Short Rotation Woody Crops (SRC) plantations for local supply chains and heat use

Project No: IEE/13/574

SRC production in Croatia, Czech Republic, France, Germany, Greece, Latvia and Macedonia

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Contents

1 Introduction

This report contains an overview on the status quo of short rotation woody crops (SRC) production in the seven SRCplus target countries (Croatia, Czech Republic, France, Germany, Greece, Latvia and Macedonia). The report presents the current situation of SRC and SRC-related species (therefore not only cultivated as SRC) in the different countries. Information is provided taking into account existing plantations and projects, local supply chains, legal framework conditions, agricultural practices for SRC plantation such as optimal climate conditions, rotation time limits, cultivation areas, and existing bottlenecks. Each chapter analyses the situation in each of the seven countries, and it is autonomous with references at the end of the chapter referring to the specific country analysed. As expected, the situation of SRC production is very variable between the different countries, but also within the same country. This document should be considered as an initial contribution, since several SRC projects are currently under way in the different countries and therefore an update throughout the development of the project is needed.

2 Overview on SRC production

2.1 Croatia

2.1.1 Overview on existing SRC plantations and projects

The technical potential for SRC production in Croatia was estimated by Kajba et al. (2011). The study identified a total of 282,500 ha of land suitable for SRC production (forest area suitable for energy crops and agricultural areas with moderately suitable soils and limited soil suitability) with technical potential for energy production of 60 PJ. The identified potential for SRC production in Croatia remains untapped since the development of SRC is related to experimental and research activities, such as research on the productivity of clones, agricultural practices and breeding.

In Croatia, due to RES electricity support in terms of feed-in tariff, there is increased interest in the production of electricity from woody biomass. Currently there are four operational CHP plants using woody biomass with an installed capacity of 7.69 MWel powered by wood processing waste and wood chips that are supplied by the Croatian Forests Ltd. Ten more projects with installed capacity of 39.91 MWel have signed electricity purchase contract with the Croatian Energy Market Operator (HROTE), but are still not connected to the grid. By the end of May 2014, plans for 101 CHPs projects with an installed power of 236.05 MWel were registered in *Registry of projects and facilities for usage of energy and cogeneration from RES, and eligible producers* at the Ministry of Economy.

Currently, 23 investors/operators have signed contracts with Croatian Forests Ltd. for wood chip supply. These 23 facilities for production of electricity and heat will consume annually around 830,000 tons of wood chips (Pavelić et al. 2013). If other projects from the Registry should be realized, woody biomass coming only from forests will not be sufficient, so that these significant quantities of wood chips could be partly supplied from SRC. Croatian Forests Ltd. has recognized the potential of SRC contribution to increased demand for wood chips and is preparing projects focused on SRC development. However, it is the only identified project developer within the country.

Poplars and willows are the most tested and most promising species in Croatia which naturally grow in certain parts of Croatia and are used for reforestation and afforestation (Table 1).

Table 1: Total area of poplars and willows in 2011 in Croatia (Source: Croatian Poplar Commission, 2012)

Indigenous	Willow	Poplar	Mix of poplar and willows
Total area 2011 (ha)	13,243	17,308	123
Area planted from 2008-2011 (reforestation and afforestation)	-	1	-
Planted			
Total area 2011 (ha)	3,615	13,056	57
Area planted from 2008-2011 (reforestation and afforestation)	3	1,279	-

The area of poplar and willow in Croatia indicated in Table 1 mostly refers to permanent stands with long rotation forestry of 20-30 years or more (only one rotation). The production from the plantations is mostly used for industrial wood. Exact data for SRC production are not indicated within these statistics.

In general, in Croatia there is no official national statistics on SRC neither at the Croatian Bureau of Statistics, nor in the Croatian National System of Land Parcels Identification and Land Use (ARKOD). Therefore, information regarding SRC plantations was gathered in direct communication with experts in the field of SRC.

Based on information from various sources, it can be concluded that in Croatia there are no commercial SRC plantations. Existing plantations are experimental and are developed either by University of Zagreb, Faculty of Forestry or by Croatian Forests Ltd. The land on which the plantations are established is state owned land managed by Croatian Forest Ltd. The species that are mostly grown are different hybrids of poplar, willow and black locust. Table 2 summarizes the information of SRC production in Croatia retrieved from Croatian Forests Ltd., as developer of SRC and the entity that has the best available information on SRC in Croatia.

Table 2: SRC production in Croatia (Source: Croatian Forests Ltd.; internal communication)

	For energy (ha)	For other purposes (ha)	Existence of experimental trials (ha)	Ownership
Poplars	0	0	25.50	Public (state owned forests)
Willows	0	0	0.50	Public (state owned forests)
Black locust	0	0	67.84	Public (state owned forests)

As it can be seen in Table 2, all SRC production is experimental. Poplars and willows are entirely grown in Osijek-Baranja county which is in the far eastern part of Croatia, while black locust is grown in Osijek- Baranja (25.04 ha) and Lika- Senj county (42.80 ha).The terrain of Lika-Senj county in not suitable for poplars and willows, since it is a mountainous county. In addition to mentioned trials, there are few additional experimental trials managed by the Faculty of Forestry, University of Zagreb. These are:

- Willow (0.5 ha each) – Dravica (f.d. Darda), nursery Topolje (f.d. Valpovo)
- Poplar (0.5 ha each) – Bobrovac (f.d. Slatina), Čazma and Podturen (f.d. Čakovec)

It is indicated that some other small trials exist, mostly in continental, eastern Croatia and Istria, but no information regarding these minor trials are available. The inquiry has not

revealed any SRC plantations that are privately owned, but the possibility of their existence cannot be excluded.

Lately there are some non-native species that gained a lot of interest among farmers such as Paulownia and indigo bush (*Amorpha fruticosa)*. One company in Croatia is distributer of Paulownia seedlings, and according to their information, currently there are 5-6 locations in Osijek-Baranja county and one in Čakovec county where Paulownia is going to be planted in 2014 at 2-4 hectares per each location. According to that company, Paulownia is considered as agricultural species, more precisely an orchard culture, and there are no obstacles to grow it on agricultural land. While Paulownia is not considered as an invasive species, indigo bush is. Indigo bush invades forest areas after tree cuttings and overshadows desired autochthonous young growth. An experimental study on indigo bush in Croatia (Krpan et al., 2014) shows that despite of downward trends in biomass productivity of plantation from first to third year, the plant retains its competitiveness, because it develops naturally and it does not require any aeromechanical measures.

2.1.2 Current agricultural practices

Poplars and willows demonstrate the best production on light alluvial soils (habitats of natural stands of broad-leaved soft species) along the Drava and the Danube rivers with two important areas: the course of the Drava in the north at the mouth of the Mura river, and in the eastern Croatia the area at the mouth of the Drava river, and in the Croatian part of the Danubian area (Figure 1).

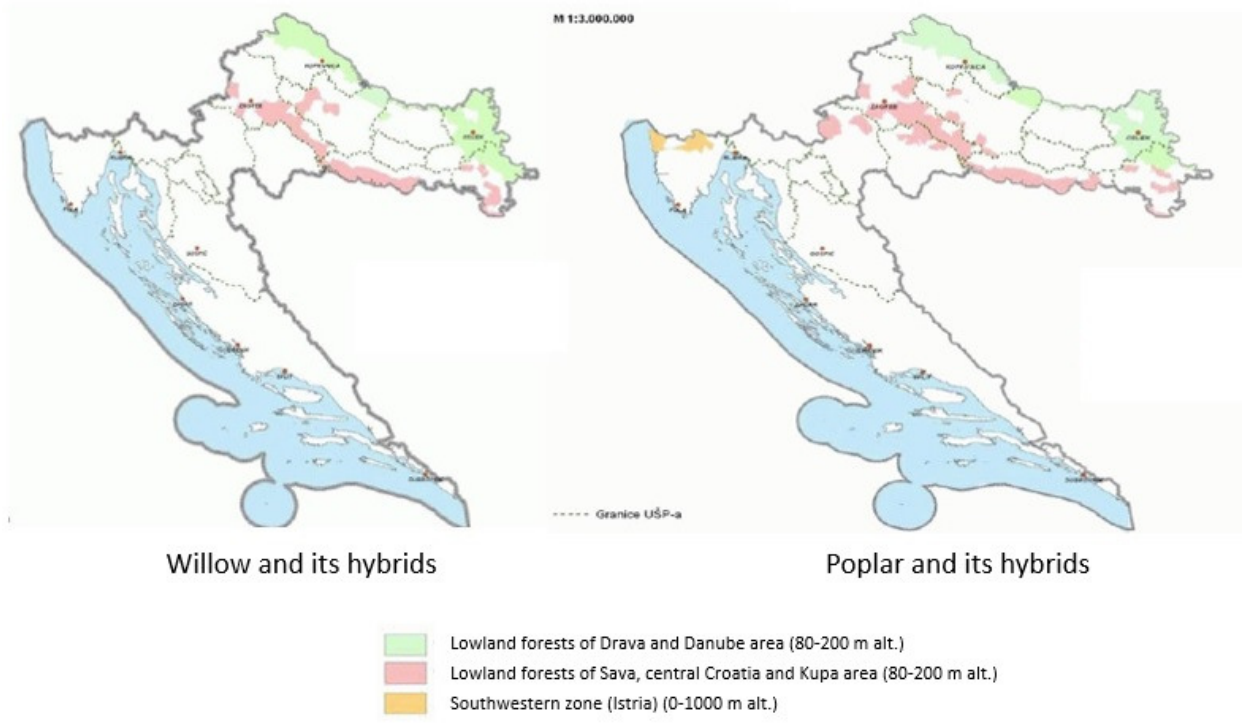

Figure 1: Occurrence of poplar and willow species and hybrid stands in Croatia (Source: Adapted from Narodne novine, 2011)

The alluvium of the Sava River, due to heavy soils, as well as due to poor results achieved on the plantations afforested between the sixties and eighties, has been converted to oak stands. There is a large potential for future plantation development on so called 'marginal' land, which is not suitable for agricultural production and is either privately or state owned (Croatian Poplar Commission, 2012).

Sixteen clones of poplar and eleven clones of willows have been officially registered and legally recognised for planting (Croatian Poplar Commission, 2012). Additionally, there are 20 clones of poplar and 240 of willow identified as experimental planting clones. The multiclonal approach with mosaic clone arrangement is practiced in poplar and willow plantations. This proved to be a good method for reduction of clone sensitivity to diseases and pests. The seedling material is partly produced in Croatia and partly imported from Hungary and Italy.

Since mechanisation for SRC planting and harvesting does not have a market in Croatia, planting was done with tractors and adapted mechanization used for other cultures like tobacco and cabbage, or by hand. Harvest is done manually by chainsaws.

There is a significant interest in more data regarding mechanisation, since it would enable the development of SRC. Croatian Forests Ltd. estimates that the minimum of 5 ha could make SRC production viable and economically sound. However, further studies on this are needed.

Some common characteristics in the preparation phase apply for both, willows and poplars.

Agricultural practices for willow (Salix sp.)

The experimental trials were established in 1999 in order to test 14 clones of white willow (*Salix alba L.*). The study identified clones that exhibit biomass production above average, and clones that are well adapted to certain soil type notable through survival rate of seedlings (Kajba et al., 2004). A breeding program with arborescent willows has been carried out with the objective to produce pioneer species for easier reforestation of difficult sites with more valuable species (oak and ash), and to establish plantations for high biomass production in short rotations on marginal sites, where agricultural production had ceased. The Chinese willow (*Salix matsudana Koidz.*) was used as partner for the inter-species hybridization with autochthonous white willow (*Salix alba L*). There was no fertilization and pest control measures applied. Weeding was applied only to a limited extent at an early stage. Despite this low-intensity management, the results have shown a high biomass production of the researched clones ranging from 9.3 tons/ha up to 19.8 tons/ha in a biennial rotation (FAO, 2012).

The willow SRC crops are harvested every 2 years, with expected 6 rotations before the decline of productivity. Therefore, the whole cycle of willow on the land is 13 years. The density of seedlings is 9,700 - 10,000 seedlings/ha, while the spacing between the seedlings is 1.3 * 0.8 m. Experiments have shown that removal of sprouts to 1-2 per plant after the first year, gives the best results in terms of productivity (Kajba et al., 2004).

Agricultural practices for poplar (Populus sp.)

Poplar SRC is harvested in rotation of 3 years, with a total cycle on the land of 16 years. In that period 5 rotations are planned. The density of planted seedlings is usually 1,700 seedlings per hectare. The distance between seedlings is 2*3 m. Unlike willow, poplars are more sensitive to pest, therefore it is crucial to keep them healthy and protect from the pests. It is noted that poplar wood production in monoclonal or oligoclonal plantations represented one of the biggest risks for the outbreak of plant diseases and the attack of damaging pathogens (FAO, 2012).

Poplar planting is carried out using a proven and tested set of technologies comprising the careful selection of planting material, soil preparation by disk harrowing, and mechanized planting. The tests of poplars include different selections of American black poplar (*Populus deltoides*), hybrids of American black poplar and European black poplar (*P. x euramericana*), hybrids of American black poplar and balsam poplar (*P. x interamericana*), as well as the clone tests of *P. trichocarpa* and *P. simonii* (Croatian Poplar Commission, 2012).

