biomasseeuropa.com]
ALLASIA PLANT (www.allasiaplant.com)	Italy	Allasia plants supplies young trees and cuttings for the establishment of short and medium rotation poplar and other forestry species. Other services include commercialization of forestry products and machineries and natural engineering services. [Source:www.allasiaplant.com]
ALASIA VIVAI (www.alasiafranco.it)	Italy	Since 1998 Alasia vivai is active in the fields of genetic improvement of energy crops (especially poplars) and production of plants and cuttings for the implementation of short rotation coppice fields. It is a member of CNER. Source: www.alasiafranco.it

8.4 COUNTRY SPECIFIC INFORMATION - SRP PLANTING MATERIAL

UK - LIST OF LOCAL SELLERS FOR SRP PLANTING MATERIAL

Seller	Contact
Coppice Resources Ltd.	LS8, Armstrong House, First Avenue, Doncaster Airport, DN9 3GA
Border Biofuels	91 Hanover Street, Edinburgh, Midlothian, EH2
Rural Generation Ltd.	65-67 Culmore Road, Londonderry, Northern Ireland, BT48 8JE

ESTONIA - LIST OF HERBICIDES, PESTICIDES AND FUNGICIDES

Organisation	Source
Taimetoodangu Inspektsioon	http://www.plant.agri.ee/?op=body&id=120

Table 20. Examples for herbicides used in SRP in Europe (before use, clarify with local authorities)

Herbicide	Reporting Country
Roundup	Czech Republic, Slovakia, Germany
Axial	Czech Republic
Fusilade Forte 150 EC	Czech Republic
Flexidor	UK
Stomp	UK
Lazer/Falcon	UK
Shield	UK
Weedazol	UK

8.5 COST BENEFIT ANALYSIS OF SRP - CASE STUDY

In the following pages a case study will be analyzed, which shows the average costs and revenues for a short rotation plantation in central Italy, based on the use of new poplar hybrids, specifically registered for the production of woodfuel.

The case study will also show the potential benefit that can be obtained by the use of wastewater and sludge in SRP, assuming that their application will replace the use of fertilizers and irrigation.

DESCRIPTION OF INITIAL CONDITIONS AND CULTIVATION TECHNIQUES

The present case study is based on the following hypothetic initial conditions:

- **location:** Central Italy, plain fields, medium fertility soils with good water retention capacity,
- **plantation density:** 5.500 plants/ha (spacing 2.5m X 0.75m),
- **cycle length:** 2 years (harvest once every two years; total lifetime of the plantation 10 years),
- **plant varieties:** new Italian hybrids of white poplar selected and registered for woodfuel production (AF1- AF2, Monviso),
- **irrigation:** rainfed plantation; occasional supplemental irrigation in summer season may occur.

8.5.1 COSTS

Costs for SRP of poplars can be divided into two categories:

- initial and final costs,
- annual costs.

8.5.2 INITIAL AND FINAL COSTS

Initial and final costs are those expenses that are necessary for the realization of the plantation, such as:

- **Initial soil preparation:** these include an initial tillage of soil at 70-80 cm depth, usually done in winter;

- **Base fertilization:** with organic or mineral fertilizers containing phosphates and potash (100 units each); nitrogen is supplied with annual surface fertilisations; this operation is usually done in winter;
- **Preparation of soil for transplanting:** includes one or two harrowings; this is usually done in late winter;
- **Transplanting of cuttings:** cuttings are transplanted with special machineries carried by a tractor and operated by 2 or 3 workers; the price includes the man-hours of workers, the cost of machinery and the cost of cuttings (usually 0,20 € each). This operation is usually done in early and mid spring.
- **herbicide treatment:** the control of weeds is essential in the first stages after transplanting; as cuttings need some time to regenerate roots and start growing. If weeds prevail in this stage they rapidly overwhelm poplars in nutrition and water uptake and this leads to slow growth rates and poor productivity. Therefore at least one (preferably two) herbicide treatment or mechanical weeding is necessary during spring and early summer.
- **Restoration of soil after the end of the cycle:** Short rotation plantations usually last for 10 years, after that time yields decrease significantly and further harvests are not recommendable nor viable. In order to restore the initial soil conditions after the last harvest, a deep cultivation of soil with a forestry harrow can be performed, to break and crash the roots of the trees so that they don't produce anymore shoots and rapidly decompose.

Table 21. Average operation costs of SRP plantations [Source: Estimation by ETA on data by Cami R., 2006 and Bartolini R., 2005]

Initial and final costs for SRP plantation	**€/ha**	**% of total costs**
Soil preparation (tillage)	200	6,77
Base fertilization (includes cost of fertilizer and spreading)	100	3,38
Preparation of soil for transplanting	75	2,54
cuttings and transplanting	2200	74,57
Herbicide treatment	75	2,54
Restoration of soil after the end of the cycle	300	10,16

ANNUAL COST

- **amortization of initial and final costs:** this is an indirect cost for the farmer, which represents the amount of money that the farmer must save from the annual incomes to repay the expenses that he already bear to realize the plantation, and that he will bear to restore the initial soil conditions after the last harvest. Since the lifespan of the plantation is ten years, this costs are simply one tenth of the total initial and final costs;
- **harrowing:** one light harrowing is necessary to avoid excessive soil compacting and to remove weeds before the start of the growing season;

- **mechanical or chemical weeding:** this operation is necessary soon after harvesting, in early spring, to avoid the competition of weeds with new shoots that regenerate from the base of the plants. If proper nutritional and water conditions are maintained, the new shoots will grow rapidly and overcome the competition; therefore, in the second year after harvesting, weeding might not be necessary;
- **annual fertilization:** fertilization with rapidly available nitrogen is recommended after harvesting to promote the growth of new shoots; in the second year after harvesting, weeding might not be necessary.

Table 22. Costs of annual operations of an SRP plantation. [Source: Estimation by ETA on data by Cami R., 2006 and Bartolini R., 2005]

Annual costs of SRP plantation	€/ha	% of total costs
Annual amortization of initial and final costs*	295	56,2
Harrowing	80	15,2
Annual fertilization	100	19,0
Herbicide treatment after harvesting (1 every two years)	50	9,5
Total costs	**525**	**100**

8.5.3 Harvesting

- Harvesting is not usually operated by the farmers themselves since it requires large dedicated machineries that are rarely affordable to single farmers. Therefore, the most common solution in Italy is that harvesting is performed by third parties who own the machineries and that are engaged by the buyers of woodfuel itself, who stipulates contracts of cultivation with the farmers. Farmers are then only responsible for growing and maintaining the plantations and supplying the "standing trees" to the buyer.

8.5.4 Revenues

Direct revenues are represented by the amount paid to farmers by the buyers of woodfuel. The product is paid on a weight basis, with a unitary price of around 2 € per ton of fresh biomass (usually 50-55% moisture at harvest). Usual yields in the conditions assumed in the present case study vary among 35 and 45 tons per hectare of fresh biomass per year. In case of use of wastewaters and sludge we can assume that the average yield will be increased to 50 tons of fresh biomass, due to the increased supply of water and their positive nutritional effect on plant growth.