Agricultural practices for black locust (Robinia pseudocacia L.)

Black locust is characterised by fast growth and good ability of vegetative regeneration. It is adaptable to various types of soil, but it prefers light and acidic soil. It can be grown on land of lower moisture content and quality that is not suitable for development of poplars and willow. On the other hand, black locust is an invasive species that can be hardly removed once it is rooted in the land. For the moment the ideal rotation period for black locust is not defined, since the trials are in their second year from establishment. This can be defined later only.

2.1.3 Local supply chains and use of SRC products

At the moment there are no local supply chains since there is no commercial SRC production. As previously mentioned, all the crops are purely experimental. Since the trials were established only recently (black locust in 2012), the usage of wood chips after the harvest is not specified yet. Therefore, within the project SRCplus the aim for Croatia is to identify potential supply chains.

2.1.4 Legal framework conditions for SRC

Since SRCs are not defined in any official legal documents of the Republic of Croatia, the Ministry of Agriculture was asked for clarification which is still pending. Respectively, it was not clear if SRC are considered legally forest plantations or agricultural plantations, and therefore on which category of land SRC can be developed. However, communication with the Agency for Payment in Agriculture reveals that SRC can be grown on any type of agricultural land.

- *List of forest species* (OG 4/11) defines willow, poplar and their hybrids, and black locust as forest species. The *Ordinance on the areas of provenance of forest tree species of economic significance* (OG 107/08, 147/11) defines the provenance of willow and poplar. Willow and poplar as forest plantations are defined by the *Ordinance on forest management* (OG 111/06, 141/08) as artificially established stand with application of agro-technical measures on productive forest land not covered with forest. However, SRC plantations and SRC reproductive material as such are not mentioned in any legal regulations connected to forestry.
- *Law on agricultural land* (OG 39/13) defines the types of cultivation that are considered as agricultural land (plough-fields, meadows, orchards, etc.). SRC are not mentioned in this law either. If SRC production would be considered as agricultural production, it would be important to define the type of the land where SRC can be grown in order to avoid conversion of highly productive land into SRC plantations, especially since in Croatia there are significant hectares of marginal land which are not in the production and could be used for SRC development.
- If SRC are to be developed at abandoned land, it is important to note that according to the *Regulation on necessity for environmental impact assessment* (OG 61/2014) if previously uncultivated or partly natural area with surface of 10 ha and higher should be converted to intensive agricultural farming, one must perform environmental impact assessment, for the authorized governing body in the county is in charge.
- SRC are briefly and directly mentioned in the *Ordinance on enforcement of direct payment program and individual measures of state support to agriculture in 2014* (OG 27/14), where it is stated that SRCs are eligible for direct payment if kept in good agricultural conditions. Eligible species are listed in the Ordinance and include *Alnus glutinosa, Betula sp., Carpinus sp., Castanea, Fraxinus, Populus, Robinia pseudocacia, Salix*, with maximal harvest cycle of 20 years. The hectares under SRC need to be registered in ARKOD system (this is under development) and good agricultural and environmental practice needs to be applied. However, a sub

regulation that should define this in depth is to be prepared, meaning that operationally it is not possible to receive subsidies for SRC. Furthermore, the list of species and the period of rotation may need a revision.

- The Agency for Payment in Agriculture, Ministry of Agriculture and other relevant institutions are currently working on amendments of *Ordinance on evidence of agricultural land usage* (OG 149/11, 131/12, 24/13, 9/14). The activities include the introduction of a new code for SRC and the definition of a methodology for the registration of SRC areas.
- The Ministry of Agriculture is at the moment engaged in the development of a national model for direct payment in agriculture in the frame of a reform of the Common Agricultural Practice 2015-2020. Currently the national model is in the draft form, while the final version is expected for August 2014. According to the draft propositions from May 2014, SRCs are proposed, but not planned to be a part of Greening scheme (Ministry of Agriculture, 2014).
- State owned agricultural land was previously managed by local administration, but from 2013 with the *Law on agricultural land* (OG 39/13) all matters regarding state owned land are now under the jurisdiction of Agency for Agricultural Land.

Table 3: Summary of missing legislation regarding SRC in Croatia

Missing legislation / problems	Potential limitations	Comments
Legal framework that defines SRC production is missing.	It is not legally defined whether SRC can be grown on agricultural or forest land. Currently all the plantations are established on state owned forest land.	Coherent and consistent regulatory framework is needed that defines on which categories of land SRC production can take place.
The regulatory framework and policies for long term SRC subsidies and other incentives are not developed.	Current regulatory framework announces the SRC subsidies but further regulations and operational scheme are missing. This inhibits engagement in SRC production.	Development of clear policy framework for incentives for SRC production is needed.
Regulation is not harmonized with EU regulations and practices.	Difficulties in interpretation of some regulations; uncertainty in the future direction and financing of projects from development funds.	Harmonization of regulations with EU.
Legal issues regarding status and ownership of the land that could be potentially used for SRC production remain open.	Land issues and question of ownership of the land, private and public, result in difficulties to engage in long term land investment.	Resolution of land issues, or establishment of plantation on surfaces with clear ownership status.

2.1.5 Bottlenecks for SRC plantations

The main problems of SRC utilization in Croatia are already recognized within the project Biomass Energy Europe (BEE, 2010). These are insufficient data about suitability and availability of land for production, insufficient collaboration between stakeholders, lack of knowledge transfer, lack of connections between farmers and research institutions, insufficient reproduction material and technology transfer, lack of public awareness programs, poor land use planning and poor commitment to cultivate the land. The identified problems remain until today.

In general, the interest in SRC was negligible in the past. Since recently SRC are becoming more interesting and their potential is recognized by Croatian Forests Ltd. that is now considering the development of SRC plantations on forest land not covered with forest in its Development strategy (Pavelić et al., 2013).

One of the main obstacles is that the legislation is not defined and current regulatory framework is not clear with regard to SRC. Respectively, it is not clear whether SRC could be developed on agricultural land or not. Until now SRC was considered as forestry production and plantations were developed on public forest land. Currently, the regulation within the forestry sector does not enable the development of SRC, but it does not inhibit it either. Therefore, on the one hand there is a need for harmonization between the sectors of agriculture and forestry within the country, and on the other hand there is a need for harmonization with EU directives and regulations.

According to the Agency for Agricultural Land (2014), the surface of agricultural land in Croatia is 2,695,037 ha from which 890,214 ha or 33% is owned by the state and 1,804,823 ha or 67% is privately owned land. Rough statistic data indicate the surface of 557,858 ha of state owned agricultural land remained at disposal (APZ, 2014). Exact quantifications of forest land and marginal land are not clear, since agricultural land sometimes obtains the characteristics of forest and is covered with forest vegetation. One of the general problems in Croatia that can inhibit the development of SRC is the unclear structure of the land and the ownership over the land, especially regarding private and public owned land.

Furthermore, Croatian agriculture is characterized by small parcels. The average size of parcels in the ownership of farmers is 0.61 ha, while the average size of parcels in the ownership business entity is 12.93 ha. This demonstrates that the parcels owned by farmers are in most cases very small to be suitable for SRC production.

Croatian Forests Ltd. as the only current developer of SRC and possibly the biggest developer in the future emphasizes the lack of experience in operation as one of the bottlenecks in SRC production. As mentioned previously, all existing crops are experimental. Therefore, it is necessary to conduct further studies on cost efficiency of SRC production. The mechanization for planting and harvesting is not well known, since there are no producers or importers in Croatia. This especially refers to harvest machinery since the machinery will determinate the way how crops should be planted.

Furthermore, for the development of SRC it is crucial to identify which clones are suitable for different types of soil. Further analysis of soil suitability for different clones should be made, and soils should be evaluated and classified according to the suitability for certain clones in terms of their ecological and biological characteristics. There are several clones that showed very good potential for SRC production in experimental trials. The Ministry of Agriculture was informed on this result by the Croatian Poplar Commission and it was asked to approve inscription of the clones in the registry. For the moment the approval is pending, and the registry remains not updated.

In Croatia the development of SRC is still on the level of experimental trials. However, interest exists, and it is presumed that it will increase in the near future.

SRCs are not defined in documents connected to agricultural production or forestry production. Therefore, existing laws and regulations do not directly limit the development of SRC, but do not predict it as well, meaning that there is certain flexibility as well as uncertainty. For the development of SRC, it is important to have promoting and clear legislative framework. Since SRC are not identified as priority in policies, more development on regulation connected to SRC can be expected in the second half of 2014, or even later.

In order to establish an efficient SRC production, regulations and support from the state are needed, preferably in form of various incentives. Certain measures of state policy on the use of land and incentive measures could help poplar and willow cultivation on private land. The potential to lease the public marginal land needs to be explored.

Finally it can be concluded that administrative capacities are not adequately developed and that currently there are no incentives and support of the government for the development of SRC. Until this situation changes, it is unlikely to expect that SRC development will take off.

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2.2 Czech Republic

2.2.1 Overview on existing SRC plantations and projects

Poplars and willows are the only species growing as short rotation plantations in the Czech Republic as they are the most promising and fast-growing species in the country. They are characterised by a high yield of above-ground biomass, particularly in the early years or after repeated scarfing.

Officially recommended planting clones of willows and poplars, selected from domestic collections, are available. The Ministry of Environment approved a list containing 25 clones of willows and 19 clones of poplars.

The selection of the right area is crucial for a good yield and the framework typology of agricultural land can be used as a support. Two factors are taken into account for the creation of typology, namely the results of suitable clones of poplar and willow and the evaluation of agricultural lands in the system BPEJ (classification of soil ecological entities). The result was the development of six groups of soils, according to the growing suitability of registered and recommended SRC clones. In the Czech Republic the plantations are not and probably also will not be grown on the most fertile soils, however, there is a large percentage of land that is not suitable for agricultural production that is very acceptable for the production of woody biomass.

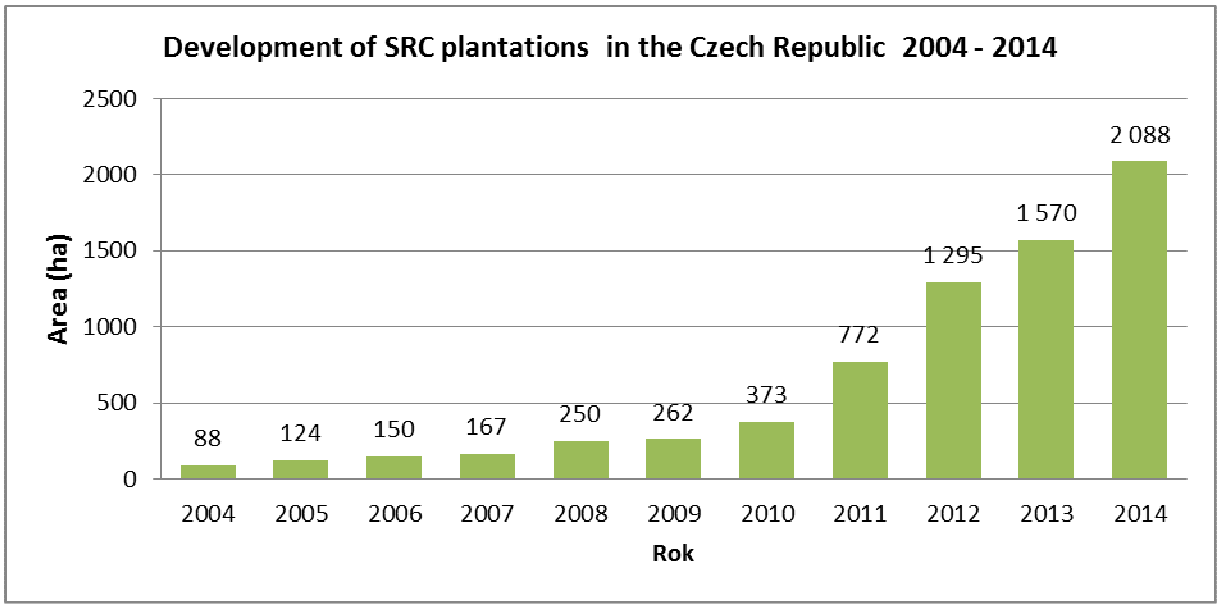

Figure 2: Development of SRC plantations in the Czech Republic (Source: Ministry of Agriculture of the Czech Republic)

In 2004, an area of 88 ha was planted with short rotation coppice in the Czech Republic. Currently, there are 2,088 ha of SRC registered, which is 24 times larger area than 10 years ago (Figure 2).

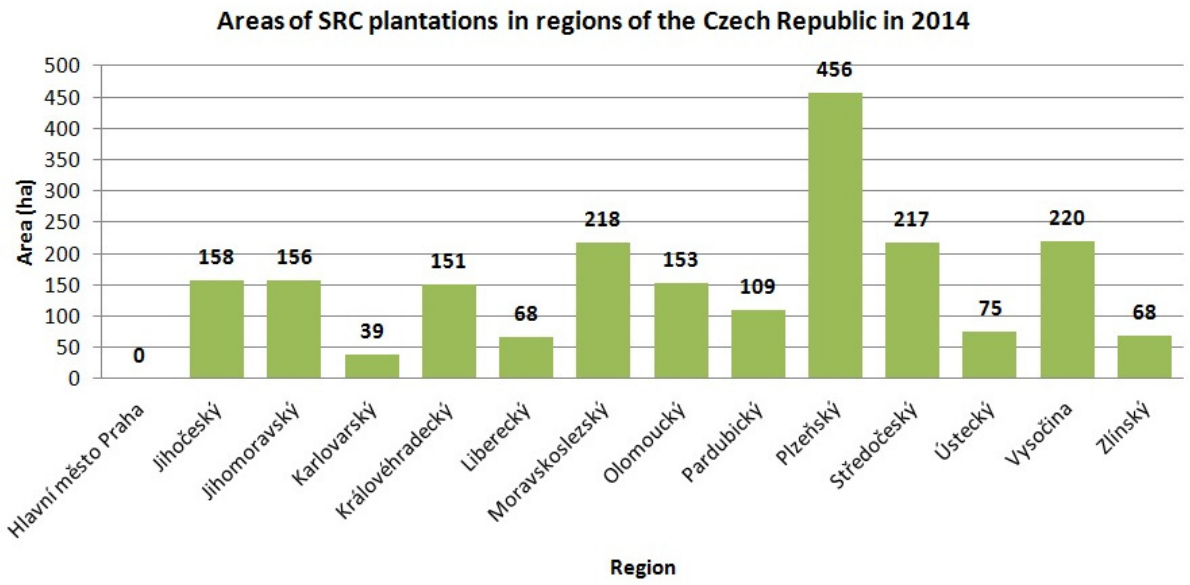

Figure 3: Cultivations by region (Source: Ministry of Agriculture of the Czech Republic)

In the Czech Republic only poplar and willow are the most commonly grown species. In the terms divided by each region, the Zlin region belongs to the region with the lowest share of SRC plantations which creates a large opportunity for the project SRCplus.

The above data were obtained from the Ministry of Agriculture of the Czech Republic. Companies operating in the country are not willing to disclose information about individual locations, acreage and crops in order to protect trade secrets.

The company Woodcapital is the biggest company dealing with SRC in the Czech Republic. With their permission, information about their plantations is disclosed in the following tables.

Table 4: Data on SRC plantations by Woodcapital

	For energy (ha)	For other purposes (ha)	Existence of experimental trials Y/N (ha)	Ownership
Poplars	445	0	N	Private corporate
Hybrid aspen	0	0	N	n/a
Willows	0	0	N	n/a
Eucalyptus	0	0	N	n/a

Table 5: The area of the plantations of SRC by Woodcapital

Area	Region	Acreage (ha)	Average size of plots (ha)	Crop
CZ	Olomouc Region	20	5	poplar
CZ	Moravian Silesian Region	32	5	poplar
CZ	Pardubice Region	32	5	poplar
CZ	Hradec Králové Region	93	5	poplar
CZ	Vysočina Region	48	5	poplar
CZ	Ústí Region	88	5	poplar
CZ	Pilsen Region	94	5	poplar
CZ	South Bohemian Region	38	5	poplar

From the above tables it is evident that poplar is the only crop growing by Woodcapital. For other entities establishing plantations it can be also assumed that the vast majority of plantations of 2,088 ha of SRC in the Czech Republic are currently poplars as well.

Positive functions of SRC crop cultivation are the most important asset for the county. Continuous growth of poplars and willows reduces the adverse effects of wind erosion and prevents soil erosion, because woody plants produce root system in two years after planting the crop, which is sufficient for hardening of the surface layers of soil.

2.2.2 Current agricultural practices

Plantation system and management

In Czech Republic, the land for SRC must be prepared at least one year before planting. Weeding of the prevailing weed species must be performed, however chemical weeding is not recommended. On extremely weedy areas a biological agent can be used. On heavy soils, it is necessary to make deep ploughing.

As far as planting material is concerned, cuttings are taken from the annual shoots which are taken from mother plants. The length of shoots should reach 20-30 cm and width of 0.5-2.5 cm. Cuttings should be stored in optimum conditions (temperature about 2-4℃). The cuttings are necessary to soak in water one day before planting. Spring is the optimum time for planting, preferably from mid-March to April. Fencing plantation is important to prevent grazing animals. Weed control is also important, which may strongly compromise the growth of newly planted seedlings in the first year.

As far as fertilization is concerned, poplars respond positively to nitrogen fertilization. Fertilization has usually a positive influence on the early start of a maximum production, but it will not affect the overall yield for the whole plantation duration considerably. Crops are harvested in a very short rotation period, normally is between 3-6 years. Lifetime of plantations is assumed between 15-25 years which means that it is harvested from 4 to 8 times. It is advisable to monitor the market situation in the selection of the harvesting period. If not favourable, it is possible to postpone the harvesting even for several years.

BPEJ (classification of soil ecological entities) system can be used for choosing ideal natural conditions, which covers the whole territory of the Czech Republic. The unit of agricultural land (BPEJ) reflects the five-digit numeric code which is composed of climate of the region, main soil unit, slope and exposure, stoniness and soil depth.

The optimal location for the efficient production of biomass in Czech Republic is:

- Climatic region – with an annual rainfall of over 500 mm, while the average annual minimum temperature of 7-8 °C.
- Depth of soil – soil with a depth of at least 60 cm
- Stoniness – land without stone till small stone
- Slope – plane and slight slope
- Altitude – up to 500 m
- The level of the groundwater from 0.5 m to 3.0 m

The optimum time of rotation in Czech Republic is:

- Poplars: rotation 20-25 years, 1x harvest
- Crops SRC (clones of poplar and willow): rotation 3-6 years, 3-7 times harvest, vitality 15-20 years
- Poplar and willow on "chunks": rotation 5-8 years, 2-4x harvest, vitality 15-20 years

The optimum cultivation scheme in Czech Republic is:

- One-liner clips: (0.3-0,5m) x (1.5-2.5m – between line)
- Two-liner clips: (0.5-0.8m) x (0.3-0.8m) x (1.5-3m between line)
- Planting density: 6-12 thousand/ha (suitable for wood chips)
- Planting density: 1.5-2.5 thousand/ha (suitable for firewood or chips)
- The scheme of planting of mother plants: Exclusively one-liner clips: (0.2-0.5m) x (1.5-3m between line)

Planting

Manual planting: In case the planter is not available, cuttings can be planted manually. Hand planting is indeed very time-consuming and physically demanding, hence it is suitable only for smaller areas. It is necessary to count that one person plants one hectare of biomass in about four days.

Planting by semi-automatic planter in single-line: A simple planter can plant about 3 ha of biomass per day (8-10 hours). One tractor driver and two human planters are needed.

Planting by semi-automatic planter in double-row: This method is one of the most modern ways of betting. These planters can create two, four and six-rows. Their performance ranges from 8 to 25 ha per day.

Harvesting technology

Cutting of trees by brush-saw and manual clearance on the edge of the plantation is suitable only for small plantations of the area about 2-3 ha. For larger areas it is advisable to use additional equipment for tractors (such as tractor-saw) or a specialized harvester which links the stems into bundles. Stems are usually left to the edge of plantation to air-drying (min 1-2 months) and then the chipping.

Cutting and chipping technology usually uses self-propelled and drawn harvesting machine that is capable of immediate production of wood chips directly on the field. These wood chips have a higher moisture content (about 50%), but are easier to handle. In addition, such wood chips are adapted to be burned in boilers or they can be dried at least to 20-30%.

Cutting, chipping and pelleting technology uses very heavy self-propelled harvesting machines capable of immediate production of pellets of dry stalk on the field. Pellets are

easily transported and handled. Pellets are suitable for combustion in boilers and fireplaces in households as well as in district boilers or in central heating systems.

2.2.3 Local supply chains and use of SRC production

The following list shows companies in the Czech Republic that offer the following seedlings and clones:

- Průhonice - VÚKOZ, v.v.i. – willows and poplars from registered list (RL) by Ministry of the Environment
- Uherské Hradiště - VÚLHM, v.v.i. – willows and poplars from domestic collections
- Neznašov (u Týna nad Vltavou) – combination J-105 a J-104
- Rosice (u Pardubic) – willows and poplars from RL
- Unhošť u Prahy – J-105 a J-104
- Zvotoky (u Stakonic, Volenice) – combination J-105 a J-104
- Nová Olešná (u Jindřichova Hradce) - J-105 a J-104, willows and poplars from RL
- Domanínek (u Bystřice nad Pernštejnem) - J-105, J-104, selected willows and poplars from RL
- Lhota (u Červeného Kostelce) - J-105, J-104
- Huntířov (u Děčína) – clones of poplar J-105 a J-104
- Maňovice a Třebčice (Plzeň - Jih) - willows and poplars from RL
- Hradec u Jeseníka – willows and poplars from RL
- Tišice u Neratovic – willows and poplars from RL
- Jeseník, Moravský Písek, Budišov (okr.Třebíč), Sedlčany u Tábora – willows and poplars from RL
- Malešov u Štetí (okr. Litoměřice) – J-105, J-104
- Arnoltice u Bulovky (Liberecko) – J-105, J-104
- Bruntál– J-105, J-104
- Havlíčkův Brod – J-105, J-104
- Tábor – J-105, J-104 a selected willows and poplars from RL
- Rohatce, (okr. Litoměřice) – J-105
- Bečkov (Bernartice u Trutnova) – varieties of poplars AF2, AF8, Monviso and clone J-105
- Bítovany, okr.Chrudim – willows and poplars from RL
- Holice (Pardubický kraj) – J-105
- Hradec Králové – willows and poplars from RL
- Hodkovice nad Mohelkou – J-105

2.2.4 Legal framework conditions for SRC

In the Czech Republic, growing of energy crops and fast-growing trees is regulated by legislation, especially by the directives of the Ministry of Environment and the Ministry of Agriculture. SRC plantations for energy purposes are considered as agricultural crops and

are treated therefore under the agricultural regulations. The explicit definition is “an intensive culture of fast growing trees for energy purposes”. Furthermore, there are other regulations for the cultivation of energy crops. The following two main legislative documents and their sections on the cultivation of energy crops in their herbal and woody form, and nature and landscape protection are important:

Act č.114/1992 Sb. On Nature a Landscape conservation

- This is undoubtedly the most important piece of legislation that may substantially affect the possibility of growing SRC in a certain location.
- Significant landscape features: § 3 -1b) and § 4-2 General protection of flora and fauna: § 5-4 and 5-5
- Protection of trees: § 7-2
- Landscape character: § 12-1 and §12-2
- Preliminary protection sites of significant European importance: § 45-2

Act on Seed planting č.219/2003 Sb.

- This law applies especially to those who sell the planting material of SRC. Fast growing trees and energetic plants are in the law categorized as ornamentals in §25 (propagating material of ornamental species). SRC are directly mentioned in paragraph 6 as “intensive culture of fast growing trees for energy purposes”. Planting material (cuttings, cores and possibly plants) can be supplied only by farmers registered at the Central Control Agricultural Institute (CCAI) and State Phytosanitary Care (SPC) in compliance with statutory conditions of so called “critical points” such as keeping records of sales or control of quarantine pests. SPC or CCAI are monitoring the compliance with critical points.

Furthermore, the following two grants support the cultivation of SRC (source: http://mail.vukoz.cz/vuoz/biomass.nsf/pages/dotace.html):

- SAPS (area payments on all land in the records of Ministry of Agriculture ´LPIS´) 2792-3072 CZK/ha/year (app 103 - 114 EUR)
- Top-Up (the national even up of SAPS) 1341-1350 CZK/ha/year (app. 50 EUR)

Table 6: Summary of missing legislation regarding SRC in Czech Republic

Missing legislation / problems	Potential limitations	Comments
The inconsistence in support and promotion of SRC and biomass on national level	Frequent changes in legislation which to the development of special-purpose projects without a long-term concept.	No comment
Relatively high state support to the traditional way of management of existing areas that are suitable for SRC.	Reluctance to invest in new technologies by stakeholders or investors as the traditional and conservative way of farming brings a certain degree of security. Under current conditions the owner of such a land will more likely to choose rather mulching than an adventure with SRC.	No comment

2.2.5 Bottlenecks for SRC plantations

No strategic document, including municipal/regional action plans, spatial plans or energy plans on any level (e.g. national, regional or municipal) includes the development of SRC plantations. Therefore, there is no background or framework on which could be built on. This causes a reluctance to develop SRC plantations and leads rather to a selection of conservative farming instead.

2.3 France

2.3.1 Overview on existing SRC plantations and projects

SRC programs have been launched in several regions of France to test agricultural practices, choice of species, machinery and to see how SRC can take part in combined bioenergy and environmental projects.

SRC are divided in two categories in France: *Taillis à courte rotation* TCR and *Taillis à très courte rotation* T(t)CR, the main difference residing in the duration of the rotation (2 to 4 years for T(t)CR, and 5 to 10 years for TCR)

The two main outcomes for SRC in France are: "*bois industriel*" – wood industry (paper pulp, insulation panels, cardboard) and "*bois énergie*" – wood fuel (wood chips, pellets, synthetic fuels, etc.).