Other sources of revenues to farmers are represented by the CAP subsidies that can be divided in two categories:

- **single decoupled payment:** this subsidy was introduced by the latest CAP reform of 2003 and is paid to farmers annually and independently from the cultivated crop and its production. The value of the decoupled subsidy is calculated on the average of the direct payments obtained by each farmer during the years 2000-2002 for different productions; therefore each farm has its own subsidy. For this reasons (independency from crop and difficulty of estimation) single payments are not considered in the present case study; nevertheless a broad estimation of their usual value in Italy can be defined in the range of 200 to 700 €/ha per year.
- **subsidy for energy crops:** this subsidy is coupled to the production of energy crops and is granted to those farmers who stipulate contracts with national or European industrial operators who process the agricultural commodities into biofuels (liquid and solid biofuels as well). The value of this subsidy is fixed at 45€/ha per year.

Table 23 shows the potential income that can be obtained by farmers from selling woodfuel with different yields. The final potential profit after deduction of production costs is also showed in the last column. With an average yield of 40 t/ha per year of fresh biomass, the net profit for the farmer, including the subsidy for energy crops would be 320 €/ha (plus the single payment that is not considered here). Even in case of lower yields (30 t/ha), it is possible to achieve a positive balance, although with marginal profits.

Table 23. Potential income and net profit from SRP plantations. [Source: Estimation by ETA on data by Cami R., 2006 and Bartolini R., 2005]

Production (t/ha*year fresh biomass)	**Income from woodfuel (€/ha)** (unit price 20 €/t)	**Total income (€/ha)** (income + subsidy for energy crops)	**Cost of production (€/ha)**	**Potential Profit (€/ha)***
30	600	645	473	173
40	800	845	525	320
50	1000	1045	577	468
60	1200	1245	630	615
70	1400	1445	682	763

8.5.5 ESTIMATION OF ECONOMIC BENEFITS OF SLUDGE AND WASTEWATER APPLICATION TO SRP

A first assessment of the economic benefit of sludge and wastewater application to short rotation plantations can be made on the basis of their "value of substitution" of fertilization and irrigation by conventional means.

Assuming that the operation of spreading is performed by the owner of the treatment facility at his own expenses, with no additional costs for the farmer, and that the quantity applied is sufficient to cover the nutritional demand of the plantation, we can consider that the value of wastewater and sewage and sludge application to SRP is equal to the value of the annual fertilizations that can be saved, that is around 100 €/ha as shown in Table 22.

The application of wastewaters, if managed properly, can also have a beneficial effect on the SRP in terms of water supply. Under normal rainfed conditions, the growth rate of the plantation would raise during spring and reach a peak in early-mid summer, when high temperatures and the reduction of water availability would limit the photosynthesis. Depending on climate and rainfall trends, an irrigation in early summer could be very helpful to sustain the rapid growth rate of the crop in the middle of the growing season, thus leading to a greater overall accumulation of biomass.

Assuming this, we can consider that the application of wastewaters would induce a higher average yield in the plantation, close to 50 t/ha year of fresh biomass instead of 40t/ha.

The combination of cost savings and increased plantation yields would boost the net profit of SRP (as shown in Table 24). With a yield of 50 t/ha, the net annual profit would be as high as 567 € instead of 320 (+77%).

Table 24. Annual income and potential profit from SRP of poplar with application of wastewaters and sludge. [Source: Estimation by ETA on data by Cami R., 2006 and Bartolini R., 2005]

Production (t/ha*year fresh biomass)	**Income from woodfuel (€/ha)** (unit price 20 €/t)	**Total income (€/ha)** (income + subsidy for energy crops)	**Cost of production (€/ha)**	**Potential Profit (€/ha)***
500	1000	1045	477,5*	567,5
600	1200	1245	477,5	767,5
* cost of production shown in Table 22 minus the cost of fertilization				

A much higher profit could be achieved in case the farmer was granted a payment by the owner of the treatment unit for the fulfillment of a task of public interest, that is the disposal of final wastes on agricultural lands, at lower prices than those requested for the disposal in landfills. This solution would be highly consistent with the concept of multifunctional agriculture that is often considered as a target by local and European agricultural policies and which refers to the modern interpretation of the role and strategic importance of agriculture not only as a producer of primary goods but also as a provider of services to the community (environmental, social, etc.).

8.6 MODEL CONTRACTS FOR SEWAGE SLUDGE APPLICATION IN AGRICULTURE

8.6.1 MODEL SLUDGE AGREEMENT

This model contract for sewage sludge application in agricultural lands was kindly provided to ETA Renewable Energies to be used for the scopes of the BIOPROS project by Emeritus Prof. Sir Alan Buckwell of the Country Landowners Association of London (www.cla.org.uk). It was prepared by CLA in 1999 and currently withdrawn because it needed updating, which was not completed yet for lack of time. Prof. Buckwell agreed to share this document with the BIOPROS consortium. We suggest that any modifications, integration or corrections to this document should be notified also to CLA.

In the following you can find a copy of a document, entitled Model Sludge Agreement (Final Draft 2 - see Chapter 8.6.2). This is the final form of a draft agreement (between water companies and landowners/farmers) which the CLA has negotiated with the water industry's trade association, Water UK. Although it is called a "model" agreement, please note our comments below, in which the document is referred to as the "MSA".

The CLA does not have a general position on the spreading of sewage sludge (also known as "biosolids") on agricultural land, but if you are considering allowing it to be spread the CLA urges you first to take professional, including legal, valuation and environmental advice. This would ensure that you are fully aware of the possible implications of applying sludge to your land, and that any agreement you sign, and of course any consideration paid, adequately addresses those implications and your particular circumstances and concerns. Whilst the MSA is not a model in the strict sense, the CLA considers the MSA to be a sound basis for such an agreement, containing a number of favourable provisions. However, there remain a number of areas which still cause concern. We recommend that you negotiate with the particular water company on your particular areas of concern.

We advise you to consider in particular the following points and draw them to your advisers' attention:

CONSENTS

1. Before signing any agreement, you must ensure that you have obtained all necessary consents, for example from mortgagees.

THE PARTIES

2. The MSA should be signed by the sewerage undertaker (the water company, referred to in the MSA as "the Supplier") itself, rather than by the contractors who, usually, spread the sludge on the water company's behalf. The water company will typically have substantial covenant strength to back its obligations. Establishing this principle has been one benefit of our MSA discussions with Water UK, and Water UK has assured the CLA that its members will not deal with tenants without involving landlords in a tripartite agreement based on the MSA. If you have tenants who might wish to accept sewage sludge onto your land, we suggest that you draw this point to their attention.

3. Before signing, you and your advisers should consider the potential liabilities involved - e.g., the possibility that allowing it to be spread could expose you to statutory or even criminal liability for "knowingly permitting" any resulting contamination or pollution. You should satisfy yourself that the undoubted safeguards in the draft Agreement, such as the water company's obligations to indemnify and clean-up as discussed below, provide sufficient comfort in this regard.