SRC experiments have been encouraged mostly by public institutions: regional agricultural chambers and other public research organisations. Other stakeholders, such as farmers and industries have also been partners in the experiments. Several projects were launched via European programs. In order to gather feedback from all these different experiences and to enable local stakeholders to exchange on their practices, a national network on biomass was created: "*RMT Biomasse*", with a specific section on SRC.

SRC tests have been conducted with different types of species, depending on the regions and climatic conditions, with a predominance of willow and poplar. In 2012, it was estimated that around 2,450 ha were planted with SRC in France (Lignoguide, 2012)

Since SRC has not been developed on a large scale in the country and that projects were launched in response to different needs, it is still difficult to deliver economic models for these cultures. It seems that, in France today, SRC supply chains that are put forward are the ones that combine more than one economic advantage and/or environmental synergies.

Table 7: Data on SRC cultivation in France

Species	For energy (ha)	For other purposes (ha)	Existence of experimental trials Y/N (ha)
Poplars	300		Yes: *experiments on harvesting / transformation into wood chips
Ash tree	very few ha		Yes: experiments to rehabilitate vineyards
Willows (Salix sp)	295		Yes: *100 ha combined wood chips + water conservation *2 ha water control zone
Eucalyptus	1,500		Yes: *4 ha Fibre excellence project: SRC for paper industry
Robinia	very few ha		Yes: *3 ha for wood chip production
SRC (all species combined)	362		
Total	2,457		

2.3.2 Current agricultural practices

Information on current agricultural practises will concentrate on the 3 species mainly planted in France: willow, poplar and eucalyptus.

Table 8: Cultivation characteristics of SRC in France

	Willow	Poplar	Eucalyptus
Optimal climate, yields, conditions	• 8 to 12 t/DM/ha/year • adapts to a variety of soils • 1st harvest after 3 years in good conditions	• adapted to most areas in France (<600 m altitude) • optimum pH between 6 and 8 • not adapted to sandy soils or pH<5 • needs regular water supplies + deep soils • 1st harvest the 7th year in good conditions	• 35-year system: production after 7 to 8 years • 9 to 11t DM/ha/year for the 1st harvest (10 years) and then 12 to 18 tDM/ha/year • not adapted to cold climates • not adapted to soils pH>7 or active limestone rate >4% • high need in water
Spacing	• 15,000 plants/ha	• 1,500-2,000 plants/ha	• 1,250 plants /ha • 4*2 spacing
Planting	• cuttings, plantation with specific equipment	• cuttings (20 to 30 cm long, 1 cm diameter)	• cuttings, plantation autumn or spring
Harvesting technology	• harvesting with agricultural equipment (harvest + transformation into wood chips); in winter (no leaves) • Wilwater project Brittany: investment in adapted harvesting material, cost 170,000 € (Stemster) • must not cut the willow too short otherwise coppicing not effective	• mechanical or manual harvesting (production of wood chips on site or later on) • tests with Silvatec machinery and other forestry equipment	• every 10 years, February to May; can also be used in very short rotation (every 3 years) • mechanical or manual harvesting (production of wood chips on site or later on)
Other management practices	• mechanical weeding especially the 1st year (chemical the 1st year if necessary) or use of biodegradable plastic coverage • Preferable to mix varieties of willows to limit diseases & pests • Fertilization: moderate needs; 6 g N/kg DM 0.9 gP/kg DM 5g k/kg DM; done after harvest between production cycles or use of waste waters (fertirrigation) or sewage sludge	• weeding: especially the 1st two years: mechanical or chemical • fertilization: moderate needs • 100 units of P2O5 before plantation • 100 units of N the 2nd year	• fertilisation: 150 kg / ha/ P205 the 1st year / very short rotation (3 years): need to fertilise after each harvest otherwise for longer rotation no need to fertilise after the 1st year.
Other issues in the supply chain	• very small scale in France, for use in local heating systems	• use of whole tree or only residuals for wood chips • easier to produce wood chips with residuals on site because they take up a lot of space inducing high costs of transport	• mainly used in paper industry
Other comments	• operational costs (cuttings, fertilizers, etc.): 172 €/ha • specific costs (subcontractors, including cuttings): 202 €/ha • need to protect the plants (1st year) from animals	• crops of 10 to 15 ha minimum, otherwise costs too high • operational costs (cuttings, fertilizers, etc.): 43 €/ha • specific costs (subcontractors, including cuttings): 421 €/ha	• operational costs (cuttings, fertilizers, etc.): 27 €/ha • specific costs (subcontractors, including cuttings): 392 €/ha

2.3.3 Local supply chains and use of SRC products

Eucalyptus and poplar are used for the paper industry and have been grown in France for more than 30 years. SRC used to produce wood chips for heating systems was introduced 10 to 15 years ago and is rapidly developing.

Wood chips from SRC are in competition with wood chips from the forest industry. And since, for the time being, SRC is produced on a small scale, wood chips from SRC plantations are not competitive. This explains why SRC projects often combine more than one economic advantage and/or environmental synergies. Projects are also mostly realised on a local scale to develop local supply chains (heat production systems in rural villages).

2.3.4 Legal framework conditions for SRC

Plantations of woody crops on agricultural land do not change the legal status of the land in France, if it is harvested at least once, at the latest the 20th year of the plantation (REF PAC, 2009).

There are three different types of subsidies available for SRC plantations:

1. Right to "single payment scheme" (CE, N°73/2009, article 34, paragraph 2) - direct payment

2. Subsidies for energy crops (other than fallow land) (articles 23 to 42 of n°1973/2004 of the Commission of 29th October 2004)

This subsidy can be combined with the one received in the "Single Payment Scheme", but not with the "Single Payment Scheme for fallow land". The subsidy will be of 45€ per ha. It is however limited globally to 1.5 million ha in the EU. SRC of woody crops must not however exceed a 20 year period on the same land.

Two scenarios exist:

- SRC destined to be sold as an energy crop – the contract between buyer and seller must be sent to state authorities (DDAF regional authority in charge of agriculture and forests/ ONIOL) – the same deadline as other CAP declarations applies.
- SRC destined to be used to produce energy directly on the farm (fuel, biogas, electricity, etc.). The farmer signs a contract with state authorities (DDAF/ONIOL) in which he agrees to keep a special accounting book for these crops (obligation to keep track of weight, etc.) – the same deadline as other CAP declarations applies.

3. Woody crops on fallow land – article 148 (CE) n°1973/2004

When woody crops are declared as fixed fallows, they activate farmers' rights to "Single payment scheme for fallow lands". The farmer does not need to sign any specific contracts. The farmer must however comply with the regulations of Article 148 (Annex XXIII) in which are listed the use that will be made of woody crops on fixed fallows.

These plantations are regarded as a production of raw material on a rotation period of 20 years and not as afforestation. The farmer must send his declaration to state authorities - the same deadline as other CAP declarations applies.

Conditions of these subsidies are that farmers must comply with the same set of rules on good agricultural and environmental conditions as for other crops. Mulching must be biodegradable, spacing between the rows must be sufficient enough to allow space for mechanical weed control. Use of herbicides is allowed to prepare the land and until the end of the 2nd year after plantation or harvest. After the 3rd year only mechanical weed control is allowed.

Regulations in case of tenant farming are not very precise. In order to avoid any litigation it seems essential to have the consent of the owner.

The European Directive 2009/28/EC of 23rd April 2009 indicates that energy crops cannot be implanted on land with high biodiversity value (Article 17).

Table 9: Summary of missing legislation regarding SRC in France

Missing legislation / problems	Potential limitations	Comments
Tenant farming	no precise regulation for SRC plantation	get the owner to sign a contract/consent
SRC not considered eligible for subsidies given for the development of agroforestry (plantation costs and 5 years of follow-up)	high costs to start a SRC plantation	find out if other private/public subsidies can cover plantation costs

2.3.5 Bottlenecks for SRC plantations

Difficulties to establish profitable business plans

Since most of SRC for heat production in France is done as an experiment, the plantations are on a small scale. This implies that economies of scale are difficult to reach for all the different stages of each project: planting, harvesting, transformation into wood chips, transportation, etc. It is also therefore difficult to get funds to invest in efficient machinery and equipment.

Available land for SRC

SRC is not destined to be planted on agricultural lands dedicated to food production. However, SRC will not be efficient on marginal lands with poor soils, poor access, etc. A model will need to be found to realise efficient SRC plantations taking into account these difficulties.

Public image of SRC

First reaction on SRC plantations is rather negative because the public is afraid that it they will be cultivated on agricultural land. The whole biomass topic is delicate and even more so in the Rhône Alpes region where a large scale co-generation plant is being launched (150 000 tonnes of wood/year). The quantities needed to supply this plant will mean that there is going to be a lot of pressure on supply chains in a 400km perimeter around the plant.

2.3.6 References

Aurélie LEPLUS, Sophie MERLE (2009) TTCR de Saules, WILWATER. – Bioénergie International n°7 – 1/2009 www.bioenergyinternational.com

Collectif, IBIS Intégrer la biodiversité dans les systèmes d'exploitation agricole, (2010) Chambre d'agriculture Centre

Elodie NGUYEN (2012), Lignoguide, Guide d'aide au choix des cultures lignocellulosiques, RMT Biomasse, France

Programme REGIX (février 2010), Récolte en plaquettes des Taillis à courte révolution, FCBA Institut technologique

Programme LIDEA (novembre 2007), Introduction des cultures lignocellulosiques dédiées dans les exploitations agricoles, Chambre d'agriculture de Picardie et de Champagne Ardenne.

Project ERA-Net Bioenergy CREFF (2012), “Cost reduction and efficiency improvement of Short Rotation Coppice” on small field sizes and under unfavorable site conditions by focusing on high product quality and a product-oriented cooperative value chain

2.4 Germany

2.4.1 Overview on existing SRC plantations and projects

The political aim of the German Federal Government is to increase the amount of energy, which is produced out of natural raw materials. As a result of this aim, the cultivation area of renewable resources increased to the calculated/estimated area of 2,395,000 ha (FNR 2013) in 2013. This trend is shown in Figure 4.

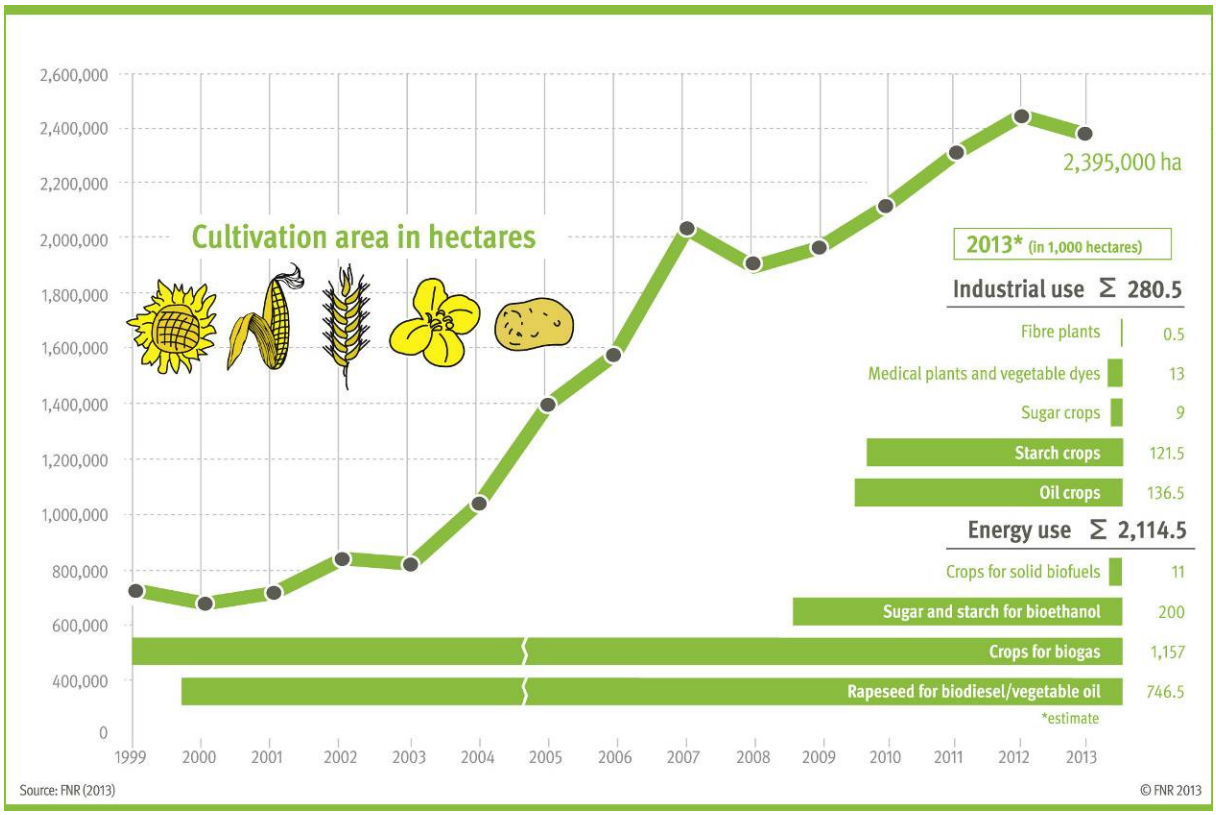

Figure 4: Cultivation area of renewable resources 2013 (FNR 2013)

As mentioned, the cultivation area of renewable raw materials increased within the last 10 years. Because of the positive legal circumstances, the focus within this development has been on the energy usage: mainly crops for biogas (e.g. maize) and rapeseed for biodiesel were seeded at the fields. Compared to these two “big players”, the area of the natural raw material used as solid biofuels (11,000 ha in whole Germany) is relatively small. Furthermore this area includes all plants, which can be used as biofuel. Therefore SRC plantations are only on between 4,000 ha (FNR 2013b) and 5,000 – 6,000 ha (vTI 2012). There are still several bottlenecks and also improvement opportunities (see Chapter 1.4.5)

There exist several small scale SRC plantations existing in Germany. Most of them are driven and controlled by public research institutes, which are using the plantations for research issues. Therefore, please find enclosed a short list of some of these research projects (see Annex 1 “Overview SRC research”).