4. If you are the occupier accepting the sludge onto the land, you will be the "Customer" as defined in the MSA, and should carefully read your obligations - especially clause 4 and Schedule 6. Ensure that you understand and have been advised on their implications and what you have to do to comply with them, and whether you should seek to modify any of them to ensure that you can comply. Alternatively, you may be simply the landowner, with the "Customer" being another person - perhaps your tenant farmer. If so, then assuming that you have satisfied yourself that you are content for the sludge to be applied to the land (or if you have no power to prevent it), you will be able to sign as the "Landowner". This will give you the benefit of an indemnity from the water company without your taking on any material obligations (except under optional clause 6.3, discussed further below). However, whether you are the "Customer" or merely the "Landowner", you should seek advice on the legal implications of having permitted the application of the sludge to the land. You should ensure that you understand, and are satisfied with, how the MSA applies to the situation where the "Customer" is not the landowner.

5. If you are the "Customer", the MSA makes you liable for the conduct of your licensees, employees, and contract or share farmers, because of the definition of "Customer". You and your advisers should consider whether you have adequate contractual rights over them, to ensure that they do not put you in breach of the agreement and you have adequate remedies against them if they do.

THE INDEMNITY

6. The main advantage of the MSA over many previous such agreements is the indemnity in your favour, given by the water company in clause 6. The indemnity covers your "Losses", which are defined widely in clause 1.1 to include damages, loss of profit, and the cost of handling or averting third party claims or enforcement actions by authorities. This is important because of the possibility that the sewage sludge could contaminate land or water, or affect produce, and because of the increasingly rigorous requirements of the major food retailers.

7. Although the indemnity is broad, it has some important limitations (see clause 6). First, it only applies where the water company or its contractor has been negligent or has breached its obligations under the MSA. It follows that the indemnity does not cover land contamination liabilities caused by the sludge unless the water company or its contractor has been negligent or breached the MSA; nor does it cover losses (including economic losses) which arise from the mere presence of the sludge; hence your need to take full professional advice before accepting the sludge onto your land. The CLA sought but did not obtain a "no-fault" indemnity. Also the indemnity would be stronger if the MSA contained a general obligation on the water company to comply with all applicable legislation. Water UK would not accept such an obligation, although Schedule 4 lists a broad range of legislation with which the water company must comply.

8. Secondly, the indemnity will not cover most losses arising from matters occurring before the date which you signed the agreement.

9. Thirdly, the indemnity does not apply to any loss, to the extent that it is caused or contributed to by the activities of, or by or any negligence or breach of the MSA by, either the "Customer" or "Landowner". (Note paragraph 5 above in this respect).

10. Fourthly, the indemnity will not cover losses arising from applying to the land materials from sources other than the water company.

11. The fact that the conduct of third parties can undermine the indemnity, has practical implications. You would be well advised to consider how, practically, you can monitor and ensure that this does not happen. Bear in mind that, in the bipartite "Customer"/water company agreement, third parties include neighbours, trespassers and any person who might subsequently become your tenant on the land.

12. In the tripartite agreement involving the 'Landowner' too, there is the additional possibility that the "Customer" and "Landowner" can, by their conduct, undermine each others indemnity from the water company. You should consider whether you need any specific contractual provisions in contracts or leases with third parties and tenants. You may also wish to consider including the square-bracketed clause 6.3, but bearing in mind that this contains an indemnity from you as well as in your favour. If you do not wish to give any indemnity then you should not include clause 6.3. If you do wish to include clause 6.3, you should consider whether any limits or procedural safeguards are appropriate. Bear in mind that the value of an indemnity from anyone is of little value if they are not likely to have the financial resources to meet their liabilities under the indemnity. Those liabilities could arise years after the agreement is signed, as of course could your liabilities under the indemnity you would be giving in clause 6.3.

13. If the land has previously had sludge or similar materials spread on it, you should consider how you would prove that a problem was caused by the sludge spread under the new agreement and not by the previous materials. Maintaining records of the chemical and other properties of the various materials would assist in this, as would a "base-line" investigation of the state of the land before the new sludge is spread, and of course monitoring that the sludge is spread in accordance with your agreement and good practice.

14. The MSA caters for either the water company (through to its contractors) or the "Customer" actually to apply the sludge to the land (clauses 3.4 and 4.1). You should ensure that you, or the "Customer" if that is not you, only take on that responsibility if you are satisfied that it will be done properly and in compliance with the MSA, and that all statutory consents are obtained and complied with.

CONTAMINATION

If a breach of the MSA by the water company leads to the sludge causing problems on the land, the water company must cany out any works required by regulatory authorities even if the requirement is imposed on you (clause 3.5). But you do not have to wait for such a requirement to be imposed - you can require the water company to remove the wrongfully applied sludge as of right, if it is reasonably possible for it to do so (clause 3.2). However, you have no general protection in respect of contamination liabilities - see paragraph 7 above.

RETAILERS AND OTHER CUSTOMERS

In considering the advisability of accepting sludge onto your land, and the terms on which you do so, one consideration is current and future attitudes of your customers to accepting produce grown on land which has in the past been spread with sludge. For instance, the CLA understands that crisping potato buyers are already, in some instances, seeking assurances that sludge has not been used on the land on which potato crops are being grown.

Another indicator of current attitudes among retailers might be the informal understanding (in the form of a matrix) which we understand has been reached between Water UK and the British Retail Consortium on the use of sewage sludge on agricultural land. However, this matrix is non-binding, informal and subject to change in light of both future research and developing attitudes, which may of course be very different from current attitudes. Currently copies of this matrix as it presently stands can be obtained from Brian Chambers of ADAS, at Gleadthorpe Research Centre, Medenvale, Mansfield, Nottingham, NG20 9PF (tel: 01623-844331). Please check with Mr Chambers that he holds the most recent version of the matrix if you ask him for a copy.

ASSIGNMENT AND TERMINATION OF THE MSA

An agreement based on the MSA will run indefinitely until one or other of the parties terminates it, either under clause 8 or by giving notice under clause 2.1. You will need to agree on a notice period for clause 2.1, and a late-payment period for clause 8.l(a). The indemnities in clause 6 will not expire on termination (clause 8.4(a)).

The MSA is not entirely clear as to whether the benefit and burden of it (including the indemnity protection) will pass to successors in title of the Customer and Landowner without being expressly assigned under clause 7.1 (which requires consent from the other parties). Your solicitors should ensure that amendments are made to make your Agreement clear on this point. We would anticipate that purchasers will often expect to receive the benefit of the indemnity. However, the Customer and Landowner are in different positions here - because of the Customer's important obligations to the water company, the water company may well resist the Customer's being able to automatically assign its rights and obligations to a successor in title (in whom the water company may not have confidence to fulfill the Customer's obligations). If this is an issue when you negotiate your Agreement, one compromise would be for any disposal of the Customer's interest in the land to be an additional ground for the water company to terminate your Agreement.

Please do not treat the above as a complete list of such issues. Neither the CLA nor any other person can or does accept any liability in relation to the MSA, or for the above comments. These are not exhaustive and are intended only to assist members in taking specific expert advice which is essential to ensure that their interests are protected in such matters.

Yours sincerely

….

8.6.2 Model Sludge Agreement 2 - Final Draft 2

This document was approved for and on behalf of the Country Landowner's Association, for use only in conjunction with the CLA's letter to its members (ref: dated 05 July 1999) and appropriate professional advice. – Simmons & Simmons solicitors 5/7/99 ref 4/mn/W33742

THIS AGREEMENT is made the day of 199

BETWEEN:

(1) ("the Supplier")

(2) ("the Customer")

(3) ("the Landowner")

WHEREAS the Supplier has agreed to supply Biosolids to the Customer [and apply such Biosolids to the Land] on the following terms and conditions

NOW IT IS AGREED as follows:

1. DEFINITIONS

1.1 In this Agreement the following terms shall have the following meanings:

- "Biosolids" (sewage sludge) means the organic matter, plant nutrients and other materials separated by the Supplier during wastewater treatment.
- "the Commencement Date" means…
- "the Code" means The Code of Practice for the Agricultural Use of Sewage Sludge (1996) (Second Edition)
- "the Customer" means occupier of the Land, and also his licensees, employees, contract or share farmers
- "the Land" means the Customer's land [shown edged red on the attached plan]

["the Landowner" means the freehold owner of the Land]

"Losses" mean:

- (a) any loss, damage, injury or liability (including any consequential, loss, loss of profits or business);

- (b) any cost or expense (including any cost or expense reasonably incurred for the purpose of complying with regulatory requirements, or averting or minimising reasonably anticipated regulatory requirements);
- (c) any valid claim (including any claim validly made by a regulatory, body or third party), and any cost or expense reasonably incurred for the purpose of averting or minimising any such claim;

which the Customer [or Landowner] may incur under contract, common law, any enactment, or otherwise, to the extent that such losses arise from the Supplier's negligence or failure to comply with any of its obligations under this Agreement.

"the Regulations" means The Sludge (Use in Agriculture) Regulations 1989 and The Sludge (Use in Agriculture) (Amendment) Regulations 1990 as currently amended.

"the Supplier" includes its agents, contractors and employees.

1.2 In this Agreement references to statutory provisions and codes shall be construed as references to those provisions and codes qualified as described in paragraph 2 of Schedule 4 below.

1.3 In this Agreement:

- (a) words expressed in any gender shall, where the context so requires or permits, include any other gender; and
- (b) words expressed in the singular shall, where the context so requires or permits include the plural, and vice versa.

Without prejudice to Clauses 7.1, 8.1 (d) and 8.2 below, references to the Customer [and Landowner] shall (where the context permits) include [their respective] successors – in-title.

2. TERM

2.1 This Agreement shall be taken to have started on the Commencement Date, and shall continue until it is terminated by any party giving   months prior written notice to others.

3. SUPPLIER'S OBLIGATIONS

3.1 The Supplier shall, in relation to the Biosolids supplied to the Customer for use on the Land, provide the Customer with the information set out in Schedule 1 below, at the times specified in that Schedule.

3.2 The Supplier:

- (a) shall only supply Biosolids which accord with the information provided under Clause 3.1 above; and
- (b) so far as reasonably practicable, shall on written demand from the Customer [or Landowner] remove any materials supplied:

    (i) which do not accord with such information; or

    (ii) which it has supplied otherwise than in accordance with the provisions of this Agreement.

3.3 In transporting and delivering Biosolids to the Land, the Supplier shall observe the precautions set out in Schedule 2 below.

3.4 The Supplier shall apply the Biosolids to the Land by the methods described in Schedule 3 below.

3.5 In exercising its rights under this Agreement, the Supplier shall use reasonable care and skill, and shall act in accordance with good practice, and (to the extent that the following obligations apply to it), shall:

- (a) comply with the statutes and regulations, and have regard to the codes of practice, listed in Schedule 4 below, and the lawful requirements of every competent authority therunder;
- (b) obtain all necessary consents from, and effect all necessary registrations with, every competent authority;
- (c) on lawful demand by any relevant authority to any party to this Agreement:

    (i) discontinue the exercise of its rights under this Agreement;

    (ii) comply with any requirements lawfullly imposed, to the extent that the requirements relate to and arise from any breach by the Supplier of any of its obligations under this Agreement; and

    (iii) carry out any consequential works and operations in consultation with the Customer [and the Landowner], and in accordance with [their] reasonable requirements in so far as consistent with such lawfully imposed requirements;

- (d) subject to reasonable notice, produce to the Customer [and/or Landowner] evidence of its compliance with this clause; and
- (e) compensate the Customer and the Landowner agaist Losses in accordance with and subject to the provisions of Clauses 6.1, 6.2 and 6.4 below.

3.6 The Supplier shall also observe and perform the obligations set out in Schedule 5 below

4. CUSTOMER'S OBLIGATIONS

4.1 The Customer shall apply the Sludge to the Land by the methods described in Schedule 3 below.]

4.2 The Customer shall observe and perform the obligations set out in Schedule 6 below.

4.3 The Customer warrants that he is legally entitiled to enter into this Agreement.

5. CONSIDERATION

5.1 The Customer [and Landowner] shall [each] pay to the Supplier for the supply [and application] of the Biosolids the sum of one pound, and the Customer shall additionally pay to the Supplier the sums calculated or assessed in accordance with the provisions of Schedule 7 below, at the times set out in that Schedule.

6. INDEMNITY

6.1 Subject to Clauses 6.2 and 6.4 below, the Supplier shall indemnify the Customer [and the Landowner] against any Losses incurred by [them (to the extent of their respective Losses)] which result from the Supplier's exercise of the rights granted by this Agreement, to the extent that such liability arises from the Supplier's negligence or failure to comply with any of its obligations under this Agreement

6.2 The Supplier shall not be liable to the Customer [or the Landowner] under Clause 6.1 above to the extent that such Losses are occasioned by: -

- a) the Customer's [and/or Landowner's] negligence;
- b) the Customer's [and/or the Landowner's] breach of any of [its] obligations under this Agreement;
- c) matters which

    (i) occurred before the date of this Agreement (other than breaches by the Supplier relating to the Land of any earlier agreement entered into between the Supplier and Customer [and/or Landowner]); or

    (ii) arise wholly or partly from the application to the Land by the Customer, [the Landowner] and/or third parties of sludge or other materials from sources other than the Supplier.

6.3 The Customer and the Landowner agree to indemnify each other to the extent that either of them is unable to recover all their Losses from the Supplier under Clause 6.1 above as a consequence of the other of them having been responsible for reducing the Supplier's liability for such Losses under Clause 6.2 above.]

6.4 The Supplier shall so far as practicable mitigate its liability under Clause 6.1 above by making good any physical damage that it may cause to the Land, or to the Customer's [or Landowner's] adjoining property.

7. NOT ASSIGNABLE

7.1 This Agreement is personal to the Supplier and the Customer, neither of whom may, without the prior written consent of the other parties assign, dispose or part with any of their interests in it, or grant any lease or license, or delegate any of their rights or obligations under it.