At the moment an online-survey is running, therefore the following table cannot yet be filled in. As soon as the survey is finalized, the results will be added in Table 10. By now, only some preliminary results can be noted in Table 10:

Table 10: Overview of SRC plantations in Germany

	For energy (ha)	For other purposes (ha)	Existence of experimental trials Y/N (ha)	Ownership (private corporate/private smallholder/public/other - %)
Poplars	20		15	Public – 75%, private – 25%
Willows (Salix sp)	5		5	Public

2.4.2 Current agricultural practises

In the following chapter, the current agricultural practices in Germany are described.

Optimal climate conditions and rotation:

According to ASP 2013, FNR 2012 and Wald21 2014b necessary climatic conditions for profit-yielding poplar and willow SRC plantations in Germany are as follows:

- Sufficient rainfall/precipitation (over 300 mm) during the vegetation period and an annual precipitation over 650 mm.
- "(Moderate) fresh to (alternating) humid, sandy-clayey loam without preservative stagnant moisture (sufficient soil aeration)" (ASP 2013)
- The pH-value optimum of the field is between 5.5 and 6.5, but also fields with a lower pH can provide a profit-yielding harvest
- The mean annual temperature shall be over 6.5°C
- The altitude of the planned plantation shall be below 650 m height above sea level (exemptions are possible).

In conclusion, the fields with a higher productivity of agriculture land often (but not always) achieve a higher output.

There also are some types of soil, on which SRC plantations shall not be planted. These are as follows:

- Very clayey soils: the roots of the trees cannot easy penetrate the soil and the preparation of the soil is quite problematic.
- Groundwater or hydromorphic soils: stagnant moisture reduces the growth of the plants/trees.
- Very wet soils: these soils can provide problems with the preparation and harvest of the trees.

Beside these climatic and soil restrictions, there are also some legal issues to take into account before planting an SRC plantation, but the topic is discussed in Chapter 2.4.5.

In contrast to the traditional timber industry, the rotation period with SRC plantations is much lower. Referring to the utilization of the produced wood, the following differentiation between three rotation periods can be drawn FNR 2012, Wald21 2014b):

- Short time (3 - 5 years)
- Mean time (6 - 8 years)
- Long time (> 10 years)

As already mentioned, the use of the produced wood is decisive for the rotation period: either it would be used for energy (short and mean time rotation) or as raw material for the pulp and paper industry (long time rotation). The pulp and paper industry uses in Germany mainly conifer trees (like spruce) and nearly all wood chips produced out of the SRC plantations were used for energetically purposes.

Spacing

According to Bemmann (2010a) there are different opinions about the optimum spacing. This is due to several reasons, e.g. the costs of the cuttings and the plantation, the productivity of the field and the following utilization of the wood. Therefore Bemmann (2010a) recommends to plant about 8,000 plants per ha for poplar and robinia and 10,000 plants per ha for willow if the wood shall be used as biofuel.

Moreover, most of the SRC plantations were planted and harvested with machines. Therefore, the spacing is complied with the harvester and harvesting gadget respectively: either the harvester is designed for a two-row or a one-row plantation. Due to this, the spacing depends on the available harvesting technology, like it is shown in Figure 5.

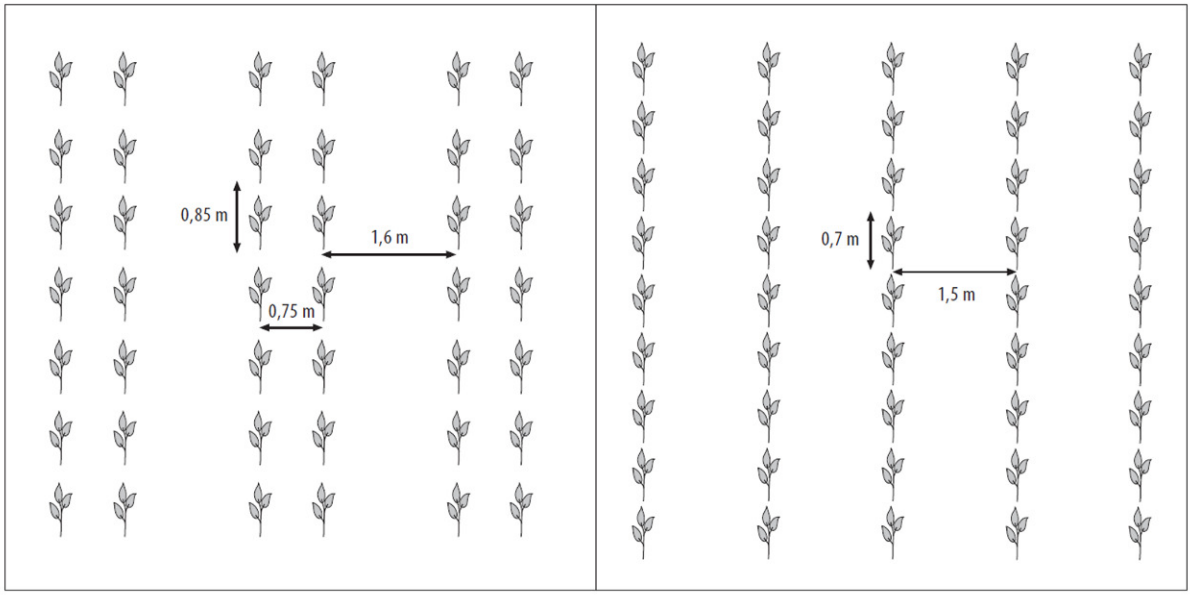

Figure 5: Schematic diagram of a two-row plantation (left) and a one-road plantation (right) for a spacing of about 10.000 cuttings per ha (Bemmann 2010a)

As shown in Figure 5 Bemmann (2010a) recommends a distance of 1.6 m – 0.75 m – 0.85 m (for the two-road plantation) and 1.5 m – 0.7 m (for one-road plantation) between the single cuttings. Not only the available harvesting technology is essential for the spacing, also the rotation period has an influence on the amount of cuttings per ha: shall the cuttings and trees respectively grow for a longer period, they need more space to develop quite well. Therefore Wolfram Kudlich (the head of the company Wald21 GmbH), one of the leading plantation companies in Germany, uses the following spacing like it is shown in Table 11.

Table 11: Overview of the spacing (plants/ha) (Source: Wald21 2014b)

	Short time rotation (3-5 years)	Mean time rotation (6-8 years)	Long time rotation (> 10 years)
Willow	13.000 cuttings / ha, Two-road plantation, Distance between the rows: 2 m * 0,75 m and approx. 55 cm within the row	-	-
Poplar	8.300 - 11.000 cuttings / ha, One-road plantation, Distance between the rows: 2 m and approx. 45 – 60 cm within the row	5.000 cuttings / ha, One-road plantation, Distance between the rows: 2 m and approx. 1 m within the row	2.500 - 3.333 cuttings / ha, One-road plantation, Distance between the rows: 2 m and approx. 1.5 – 2 m within the row

The recommendation for the spacing also differs between the pressure groups: nature conservation authorities (like the German Nature And Biodiversity Conservation Union, "NABU" or the German Environment Foundation "DBU") advise a wider spacing and a longer rotation period (DBU 2010), whereas farmers and/or land owners prefer a higher spacing and a shorter rotation period because of an earlier return of capital.

Planting

Before an SRC plantation can be planted a preliminary preparation of the field has to be performed. This enables an easier plantation and good growing conditions for the cuttings. Usually soil cultivation with a plough (30 cm deep) is performed in autumn. Often the soil cultivation is combined with spreading a (total) herbicide, which prevents the growth of weed.

Before the cuttings are planted in spring time, the soil shall be treated with a grubber or an equivalent device (Bemmann 2010a) to inhibit the weed vegetation.

If bigger cuttings are used (see Table 12), herbicides are not absolutely necessary (ASP 2013, Bemmann 2010a, DBU 2010), however this increases the costs for the plantation. Therefore, for most of the SRC plantations in Germany, the small size cuttings are used.

Table 12: Overview of the used cuttings (Source: FNR 2014)

	Cutting (small)	**Cutting (medium)**	**Cutting (large)**
Age (y)	1	1 - 2	2 - 4
Length (cm)	20	100 - 250	200 – 400 (600)
Diameter (cm)	1 - 2	1 - 3	2.5 - 5
Depth of planting (cm)	20	30 - 50	70 - 100
Quality	straight, healthy, well cutted down	straight, healthy, without bark violation	straight, healthy, no branches

Depending on the dimension of the field, there can be distinguished between three kinds of planting: manual seeding by hand (see Figure 6), with a half automatic planting machine (see Figure 7, left) or fully automatic planting machine (Figure 7, right).

Figure 6: Manual seeding (left, LWF 2011) of the 20 cm tall poplar cuttings (right, LWF 2014).

As shown in Figure 6, the 20 cm tall cuttings have to be pushed in the soil. This procedure can be performed also upon the planting device, like it is shown in Figure 7.

Figure 7: Tractor with the semi-automatically plantation device of Wald 21 GmbH (left, BMA 2011) and fully automatic planting machine (right, Agraligna 2011)

Harvesting technology

SRC plantations in Germany are harvested during the dormancy in winter time. Therefore, the ability to re-grow is not endangered and it is possible to drive with machines easily on the fields. The harvesting technology can be distinguished according to LWF (2011) and Burger (2010) due to their degree of mechanisation:

- Moto-manual procedure
- Fully automatic procedure

With the moto manual procedure, the trees are cut by a person with a chainsaw or a brush cutter. According to the harvest the timber is either chipped at the field, or forwarded and chipped at a central place or the chipping is performed with a big chipper at the heating plant (Burger 2010).

The fully automatic procedures are as follows: Feller Buncher unit with chipping the wood at the field, special wood chip harvesters and wood-harvesting attachments for tractors or crop choppers (Burger 2010).

Figure 8: Attachment of the company Biomasse Europa (left), harvester of the company Krone (right) (Burger 2010)

More information about the harvesting devices is noted amongst others in Burger 2010, FNR 2013B; Scholz 2008, Schulze 2008 or Stoll 2012.

Other management practices

One of the advantages of SRC plantations is, that the plantations do not need to be fertilized (e.g. ASP 2013). This is on the one hand due to the leaves, which deposit on the field and decompose there as well. On the other hand, the natural deposit of nitrogen out of the air (yearly rate of about 20 – 50 kg/ha) is sufficient for a profit-yielding SRC plantation. Therefore, fertilizing is not very much practiced in Germany, but there are some ideas about using the ashes (grit ash) of the wood chip boilers or the wood chip driven heating plants as fertiliser on the fields. These ideas are at the moment still under discussion and have not yet started.

Herbicides are used before the SRC cuttings are planted. Nevertheless, there is the possibility to do the SRC plantation without them. The cuttings need about 6 to 8 weeks before they are budding and within this period, they are very sensitive to weed. Hence weeding is then absolutely necessary (ASP 2013). The disadvantage of weeding is the higher costs in comparison to herbicides.

Other issues in the supply chain

In Germany, SRC plantations are planted not before the usage of the wood chips is clear. Therefore, mainly all SRC wood chips are used in wood chip boilers (> 250 kW) or wood chip driven heating plants (< 600 kW). Due to the different sizes of the combustion unit, the wood chips need or don't need to be dried before burning. If the wood chips are used in a small combustion, then they have to be dried.

At the moment SRC wood chips are not traded in Germany, because of the above mentioned problem: if the outlet market is still not clarified, the SRC plantation is not planted.

2.4.3 Local supply chains and use of SRC products

At Allendorf, a small German city in Hesse, the company Viessmann (manufacturer of e.g. heating technology) planted on a company-own area of 170 ha poplar and willows, which shall be harvested by the local agricultural company every three years. The produced wood chips shall then be used for the heat demand of the company (ELKE 2013).

Another example is the 3 ha-SRC-plantation nearby Übersee, which belongs to a local farmer. The cuttings for the plantation were produced in Germany and were seeded in

cooperation with the company Wald21 GmbH. The harvest is planned in February 2015 and shall be performed of a local agricultural company. The produced wood chips shall be sold to the Biomassehof Achental GmbH, which will use the wood chips for the local heating plants. More local supply chains can be found e.g. in Burger 2010 or ELKE 2013.

2.4.4 Legal framework conditions for SRC

Several legal framework conditions have to be taken into account, if a new SRC plantation shall be planned and planted.

According to the amendment to the German Federal Forests Act in 2011, SRC plantations are pursuant to § 2 Abs. 2 (BWaldG 2011). SRC plantations are not forests as long as the harvest is performed within 20 years (short rotation). Therefore, the status of the field is not changed with an SRC plantation. The result of this amendment is that no permissions are needed in several German federal states. Nevertheless, nature conservation aspects can hinder a successful new SRC plantation. Therefore, it is important, to contact the local nature conservation authority in order to get their permission.

In contrast to the legal framework of new SRC plantations on fields, the situation of establishing SRC plantations on grassland is different. A new plantation is considered as ploughing the grassland (change of grassland into field; except only 50 trees per ha are planned) and therefore the legislation of the “Common Agricultural Policy” (CAP) with “Cross Compliance” and especially “Greening” has to be taken into account. In the Greening regularities is written that grassland shall be preserved (because of the positive carbon footprint) and not more than 5% of the grassland shall be rededicated in fields. One possibility to have a SRC plantation permitted is to increase the ecological value of the grassland. In order to prove this, the local nature conservation authority has again taken into account. (Bärwolff 2012, Marx 2012)

The Common Agricultural Policy is on the one hand part of the federal government and on the other hand of the federal states. Therefore every single federal state has its own regulations referring to subsidies. If a new SRC plantation gets a subsidy can be checked on FNR website (http://energiepflanzen.fnr.de/pflanzen/mehrjaehrige/energieholz/kup-foerderung/ or http://bioenergie.fnr.de/ru/rahmenbedingungen/foerderung/kup-foerderung/)

Table 13: Summary of missing legislation regarding SRC in Germany

Missing legislation / problems	Potential limitations	Comments
In regions with mainly grassland, it is almost impossible to plant a new SRC plantation.	almost impossible to plant a new SRC plantation	
A positive SRC-guideline for nature conservation authorities is missing, therefore they often deny a new SRC plantation on grassland.	Many potential SRC plantations are denied	

2.4.5 Bottlenecks for SRC plantations

In the following Chapter, the existing bottlenecks (other than legislation) are listed.

- There are only several best-practice examples missing across Germany.
- The first SRC plantations have used the wrong species of e.g. poplar or willow.

- The farmers are used to their crop rotation: every year, they can change their "product" and therefore they are not used to be fixed about 30 years to the same crop (in this case wood chips).
- Landowners earn a lot if they rent their arable land. Therefore the arable land is often used for the nutrition sector or the biogas raw material production (mainly maize) and a SRC plantation is getting uninteresting for them.
- Farmers only want to use their fields with a low soil quality for SRC plantations. Therefore the yield of the plantation is often lower than expected.
- Depending on the plantation, the owner of the plantation has to wait for the first harvest in order to have a return of money.
- Harvesting device for small scaled plantations is still missing.
- In areas with a high density of grassland, SRC plantations cannot be planted because of nature conservation und "Greening" reasons.
- Nature conservation authorities are worried about the usage of herbicides.
- Sometimes a (local) sales market for the SRC wood chips is missing.

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2.5 Greece

2.5.1 Overview on existing SRC plantations and projects

Wood fuels have been the main biofuels for heating in the domestic sector. In Greece until the 1950's, 15% of energy production was based on wood fuels from forests, in the form of firewood and charcoal. From the beginning of the 1960's, Greek households have turned to other sources of energy and thus the consumption of woody biomass for energy purposes continuously decreased. During the last years, the consumption of woody fuels has been increased, especially in the forms of split firewood, wood pellets and briquettes, due to increase of taxes and the retail price of heating oil. An important parameter affecting the increment of biomass use is the low number of medium and large scale applications of bioenergy production, such as district heating and cooling, electricity generation and cogeneration. Biomass is mainly used in small systems in residential heating applications, so far.

Currently, there is no SRC cultivation for the production of woody biomass and bioenergy exploitation. Only small scale experimental plantations are established for research on production and yields of different species and cultivation techniques. For that reason it is not possible today to describe the exploitation and supply chains of woody biomass for energy production from SRC. Information and data about yields and cultivation practices in experimental plantations with species like Eucalypt, Black Locust, Plane trees, Willow and Poplar can be found in literature.

Table 14: Overview of SRC plantations in Greece

	For energy (ha)	For other purposes (ha)	Existence of experimental trials Y/N (ha)	Ownership (private corporate/private smallholder/public/other - %)
Poplars	0	~3,500	Y	For saw wood production: Public ~10% Private ~90% Public for experimental trials
Willows (Salix sp.)	0	0	N	n/a
Eucalyptus	0.04[1]	0	Y	Private ownership for energy use Experimental trials on public ownership
Robinia	0	9,727	Y	Experimental trials on public ownership
Plane trees (Platanus sp)	0	0	Y	Experimental trials on public ownership

[1] Easy2Find Energy

2.5.2 Current agricultural practises

Before planting of cuttings or nursery plants, soil preparation (plowing, harrowing) will be performed. Transplanting of stems or cuttings takes place from March to April. Planting of nursery plants could be made a little earlier (February) or later after summer.

Chemical weed control is made using pre-emergence herbicides. During the first year, a periodic weeding and harrowing (30 cm in depth) is necessary to control weeds.

In case of poplar plantations, health care about beetle whites might be necessary for a few years after planting. Before the start of the growing season, chemical fertilization with nitrogen (100 kg N/ha for poplar) could be recommended, depending on nutrients availability in the soil.

At the end of life (10-15 years) soil remediation will be performed. Stumps are crushed using milling machines and used for recycling of nutrients (organic fertilizer). Alternatively, stumps could be extracted and used for energy production, after chipping process (using wood shredders).

Optimal climate conditions and rotation:

- Poplars: wet and well drained soils, two years rotation period; well adopted to high summer temperatures and low winter temperatures
- Willows (Salix sp): wet soils; 2 years rotation period
- Eucalyptus: well drained soils; well adapted to high summer temperatures and low water availability; irrigation has positive impact of biomass production; low winter temperatures is a problem; 2-3 years rotation period
- Robinia: 2-3 years rotation period; in fertile soils there is no need for fertilization; irrigation is required
- Plane trees (Platanus sp.): wet and drained soils; 5 years rotation period; well adopted to high summer temperatures and low winter temperatures

Spacing:

- Poplars: 10,000-20,000 plants/ha
- Willows (*Salix sp.*): 20,000plants/ha (Salix babylonica)
- Eucalyptus: 10,000-20,000 plants/ha
- Robinia: 10,000-20,000 plants/ha
- Plane trees (*Platanus sp.*): 10,000 plants/ha (*Platanus orientalis, Platanus occidentalis*)

Planting:

- Cuttings - the use of machinery is possible
- Seedlings - manual planting

Harvesting technology:

- Modified forage harvesters
- Logging with chainsaws and wood chippers

Other management practices:

- Poplars: 100 kgN/ha, chemical and mechanical weeding
- Willows (*Salix sp.*): n/a information about fertilizers and weed control
- Eucalyptus: not important impact from fertilization, weed control might be recommended only during the first year
- Robinia: n/a information about fertilizers; weed control 1 month after planting

- Plane trees (*Platanus sp.*): n/a information about fertilizers and weed control

Other issues in the supply chain:

Seasoning is efficient for drying of wood chips due to high summer temperatures. Trading of wood chips is not the common practice due to the lack of installation using wood chips as fuel.

2.5.3 Local supply chains and use of SRC products

As result of the lack of SRC plantations in the country, supply chains have not been developed yet, but a potential supply chain could be planned based on potential energy production, current needs for energy and plans of potential energy investors. This development could be based on current agricultural exploitation system and final uses of energy. The proposed system has two basic pillars: one is the harvesting method and the second is the final conversion technology and use. Figure 9 presents potential supply chains for wood chips from SRC.

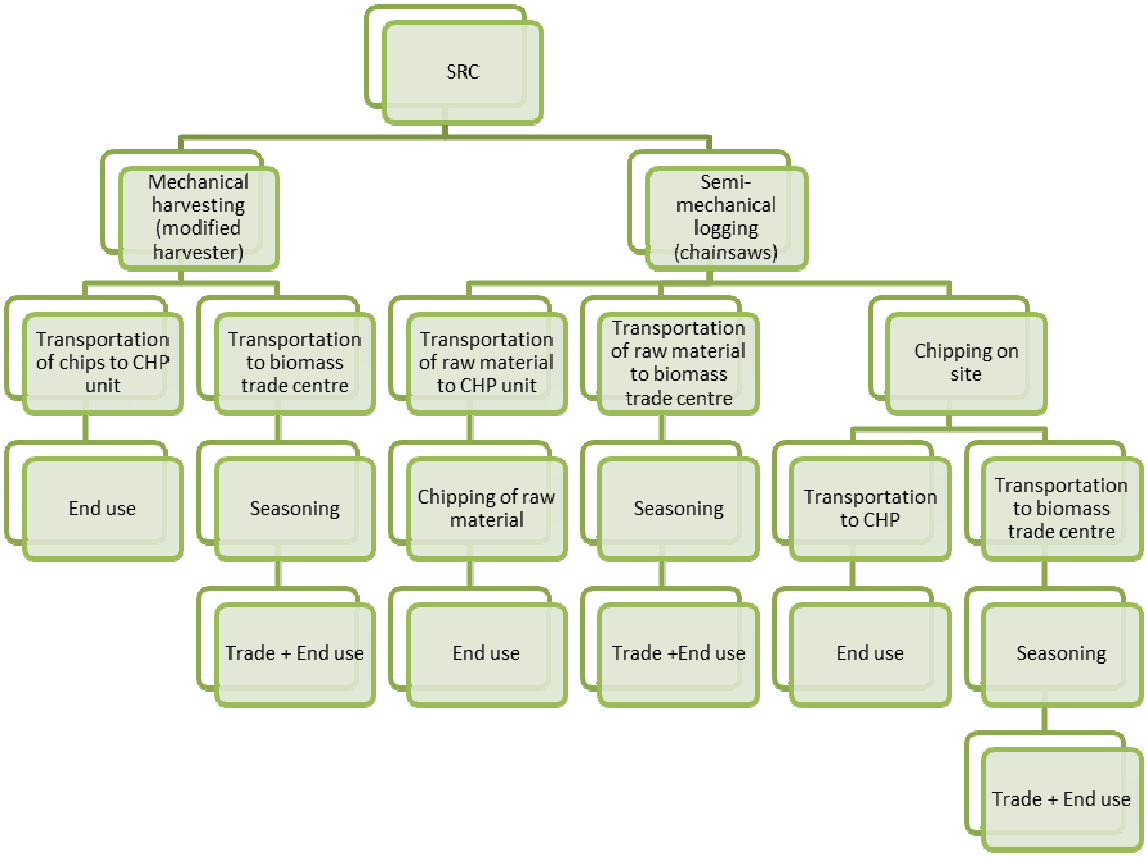

Figure 9: Development of a potential biomass supply chain from SRC

Harvesting of SRC production can be totally mechanical of semi-mechanical. In the mechanical method automated harvesters are used and the final product of this process is wood chips. In the existing agricultural systems, forage harvesters are used for harvesting of maize. Modified forage harvesters, using special accessories, can be used for the harvesting of wood chips. The produced material can be transported directly for final use in case that it would be used in CHP units for combined heat and power production. In case that wood chips will be used for residential heating, it will be transported to a biomass trade centre available for trade and final use, after seasoning, in order woody biofuels the reach appropriate specifications for combustion in small and medium scale unit (e.g. moisture content < 30%).

When automated wood chips harvesters are not available, harvesting could be based on semi-mechanical logging of plants with the use of chainsaws, due to the lack of other machinery for logging. The produced raw material could be chopped on site for wood chips production and transported directly to CHP unit of to a biomass trade centre, depending the used energy exploitation system. Alternatively, the harvested plants could be directly transported to the site of final use for chopping.

The selection of the supply chain must be based on availability of equipment, properties of agricultural system, the existing energy exploitation scheme and economic viability of the supply chain.

2.5.4 Legal framework conditions for SRC

There is no specific legal framework for SRC in the country. Wood chips production from SRC for energy production is affected by legislation and measures of the agricultural and energy policy in the country. Next, existing measures of the current framework are presented.

By Ministerial decree "Regulations for issues related to the operation of combustion units for the heating of buildings and water" (189533/07.11.2011, Ministry of Environment, Energy and Climate Change) restrictions on the use of solid biofuels in prefectures of Attiki and Thessaloniki were lifted, providing new opportunities for higher penetration of woody biofuels in the national energy balance.