7.2 Without prejudice to Clauses 8.1 (d) and 8.2 below, Clause 7.1 above does not apply to any such transfers effected involuntarily by operation of law.

8. TERMINATION

8.1 Any party may at any time by written notice terminate this Agreement immediately, and without liability for compensation or damages in respect of such termination:

- (a) if any money payable to it or him under this Agreement is in arrears for more than days;
- (b) if after the date of this Agreement there is any modification, amendment, variation, extension, substitution or re-enactment of any of the statutes, regulations or codes listed in Schedule 4 below, or there are any new legislative provisions, all as described in paragraph 2 of that Schedule;

  (i) If any of the other parties fails to comply with any of its, his or their obligations under this Agreement and the failure is irremediable or (if capable of remedy) remains unremedied for days after being called to its, his or their attention by written notice from any party not in default; or

  (ii) if either the Supplier or the Customer becomes insolvent, or if an order is made or a resultion passed for the winding up of either of them (other than voluntarily for the purpose of solvent amalgamation or reconstruction), or if an administrator, administrative receiver or receiver is appointed in respect of the whole or any part of either of their assets or business, or if either of them makes any composition with its or his creditors, or takes or suffers any similar or analogous action in consequence of debt.

8.2 The Supplier may by written notice terminate this Agreement immediately, and without liability for compensation or damages in respect of such termination, if the Customer dies, becomes bankrupt, has a receiving order made against him, makes any arrangement with his creditors generally, or takes or suffers any similar action as a result of debt.

8.3 The Customer [or Landowner] may at any time by written notice terminate this Agreement immediately, and without liability for compensation or damages in respect of such termination, if there is a material change in the contents of the Biosolids or if there is any change in the treaments to which the Biosolids have been subjected prior to supply.

8.4 The expiration or earlier termination of this Agreement shall not affect:

- (a) the provisions of Clauses 6.1 to 6.4 above in relation to Losses arising from the Supplier's performance or purported performance of this Agreement; or
- (b) any right of action already accrued to any party in respect of any breach of this Agreement by any of the other parties.

9. FORCE MAJEURE

9.1 If the performance of this Agreement or any obligations under it is prevented, restricted or interfered with by reason of circumstances beyond the reasonable control of the party obliged to perform it, the party so affected (upon giving prompt written notice to the other parties) shall be excused from performance to the extent of the prevention, restriction or interference, but the party so affected shall use its or his best endeavours to avoid or remove the causes of non-performance and shall continue performance under this agreement with the utmost dispatch whenever such causes are removed or diminished.

10. OBLIGATIONS IN ADDITION TO THOSE IMPOSED BY LAW

10.1 The obligations and restrictions imposed by this Agreement are in addition to and not in substitution for the obligations and restrictions imposed or implied by law.

11. ENTIRE UNDERSTANDING AND VARIATIONS

11.1 This Agreement embodies the entire understanding of the parties in respect of the matters contained or referred to in it and there are no promises, terms, conditions or obligations, oral or written, express or implied, other than those contained in this Agreement.

11.2 No variation or amendment of this Agreement, or oral promise or commitment related to it, shall be valid unless committed to writing and signed by or on behalf of all parties.

12. DISPUTES

12.1 Any difference which may arise between the Supplier, the Customer [and/or the Landowner] shall be determined by an expert to be agreed between the parties in dispute, or failing such agreement to be appointed on the application of any such party by the President of the Royal Institution of Chartered Surveyors having regard in such appointment to the area of expertise required for the satisfactory determination of that difference.

SCHEDULE 1

(PARTICULARS OF BIOSOLIDS DELIVERED)

(1) The date of application.

(2) The area of field treated.

(3) The quantity and rate of Biosolids application.

(4) Particulars of any treatment applied to the Biosolids.

(5) The rate of the trace element additions in respect of the metals listed in the Regulations.

(6) An estimate of the Biosolids minerals fertiliser replacement values.

Such information shall be provided at the times specified in the table below.

Table (to be fulfilled)

SCHEDULE 2

(PRECAUTIONS – TRANSPORTATION AND DELIVERY)

The Supplier shall:

(1) Ensure vehicles delivering Biosolids are (so far as practicable) sufficienty self-contained or covered to contain odours;

(2) Have regard to sensitive areas when routing vehicles;

(3) Take precautions for minimising the risk of causing soil damage;

(4) Clear up any deposits of mud or spillages of Biosolids as soon as practicable so as to minimise road traffic hazards, nuisances and risks of pollution;

(5) Take reasonable precautions to prevent vehicles taking mud onto the highway;

(6) Before storing Biosolids on the Customer's property, obtain the Customer's consent; and, so far as is practicable, construct and maintain stores so that they are safe, do not cause a nuisance, and comply with the Codes of Good Agricultural Practice for the Protection of Water, Soil and Air (October 1998); and

(7) Ensure that, so far as is reasonably practicable, vehicles used to carry untreated sludge or any other substances do not cross – contaminate subsequent loads of treated sludge.

SCHEDULE 3

(METHODS OF APPLICATION OF BIOSOLIDS)

(1) Biosolids shall be applied in accordance with the Regulations and the Code of Practice for the Agricultural Use of Sewage Sludge (1996) (Second Edition).

(2) High trajectory guns shall not be used.

(3) Biosolids shall be evenly applied to those parts of the Land, and at the rates, as may from time to time be agreed between the Supplier and the Customer.

(4) Biosolids shall be applied so as to minimise the risk of causing soil damage.

(5) Biosolids shall be applied with due regard for the Codes of Good Agricultural Practice for the Protection of Water, Soil and Air (October 1998).

SCHEDULE 4

(RELEVANT LEGISLATION)

1. Statutes, Regulations and Codes of Practice:

- Health and Safety at Work etc Act 1974
- Ancient Monuments and Archaeological Areas Act 1979
- Control of Pollution (Amendment) Act 1989
- Environmental Protection Act 1990
- Water Industry Act 1991

- Water Resources Act 1991
- Environment Act 1995
- Regulations which have been made under the above legislation
- Sludge (Use in Agriculture) Regulations 1989
- Sludge (Use in Agriculture) (Amendment) Regulations 1990
- The Code of Practice for the Agricultural Use of Sewage Sludge (1996) (Second Edition)
- The Codes of Good Agricultural Practice for the Protection of Water, Soil and Air (October 1998).
- Any other legislation referred to in the above Codes so far as relevant to applying biosolids to land.

2. The above-mentioned statutes regulations and codes shall extend to such provisions as they may from time to time be modified, amended, varied, extended, substituted or re-enacted, whether before or during the currency of this Agreement, including new legislative provisions which contain more onerous, comprehensive or stringent environmental requirements relevant to the rights or obligations of any of the parties to this Agreement.

SCHEDULE 5

(ADDITIONAL SUPPLIER'S OBLIGATIONS)

1. SAMPLING AND ANALYSIS OF BIOSOLIDS

On the commencement of this Agreement, and once a month while Biosolids are being produced at [the waste water treatment works] from which the Biosolids are being supplied, the Supplier shall take representative samples of the Biosolids which are being supplied to the Customer, shall analyse them in accordance with the Regulations and the Code, and shall provide the Customer with the results and such analyses.