Solid biomass fuels and their specifications are now classified according to the EN 14961 technical standards. This promotes the use of solid biofuels, in central heating systems of the two largest urban areas in the country and it is expected to boost the market for biomass fuels.

Measures of the national programme for the rural development during the period 2007- 2013 call existing small enterprises to submit proposals for funding in order to increase the added value of their products through the upgrade of their existing infrastructure or creation of new very small enterprises and improvement of trade, including woody fuels trade.

The aim of the programme is the increment of added value and competitiveness of wood products (including wood fuels) through new investments for creation of small scale units for wood products, further development of wood products trade and wood processing enterprises.

Activities related to woody fuels and eligible for funding under the same funding scheme are:

- Storage areas for wood products
- Pre-process
- Creation or upgrade of wood processing units
- Infrastructures
- Supply and installation of new machinery, technical equipment and software
- Other expenses related to the investment (engineers, studies, consultants, etc)
- Costs for quality certification

The call for this measure of the programme for rural development is now closed but it is expected to be announced again during the next period of the programme (2014-2020).

In 2011, the Ministry of Environment, Energy and Climate Change announced the ‘Energy Efficiency at Household Buildings’ programme (decision 31654/ΕΥΘΥ1415/20.07.2010). According to description, several actions for the energy improvement of household buildings are co-funded. The replacement of old technology domestic boilers with pellet boilers is eligible for co-funding. The implementation of the programme supports, indirectly, the use of pellets for heat production in the domestic sector.

Aiming to improve the development of Renewable Energy, in order to mitigate climate change, the Ministry of Environment, Energy and Climate Change implemented a rationalization of pricing for electricity produced from CHP units and power plants using RES (L3851/2010). The table below presents the specified feed-in tariffs of energy generated from specific biomass applications.

Table 15: Electricity production from organic materials

Electricity production from:	(€/MWh)
Biomass ≤ 1 MW (excluding biodegradable sewages)	200
1 < Biomass ≤ 5 MW (excluding biodegradable sewages)	175
Biomass >5 MW (excluding biodegradable sewages)	150
Landfill gases, sewage treatment plants and biogases (including biodegradable sewages) ≤ 2 MW	120
Landfill gases, sewage treatment plants and biogases (including biodegradable sewages) > 2 MW	99.45
Gas from biomass ≤3 MW	220
Gas from biomass >3 MW	200

The L3851/2010 is also focused on:

- Protection of the ecosystems from climate change, through promotion and encouragement of renewable energy for power production.
- The contribution of RES, in the national energy balance, of 20% of gross energy consumption equivalent.
- The contribution of energy from RES of 40% of total electricity consumption.
- The contribution of energy from RES of 20% of total energy consumption equivalent for heating and cooling.
- The contribution of energy from RES of10% of total energy consumption equivalent for transport.

2.5.5 Bottlenecks for SRC plantations

An important parameter affecting the increment of biomass use is the low number of medium and large scale applications of bioenergy production, such as district heating and cooling, electricity generation and cogeneration. Biomass is mainly used in small systems in residential heating applications, so far. For further penetration of new bioenergy production systems, it is important the support of the market, for the replacement of systems using fossil fuels, through direct subsidies or tax reductions. Today, such measures are included only in the project of Ministry of Environment, Energy and Climate Change for energy saving for the residential sector.

The creation of reliable biomass supply schemes is important for further development of the bioenergy sector.

2.6 Latvia

2.6.1 Overview on existing SRC plantations and projects

Due to current legislation in Latvia, SRC plantations are either agricultural crops or plantation forestry. As agricultural crops are categorized the crops with a rotation period of maximum 5 years before harvest, such as *Salix spp., Populus spp.* and *Alnus incana*, but no species that can be cultivated as short rotation forestry for longer time, such as first rotation of aspens.

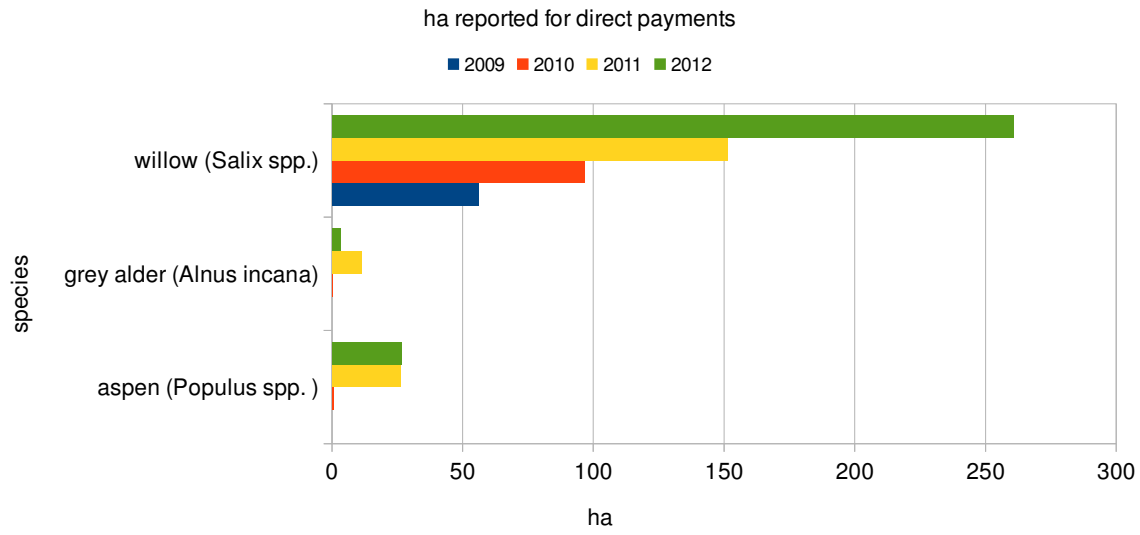

Figure 10: Changes of areas supported according to EU Regulation Nr. 73/2009 124. 2

Concerning ownership, most small sized SRC plantations are owned by farmers and private persons, but there are also larger fields that were planted by companies investing in “growing of green energy” for wood chip production. There is no explicit registration of SRC for agricultural land use, and all available information comes from the direct payment registration reports (single area payment). For plantation forests (Figure 10), there is also lack of registration, but since 2008 almost 91 ha of SRC plantations were planted with aspen, poplar, and grey alder, and 144 ha with these species are reported as naturally ingrown.

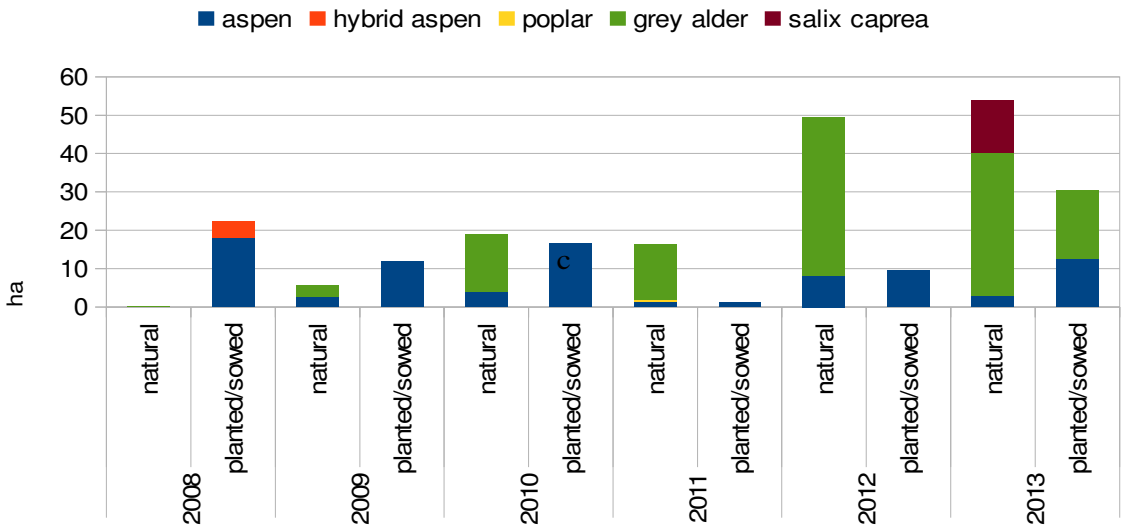

Figure 11: Establishment of plantation forest with SRC species in Latvia

The Latvian State Forest Research Institute "Silava" has experimental and demo plantations of aspen, alder, willow, poplar, birch and other species potentially used as SRC (Lazdina et al. 2007, 2010, 2011, 2012, 2013, 2014; Makovskis 2012, Bardule et al. 2012, 2013; Lazdins et al. 2010, 2011). Information about the ownership of these plantations is not available due to confidentiality issues. No other state owned plantations exist as demo fields of scientific organizations in the country. Possibly not all private owned plantations are included in the available registers, therefore the given data is probably underestimating the current size of SRC in Latvia.

Table 16: Total areas covered by short rotation woody crops (SRC) for the different species in Latvia (2012/2013)

	For energy as SRC (20012 ha)	For other purposes as plantation forest (2013 ha)	Existence of experimental trials Y/N (ha)	Ownership (private corporate/private smallholder/public/other - %)
Poplars			Y (6 ha)	Private. State 2 ha
Hybrid aspen/Aspen	26.64	19.4/74.0	Y (10ha)	Private. State 10 ha
Willows (*Salix sp.*)	260.64	13.4	Y (20 ha)	Private. Just 2 ha on state land
Eucalyptus	-	-	N	
Robinia		0.01	Y (0.01 ha)	Private
Grey alder (*Alnus incana*)	3.35	129.14	Y (6 ha)	Private. Just 2 ha on state land

2.6.2 Current agricultural practices

There is no strictly defined minimum or maximum number of trees planted per hectare. Willows are planted 10-15,000 cuttings per ha. Grey alder and hybrid aspen are usually

planted like forest trees with approximately 2,000 plants per ha. The idea is to develop a root system and just in the second rotation to reach density of trees (root suckers) which could provide with reasonable yields in five years. Willow plantations are established by using the widely adapted double row system.

Figure 12: Harvesting of first experimental demo willow plantation of LSFRI Silava in 2008

Such system allows mechanical weed management as well direct mechanical harvesting. The first large scale plantations were established in 2009 and the first commercial harvesting will start this winter (2014-2015). Some commercial willow plantations are fertilized with wastewater sludge and biogas production residues (Lazdins et al. 2005, Lazdina & Lazdins 2008, Lazdina & Lazdins 2011).

Weed management like tending in young forest stands are used in SRC tree stands. Forest machines suitable for early thinning is used for harvesting and chipping of wood from Alder, Aspen and Populus stands (Daugavietis et al. 2006, Zeps 2008, Zeps et al. 2011).

2.6.3 Local supply chains and use of SRC products

Because of the limited number of plantations and the young stand structure, there are no developed supply chains yet. When the first willow plantations (6 ha) were harvested and chipped in Latvia, the chips were used for heat production in local boiler house. When the first 100 ha of industrial willows plantations will be ready for harvesting in 2015, more can be said about the supply chains.

2.6.4 Legal framework conditions for SRC

Currently, there is no necessity to apply for permission to plant SRC as agricultural crops, since the status change of land use is not necessary.

No establishment support/subsidy exists, except the direct farm payments for the farmers. If the plantation is established on agricultural land and no active management occurs, these are characterized as non-operating and are taken out from data bases. Only registered farmers can be eligible for EU support under agriculture scheme (Rules of Cabinet of Ministers No 139).

Since April 2011, farmers that have planted SRC in tube drained land were not eligible to receive EU support. Additionally, in case SRC destroys some part of the drainage system, farmers need to pay penalties and have to cover costs for new drainage systems (Rules of Cabinet of Ministers No 714).

The land owner needs to ask for permission from the local authorities (municipality level) and "Zemkopības ministrijas nekustamie īpašumi" in case of afforestation as common forest or as plantation forest (Rules of Cabinet of Ministers No 308).

Sowing or planting forests can be established on other land types:

- Where afforestation is not contrary to the territorial planning documents specified requirements. If the documents referring to afforestation are not directly specified, planned afforestation should be discussed with the municipality.
- Reclaimed land in accordance with the statutory requirements of drainage.
- Areas of laws and regulations of the Nature Protection Board maintained by the National Register, when these areas are not registered as a specially protected habitats and protected species habitat (Rules of Cabinet of Ministers No 308).

Willow clones are developed for SRC, but theoretically could be also recommended for plantation forest. Rules of cabinet of ministers "Forest reproductive material usage" associated with Forest law describe how to collect certificate planting material, regulate forest planting material propagation, and set regions where different material should be used (Rules of Cabinet of Ministers No 159).

Forest trees should have a certificate of forest reproductive material, which implies that for material coming from abroad, either a decision of LSFRI Silava should be asked or these should be registered as "forest reproductive material source" (Rules of Cabinet of Ministers No 159).

The owners of young plantation forest do not pay property taxes for grey alder during the first 10 years, and for other deciduous species for the first 20 years (Law On Immovable Property Tax).

2.6.5 Bottlenecks for SRC plantations

Only lately the first company for SRC plantation establishment, management and harvesting named "SalixEnergi Baltic" started operating. It is based at Madona district and provides service in all Baltic countries.