2. SAMPLING AND ANALYSIS OF THE LAND

On or before the commencement of this Agreement, on its termination, and during its existence at such intervals as are required by the Regulations and the Code, the Supplier shall take representative samples of the Land and analyse them in accordance with the Regulations and the Code, and provide the Customer with the results of such analyses.

SCHEDULE 6

(ADDITIONAL CUSTOMER'S OBLIGATIONS)

(1) On the commencement of this Agreement, the Customer shall (to the extent that he knows or ought reasonably to know) provide to the Supplier full particulars of:

- a) the drainage arrangements for the Land and surrounding
- b) area, and the frequency and extent of the flooding of the same;
- c) wells and boreholes in the area which are used for supplying
- d) water for use by the Customer or third partties for human consumption or in farm dairies; and
- e) rights of way.

(2) On the commencment of this Agreement and thereafter, the Customer shall (as required by the Regulations) inform and keep the Supplier informed of any Biosolids, sludge and similar materials which are applied to the Land and which have not been supplied by the Supplier.

(3) The Customer shall also (to the extent that he knows or ought reasonably to know):

- a) inform the Supplier of areas likely to be sensitive to delivery traffic;
- b) take account of the nutrients in the Biosolids (as notified to the Customer by the Supplier under Clause 3.1 above) when estimating his crop nutrient requirements;
- c) have regard to the Codes of Good Agricultural Practice for the Protection of Water, Soil and Air (October 1998); and
- d) inform and keep informed the Supplier of any veterinary problems relevant to the Land and the surrounding area.

(4) The Customer shall not:

- a) add to or interfere with any Biosolids stored by the Supplier on the Customer's property;
- b) graze animals or harvest forage from any parts of the Land treated with Biosolids, within three weeks fo the completion of application;
- c) permit turf to be harvested from any parts of the Land treated with Biosolids, within six months of the completion of application;
- d) harvest soft fruit from any parts of the Land treated with Biosolids, within ten months of the completion of application;
- e) harvest crops that are normally in direct contact with soil and may be eaten raw from any parts of the Land treated with Biosolids, within ten months of the completion of application; and

- f) grow seed potatoes or nursery stock for cropping rotation, on any parts of the Land treated with Biosolids.

SCHEDULE 7

(CONSIDERATION)

SIGNED by or on behalf of the Supplier }

SIGNED by or on behalf of the Customer }

SIGNED by or on behalf of the Landowner }

8.6.3 MODEL CONTRACT FOR ESTABLISHMENT AND HARVESTING OF SRP OF WILLOW OR POPLAR

The present document is a summary of a framework agreement kindly provided by Renewable Fuels ltd. the first British company in the wood energy business from dedicated energy crops, and is meant to provide for an example of the general structure and the main specifications that should be included in a contract between a grower of SRP and a buyer of woodfuel. Please refer to the original contract for more detailed information.

FRAMEWORK AGREEMENT FOR THE ESTABLISHMENT AND HARVESTING OF

WILLOW SHORT ROTATION COPPICE

CONTRACT NO: []

THIS FRAMEWORK AGREEMENT is made BETWEEN:

(1) [Name and Address] (the Grower); known as the applicant for Energy Aid Payments growers holding number [ ], growers SBI number [ ]; and

(2) [The company] is a company registered in England and Wales whose registered number is [ ], known as the first processor for Energy Aid Payment purposes. [The company]'s office for administration purposes is, [Address].

WHEREAS:

(1) [The company] is a party to agreements with energy generators to supply Short Rotation Coppice as biomass fuel for the production of heat and/or power;

(2) The Grower wishes to facilitate the growth of Short Rotation Coppice on their land by [The company] during the Term of this Agreement; and

(3) The Parties have entered into and/or anticipate entering into one or more agreements that supplement and are or will be governed by this Framework Agreement such agreements to be in the form set out in Annex A (the "Confirmation");

1. Date and Duration of the Agreement

2. Definition of legal and commercial terms and expressions included in the contract;

3. Definition of Grower's obligations and rights;

4. Definition of Buyer's obligations and rights;

5. Specifications for solving disputes;

6. Specifications for payments and invoicing;

7. Confidentiality agreement;

8. Limitation of Liability;

9. Date and Signature of the parties;

ANNEXES

- Procedure for the determination of moisture content of a consignment;
- Specifications for land preparation;
- Specifications for storage of woodchips;
- Planting detail of SRC land (number of hectares, plant density etc.);
- Buyer's costs relating to SRC land (harvesting etc.);
- Buyer's costs relating to SRC land (harvesting etc.);

8.7 Additional Information – Chapter 4 and 6

8.7.1 Additional information - Chapter 4

The irrigation of wastewater can be seen as an extension to a conventional treatment plant. Therefore the same standards should be applied in terms of sanitation, reliability and monitoring/control. Depending on pretreatment, the health risks to wastewater may vary, which will to a large degree influence the choice of irrigation system. As well as the lifespan of the SRP plantation, the predicted lifetime of the irrigation system must also be taken into account.

In the following more detailed information will be provided in addition to chapter 4, particularly Table 6 (page 35). The next headlines refer to the specific aspects for irrigation system selection as shown in Table 6. After that the specific validation of each shown irrigation system will be further explained against these aspects using the numbering of 1-8 as shown in Table 6.

Health protection

It is fundamental to maintain a good standard of sanitation when wastewater is used for irrigation. The irrigation system should act as a barrier between humans and the potential pollutants found in wastewater. The design of an irrigation system should avoid the creation of aerosols, runoff, local overload, and leakage to groundwater, as well as having a non-irrigated edge around the field. Irrigated wastewater should exist on the soil surface for as short a time as possible, as the transmission of infection causing agents is dramatically decreased as the water is taken up by the soil. An irrigation system should be near the surface and irrigate different areas in sequence, i.e. small quantities of wastewater should be irrigated instead of allowing the formation of pools of standing water. In warmer climates, standing water could create an environment for insects and algae. Depending on the pretreatment of the wastewater, some irrigation systems are not recommended. In practice, sprinklers are only advisable for wastewater which has been stored for 4-6 months to prevent any subsequent health risk.

Nutrients control

In a soil plant system the amount of applied fertilizer in the wastewater (mainly NPK) should be in balance with the levels of biomass harvested and brought away. For N there is also a quantity that is taken up in the atmosphere that could be two or three times that taken up by the plants. It is necessary to have a good tracking system in place for the utilization of wastewater, which in itself needs to be monitored and controlled on an ongoing basis.

EVEN DISTRIBUTION

To meet the demand of health protection requirements and nutrient level control the wastewater must be distributed evenly to the SRP site. This can be done in a number of ways depending on soil, crop, and the elevation/slope of the fields. The irrigation designer should document tests on wastewater irrigation when ascertaining the input such factors would have.

INVESTMENT COSTS

Investment costs differ between the type of irrigation system and local conditions. Regulation and demand will dictate the most suitable method of irrigation. Some methods may involve the use of specialist equipment, while others may only require standard equipment found in a local hardware store. Economies of scale will be achieved on larger SRPs lowering the irrigation cost per ha or m^3, as the cost of the control unit and pumps for example will be spread across a larger area. Furthermore, there will be a cost involved for the replacement of equipment to meet the theoretical lifespan of the SRP plantation (approx. 20 years). Different designs must be compared but the running costs associated with these designs must also be considered.

RUNNING COSTS

Running costs are largely sub-divided into running costs and maintenance costs. Running costs are largely taken up with electricity costs to run the pumps. An irrigation system requiring low pressure demand is generally cheaper. A sprinkler system requires 2-3 times more energy than the cheapest free flow system. Maintenance costs differ widely from those systems with daily maintenance requirements, to systems that only need care pre and post season. The number of man-hours required can be reduced by using automatic systems that are self-controlling. Investment costs and running costs must be carefully examined for selecting the proper system.

HARVESTING FRIENDLY

With three-yearly repeated harvesting of SRP (willow), the logistics and site conditions for using modern harvesting equipment, particularly of the field, are very important. Ditches can make it impossible to run a harvester on a field for example. Within the harvesting costs, care should be taken to include, if required, the removal of all the sprinkler arms and any other necessary actions.

LIFESPAN

The normal lifespan of a plantation is up to 20 years. The lifetime of the irrigation system should be the same if maintained properly in accordance with the suppliers guidelines.

SRP FEASIBILITY

How well do the separate techniques meet the proposed application of pre-treated wastewater into intensive cultivated SRP plantation? The wastewater is assumed to be only pre-treated and will still pose some health risk. Harvesting is done by modern harvesters. The average lifespan of a SRP is assumed to be about 20 years or longer.

IRRIGATION TECHNIQUES - EXPLANATIONS

A. Drill hole in pipes

A wastewater irrigation system specially developed for willows has been used in Sweden and England since 1996. It consists of standard PE pipes and fittings, which are widely available. These systems have shown they can withstand the tough environment including browsing animals, harvesters and a high BOD load. The system consists of a pipe with drilled holes (3-6mm) every 10m covered by a yellow cap to prevent the water spraying up in the air. The pipe is laid within the double rows away from the tracks of harvesting machinery. The principle involves controlled flooding as the water is only irrigated for a short period allowing the water to settle into the soil but long enough to create a water front in the soil. It is simple to install in small- to large-scale applications. To minimize the workload, automatic valves and a controller are recommended. There is no need for maintenance in the fields between harvesting.

Picture 38. Wastewater irrigation system developed for application on willows. [Photos by: A) C. Johston, RGL B) D. Rosenquist, Laqua Treatment AB].

For a yet safer method of irrigating wastewater with a potentially higher health risk, a variation of this system has been developed where the pipe is laid underground in a shallow trench. This is suitable where people may be present such as a town park, garden or other public area. This guarantees a barrier between the wastewater and people.

1: Studies in Sweden have shown low risks with regards to health aspects. Water outlets are laid on top of the soil but are normally also covered with grass. There is no risk of smell and a low risk of walking into an irrigation area even during irrigation.

2/3: Nutrient control and wastewater distribution are easily managed with a controller and a flow meter. In some cases the irrigation system has been incorporated into the treatment plant's control system.

4: High. This is the same level as B and C.

5: Running pressure 1,2bar. This system has a low requirement for maintenance. Normally only an inspection before season and a flushing after season on equipment outside fields is required. Piping within the fields only needs maintenance during the harvest years. This system could be monitored and operated by a controller with automatic alarms notifying of any systems failure.

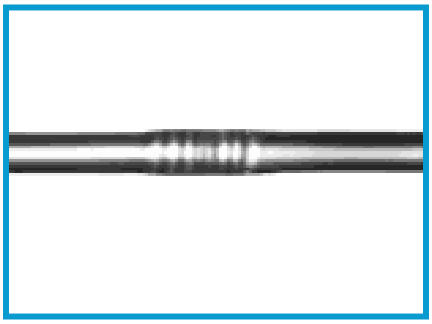
6: All of the equipment is placed out of the way of harvesters.

7: At least 20 years.

8: Meets all conditions. High investment cost but low running cost. Robust and simple system, which is easy to construct and support.

B. Drip pipe / emitters

Drip pipes are a common way to irrigate agricultural crops such as fruits and vegetables. They were basically developed to save water in warmer climates; however, they are now widely used in several applications. There are numerous manufacturers of such systems and several models available, but basically it consists of a thin PE pipe with drip emitters (a narrow labyrinth only a fraction of a millimetre wide) that create drops of water. There are pipes with different distances between the emitters, which results in different drip intensities. A high degree of filtration is required which could create a large quantity of flushing water. Observations have shown that in the worst case, up to 1/3 of Phosphorus content is filtrated to flushing water.



Picture 39. High efficient drip pipes

Drip pipes are simple to install from small- to large-scale applications. To minimize the workload, automatic valves and a controller are recommended. A safer method of irrigating wastewater with potential health risks is to have the pipe laid underground at a shallow depth. This is suitable where people are present and could be used in a garden or other public area. This guarantees a barrier between the wastewater and people. The pipes are at a high risk to the infiltration of rats, but special pipes have been developed for underground applications.

1: Swedish studies show a low risk regarding health aspects. The water outlets are just on top of the soil and normally also under grass. There is no risk of smell, and a very low risk of walking into an irrigated area even during irrigation.

2/3: Nutrient control and wastewater distribution are easily managed with a controller and a flow meter. In same cases the irrigation system has been incorporated into the treatment plant's control system.

4: High, this is the same level as the systems described under A and C.

5: Low running pressure 1 bar. Need of daily/weekly maintenance. The thin pipes have shown susceptibility to rats and moles which bite into the pipe. Manufacturers recommend several flushings of all pipes during the season and in some cases chlorinating them to prevent the build up of organic matter. This system could be monitored and operated by a controller with automatic alarms notifying of any systems failure.

6: All equipment is placed out of the way of harvesters.

7: There are different drip pipe qualities, varying in expected lifetime from 1-2 to 8-20 years.

8: Mostly meets the conditions. High investment cost but low running cost. Need constant maintenance to work well. Shows sensitivity to water with high BOD load and damage on the thin pipes can e caused by machinery. Back flush water must be taken care of as it may contain high levels of P and BOD.

C. Sprinkler

Sprinklers are a commonly used technique to irrigate farm crops. Numerous manufacturers and several models exist, but basically water runs through a nozzle which rotates. To work well the pressure of the water has to be 2-5bar. As the water is pushed through the nozzle a whole range of drops, from very small (aerosols) to large drops, are subsequently created. The ratio depends primarily on the pressure and the nozzle size. The knowledge of designing sprinkler systems is widespread across Europe. This system can easily be adapted to an area less than a hectare to a 100 ha SRP site (if allowed, see below).

Picture 40. Sprinklers [Photo by: RMV AB]

1: Creates lots of aerosols that can be a critical risk. Observations have also shown the sensitivity of trees to irrigation on their leaves. In this moisture-rich environment, disease and also something similar to sunburn (UV + ammonium) can occur. There is a risk of odours or foul smells depending on pretreatment. The area under irrigation should not be entered without a protective suit.

2: It is easy to trace and foresee the water distribution and subsequently calculate the fertilization levels. In this way we have control over the nutrient balance.

3: Sprinklers could be situated within the crop or over the canopy of crops. Within the crop the stem will screen off the jet and in practice the radius of the sprinkler will not be more than 3-5m. If there are paths through the SRF, hose irrigation machines are another option.

4: High, this is the same level as for the systems A and B.

5: Running pressure of 3-5 bar. In willow plantations, the sprinkler system has to be dismantled if harvesting is to be carried out by machinery. It is very difficult to supervise as it is not recommend being present in the sprinkler area when it is in operation and therefore it is hard to see if it is functioning properly.

6: Need to be disassembled before harvesting in most cases.

7: Good quality sprinklers will last up to 20 years.

8: Disqualification as it creates aerosols which could spread potentially infectious agents.

D. Free Flow

In its simplest form, this could consist of an outlet from a pipe where the water is flowing without any control. It could also be the flooding of fields near rivers with constructed in/outlets. It is suitable for water coming from a few households or water with a low health risk and low nutrient content.

1: Poses a risk at the outlet point, as it could create foul smells and a risk of infection (vector).

2: High risk of leakage to ground water in case of light soil conditions.

3: No control or badly controlled.

4: Low cost.

5: Low cost.

6: Friendly.

7: Long lifespan.

8: Disqualification as there is no or very little control over the discharge. It poses a high risk for wastewater to reach groundwater or as runoff from the field.

E: Ditches

Constructed ditches either dug or ploughed. They are similar to free flow, but with a more even distribution. Furthermore they are suitable for water quality with a low health risk. This system could be an option in areas with a history of using ditches.

1: Could create bad smell and a risk of infection (vector) with standing water conditions.

2: Risk of leakage to ground water. Only with special soil conditions

3: Depending on design and field condition

4: Low cost

5: Low cost

6: Ditches that harm the mobility of the harvester

7: Long life

8: Disqualification as the ditches make impossible to use harvesters. Soil qualifications and land inclination has to fit using ditches.

8.7.2 Additional information - Chapter 6

The example in Table 25 refers to Salix SRP grown and managed under Swedish conditions. This example is presented here to provide a tool for farmers to enable them to make their own calculations in Excel based on their own conditions. Therefore, farmers should contact SLU for more information on how to practically use the material illustrated below.

NOTE: ALL CALCULATION EXAMPLES BELOW ARE FOR SALIX SRP WITH PRODUCTIVE PERIOD OF 22 YEARS (REGROWTH 6 TIMES), 6% IN INTEREST RATE, PRICE LEVEL 2007, SWEDISH CONDITIONS

Table 25. Example of economic calculations for Salix SRP.

SOURCES OF REVENUES	Quantity	Price	Revenue per hectare	Factor	Average per ear (Euro/ha)
Chips (t DM, year 4)	21	68	1422	0.066	94
Chips t DM year 7,10,13,16,19,22	27	68	1828	0.224	409
Subsidy year 1	0	549	0	0.078	0
Subsidies year 1...22	0	45	0	1.000	0
Sum of revenue					503

Table 26. Example of economic calculations for Salix SRP – Additions to Table 25.

COSTS	Quantity	Price	Hectare cost	Factor	Average per year (Euro/ha)
Planting (year 1)	0	854	0	0.078	0
Cuttings (year 1)	12240	0.053	646	0.078	50
Transplanter (year 1)	1	198	198	0.078	15
Transport of cuttings (year 1)	1	11	10.989	0.078	1
Severing of cuttings (year 1)	1	27	27.473	0.078	2
Control with glyphosate (year 0)	4	5	20.22	0.083	2
Control with wetting agent (year 0)	0.5	3	1.6484	0.083	0
Mechanical weed control (year 1)	2	44	87.912	0.078	7
Mechanical weed control (year 2)	1	44	43.956	0.074	4
Control with glyphosate (year 5,11,17)	2	5.1	10.11	0.137	1
Control with wetting agent (year 5,11,17)	0.5	3.3	1.6484	0.137	0
Fertilizer N (year 2,5,8,11,14,17,20)	80	0.9	70	0.325	23
Fertilizer N (year 3,6,9,12,15,18,21)	120	0.9	105	0.307	32
Fertilizer spreading (year 3,6,9,12,15,18,21)	1	24	24.176	0.307	7
Fertilizer P (year 5,8,11,14,17,20,23)	22	1.21	27	0.273	7
Fertilizer K (year 5,8,11,14,17,20,23)	73	0.44	32	0.273	9
Brokerage (year 4)	1422	0.06	85	0.066	6
Brokerage (year 7,10,13,16,19,22)	1828	0.06	110	0.224	25
Harvest (year 4)	1	330	330	0.066	22
Harvest (year 7,10,13,16,19,22)	1	373	373	0.224	83
Field transport (year 4)	1	52	52	0.066	3
Field transport (year 7,10,13,16,19,22)	1	67	67	0.224	15
Road transport 30 km (year 4)	21	11	231	0.066	15
Road transport 30 km (year 7,10,13,16,19,22)	27	11	297	0.224	66
Winding up (year 22)	1	220	219.78	0.023	5
Total costs					**402**
GROSS MARGIN 1					
Income - costs					**101**

COST LEVEL 2	**Quantity**	**Price**	**Hectare cost**	**Factor**	**Average per year (Euro/ha)**
Harrowing (year 1)	3	14	42.857	0.078	3
Rolling (year 1)	1	10	9.8901	0.078	1
Spraying (year 0,5,11,17)	1	14	14.286	0.220	3
Fertilizer spreading N (year 2,5,8,11,14,17,20)	1	15	15.385	0.325	5
Fertilizer spreading PK (year 5,8,11,14,17,20,23)	1	15	15.385	0.273	4
Irrigation (year 1,2,3…22)	0	154	0	1.000	0
Charge for administration (year 1,2,3,4…22)	1	18	18.132	1.000	18
Total costs					**437**
GROSS MARGIN 2					
Income – costs					**66**
COST LEVEL 3	**Quantity**	**Price**	**Hectare cost**	**Factor**	**Average per year (Euro/ha)**
Tenancy, land cost (year 1,2,3...21)			0	1.000	0
Total costs					**437**
GROSS MARGIN 3					
Income - costs					**66**
COST LEVEL 4	**Quantity**	**Price**	**Hectare cost**	**Factor**	**Average per year (Euro/ha)**
Common costs in enterprise (year 1,2,3...21)			44	1.000	44
Total costs					**481**
GROSS MARGIN 4					
Revenue					22

Table 27. Results from exemplary calculations in Table 26

Productions costs (per ton)				
Costs per ton 4		**65**		**Euro/ton DM**
Energy content		**4.4**		**MWh / ton**
Costs per MWh		**14.70**		**Euro per MWh**
Costs per GJ		**4.08**		**Euro per GJ**

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