Since 2013, there have been several willow planting material sellers at Vidzeme region – Latsalix, Nova days, "Salix energi Baltic" (http://www.salixenergi.se/Seedproducers) and "Latvijas Bioenergijas Kompānija" (http://www.ewb.nu/index.php/en/licenssale).

Despite the promising first results after growing hybrid poplar plantations, until now there are no providers of poplar planting material operating in Latvia.

Hybrid aspen propagated by tissue cultures in nurseries of JS company Latvia state forests "Seeds and plants" (http://old.lvm.lv/eng/seeds_and_plants/forest_plants/) are on market with an approximate production of half a million plants per year.

The short rotation period for woody crops eligible for agricultural crop production is five years, which can be enough for willow, but considering conditions in Latvia it is not enough for poplars, aspens and alders.

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2.7 Macedonia

2.7.1 Overview on existing SRC plantations and projects

Macedonia has dry - warm summers and cold – humid winters. The average temperature in summer is 24ºC and 0.3ºC in winter. There are three main climate types:

- Mediterranean type in south-east parts of the country
- Equability continental in south – west, east and northern parts of the country
- Mountain type mostly in the western parts of the country

The Prespa region is characterised by its continental type of climate with remarkable influence of the lake basin.

According to the *spacious plan* (Agricultural Land Law No.135/07) of Macedonia there are three natural areas:

- Water surfaces on 48,800 ha or 1.9% of the total territory
- Flatlands on 490,000 ha or 10.1% of the total territory
- Hills and mountains on 2,032,500 ha or 97% of the total territory

The Prespa region is mostly hilly and mountainous area on 12,500 ha with 800 m above the sea.

According to the *Land registry - cadastre* the quality of 687,352 ha agricultural land is divided into 8 classes. The smallest percentage of 2.24% is classified as the first class and the largest percentage of 20. 41% is classified as the fifth class. The total surface from first to fifth class takes 60.19% or 413,596 ha of the total classified agricultural land. This shows that there is a relatively low percentage of good quality agricultural land in Republic of Macedonia.

There are 197,764 ha agricultural land in state property and the other part is in a private property. Most of the private agricultural land (67.6%) are 2 ha or smaller (24% from 2 ha to 5 ha, and 8.3% are from 5 ha to 10 ha).

According to climate, space and paedological conditions there are several types of plants that are cultivated in *Republic of Macedonia:* 40% of wheat and cereal crops, 12% industrial crops, 7% fodder crops, 8% vegetables, 3% fruits and 30% other.

The forest land occupies around 988,835 ha with total wood amount of 74 million m^3 and that is 38.8% of total territory of Republic of Macedonia. There are coniferous forests with fir tree, pine tree, and deciduous forest with beech tree, oak, and poplars.

90.14% of the forests are in state property and 9.86% in private property. The private forests are small, mostly around 1 ha as separated parcels. The public enterprise “Macedonian forests” is nominated by the Government for management of the public forests sustainable development, planning, operating, protecting and providing biological diversity and product ability.

Biomass takes an important place in the energetic balance in Republic of Macedonia. It provides 166 ktoe (1,930 GWh, 6,950 TJ) or 11.5% of total produced energy.

Biomass for burning has 59% in the usage of renewable sources for energy and it is present in households with 30%-33% of total needs for energy. Approximately 76% of the households in Macedonia use biomass for heating.

Macedonia has experience in waste biomass treatment (around 380 GWh), especially biomass from cutting forests and processing trees in industry which is used for heating. Also this type of biomass is suitable for combined production of heat and electricity.

More than 100 private sawmill companies are processing 160,000 m³ technical wood during one year period, mostly for heating and for producing pellets and briquettes.

There is outstanding part of unused waste biomass which can be used for heat and electricity production. It will be economically feasible in the future and will give additional 50-70 GWh electricity and 120-180 GWh heat energy.

Table 17: Waste biomass from cutting forests, processing woods and agriculture

Type of waste biomass	Tones per year
Cutting forests	20,000
Processing woods	10,000
Waste from agricultural activities	35,000
Total	**65,000**

National legislation provides legal framework giving directions for using all types of renewable sources of energy (hydro energy, biomass, wind energy, solar energy and geothermal energy). The efforts of the current Macedonian Government focus on the harmonisation of national legislation with European Union legislation for improving all further actions in the field of energy efficiency and renewable sources for energy production.

Several departments of the Macedonian government are directly involved in the legislation process (Ministry of Agriculture, Forests and Water Management, Ministry of Economy, Ministry of Finance, National Agency for Energy, Ministry of Local Government, and National Regulatory Commission for Energy). NGOs' and citizens' contribution in legislation process is on a relatively high level. All activities are focused on making easier procedures and improving the conditions for further domestic and foreign investments in the process of using renewable sources of energy and achieving higher energy efficiency.

There are support activities for biomass targeted to:

- Programs for stimulating small and middle enterprises for producing equipment for biomass combustion with high rate of usefulness
- Subsidies for changing old equipment with effective equipment for heating
- Programs for decreasing the loss of biomass as well as decreasing the unregistered consumption of biomass
- Providing technical and financial support for establishment of the first combined thermoelectric and heating producer company

According the Strategy document for Energetic Development of Macedonia until 2020, there are conditions for renewable energy sources to cover 21% in energy supply.

Table 18: Overview on existing forests in Republic of Macedonia

	For energy (ha)	For other purposes (ha)	Existence of experimental trials Y/N (ha)	Ownership (private corporate/private smallholder/public/other - %)
Poplars	500	0	N	92% public 8% private smallholder
Hybrid aspen	0	0	N	0
Willows	470	2,900	N	97% public 3% private smallholders
Eucalyptus	0	0	N	0
Robinia	0	0	N	0
Paulownia	0	200	N	70%agro cooperative 30%individual producers
Beech	179,773	50,000	N	92.5% public 7.5% private smallholders
Oaks (all)	225,973	64,000	N	83.7% public 16.3% private smallholders
Chestnuts	0	2 754	N	96.3% public 3.7% private smallholders
Other broad-leaved species	0	48,634	N	87% public 13% private smallholders
Spruce	0	1,176	N	98% public 2% private smallholders
Fir	0	5,703	N	96% public 4% private smallholders
Black pine	0	47,452	N	89% public 11% private smallholders
Scots pine	0	9,900	N	77.48% public 22.52% private smallholders
Macedonian endemic pine (Molika)	4,270 This kind is protected with law and it is not available for cutting and using for anything			100% public
Other conifers	0	3,729	N	99% public 1% private smallholders
Mixed forests	201,000	96,201	N	93.7% public 6.3% private smallholders
Degraded forests	43,318	1,500	N	93% public 7% private smallholders

2.7.2 Current agricultural practises

So far 60 producers have planted approximately 200 ha private land only with one type of species - paulownia. This production is committed only for export abroad as raw material for processing in the industry. Very small percentage of it (which is low quality) is used for heating private houses.

With the new law for agricultural land, the producers of SRC in Macedonia will have an opportunity to rent a land which is in a state property for SRC plantation, but only the land which is higher than 700 m above the sea. This is one of the policies of the Ministry of

Agriculture in order to eliminate the threats of replacing agricultural land for food production by short rotation corps, even though SRCs have useful characteristics for protecting lands from erosion, increasing forests potential, landscapes and biodiversity.

2.7.3 Legal framework conditions for SRC

SRCs are incorporated in the legal framework for biomass, however is it is not complete. The reason for this situation is the fact that SRCs are not yet planted in Republic of Macedonia and there are not enough information and awareness for them.

At the moment the program for financial support of agriculture and rural development presents subsidies for planting SRC only 100 EUR per ha. This is very low financial support that has to be changed in the future, if the state wants to develop SRC production.

Table 19: Summary of missing legislation regarding SRC in Macedonia

Missing legislation / problems	Potential limitations	Comments
Determination and regulation of land categories and classes which can be used for SRC production	The land in state property can be used for SRC plantation if it is higher than 700 m. This gives limitation because most of these lands are waterless.	The limitation is better to be according the classes of land and soil quality
Determination for the SRC plant materials according their characteristics and conditions for growing	Inappropriate plant material – species of SRC plants will give limitation	Experimental plantations to be developed in near future for testing species of SRC that can be produced in Macedonia
Regulations for management of SRC plants (planting period, irrigation, fertilizing, harvest period, transport and storage)	Missing know- how knowledge and exchange practices is potential limitation	Developing projects for capacity building like SRC plus project and projects for exchange practices and experience
Economic analysis for SRC production, market researches, investments opportunities for SRC, competition with other countries and markets, costs, loans, income	It is very important to find markets where SRC can be put up for sale because the risk of unsuccessful investments can be serious threat	Developing investment programs for SRC production for heating or for industrial processing
Regulations for infrastructure and technical conditions for SRC plants and local supply chains	Water supply systems, road structure, electricity supply if it's necessary, objects for storage and processing, suitable equipment	Developing infrastructural and technical plans for SRC local chains supply in Republic of Macedonia
Determination of long term subsidies policy for SRC production and local supply chains	Current situation with subsidies for SRC in Macedonia is very limited and it is regulated with symbolic sums that have to be changed as soon as possible.	To make a plan for intensive promotion of SRC, promotion of successful practices and promotion of benefits that SRC can offer for the communities, society, nature and to Republic of Macedonia

2.7.4 Bottlenecks for SRC plantations

- Currently public institutions do not plan analysis and research for SRC production in the nearest future
- It is not legally clear if SRC sector is under forestry or agriculture sector
- Suitable land for SRC planting (quality, property, and other parameters) is not defined
- Low level of knowledge, experience, and know-how for SRC production
- There are no experimental trails with SRC varieties in order to define which of them are suitable under existing conditions
- Local supply chains for SRC production and supply are not established
- The government does not provide sufficient support (grants or subsidies) for SRC production

2.7.5 References

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2.8 Summary

SRC production is very variable between the different countries, but also within the same country. In general, the production of SRC is limited and takes place at very small scale in most of the countries. Most of existing plantations are experimental. Poplars and willows are the dominating species for SRC plantations. The main obstacles for SRC plantations are insufficient data about suitability and availability of land for production, insufficient collaboration between stakeholders, lack of knowledge transfer, lack of connections between farmers and research institutions, insufficient reproduction material and technology transfer, lack of public awareness programs, poor land use planning and poor commitment to cultivate the land. In addition, most of the countries have unclear or no legal framework conditions for SRC production.

In Croatia there are no commercial SRC plantations so far. Existing plantations are experimental and are developed either by University of Zagreb, Faculty of Forestry or by Croatian Forests Ltd. The land on which the plantations are established is state owned land managed by Croatian Forest Ltd. The species that are mostly grown are different hybrids of poplar, willow and black locust. At the moment there are no local supply chains since there is no commercial SRC production. It was identified, that approximately 282,500 ha of land can be suitable for SRC production with technical potential for energy production of 60 PJ. The identified potential for SRC production in Croatia remains untapped since the development of SRC is related to experimental and research activities, such as research on the productivity of clones, agricultural practices and breeding.

Poplars and willows are the only species growing as short rotation plantations in the Czech Republic, as they are the most promising and fast-growing species in the country. In the Czech Republic the plantations are not and probably also will not be grown on the most fertile soils, however, there is a large percentage of land that is not suitable for agricultural production that is very acceptable for the production of woody biomass. Currently, there are 2,088 ha of SRC registered, which is 24 times larger area than 10 years ago. Crops are harvested in a very short rotation period, normally is between 3-6 years. Lifetime of plantations is assumed between 15-25 years which means that it is harvested from 4 to 8 times.

In France, SRC programs have been launched in several regions to test agricultural practices, choice of species, machinery and to see how SRC can take part in combined bioenergy and environmental projects. SRC experiments have been encouraged mostly by public institutions: regional agricultural chambers and other public research organisations. Other stakeholders, such as farmers and industries have also been partners in the experiments. In 2012, it was estimated that around 2,450 ha were planted with SRC in France. It seems that, SRC supply chains that are put forward are the ones that combine more than one economic advantage and/or environmental synergies. Eucalyptus and poplar are used for the paper industry and have been grown in France for more than 30 years. SRC used to produce wood chips for heating systems was introduced 10 to 15 years ago and is rapidly developing. Wood chips from SRC are in competition with wood chips from the forest industry. And since, for the time being, SRC is produced on a small scale, wood chips from SRC plantations are not competitive.

There are 4,000-6,000 ha of SRC plantations in Germany. Usually, SRC plantations are planted not before the usage of the wood chips is clear. Therefore, mainly all SRC wood chips are used in wood chip boilers (> 250 kW) or wood chip driven heating plants (< 600 kW). Due to the different sizes of the combustion unit, the wood chips need or don't need to be dried before burning. If the wood chips are used in a small combustion, then they have to be dried. At the moment SRC wood chips are not traded in Germany, because if the outlet market is still not clarified, the SRC plantation is not planted.

In Greece, currently there is no SRC cultivation for the production of woody biomass and bioenergy exploitation. Only small scale experimental plantations are established for research on production and yields of different species and cultivation techniques.

Trading of wood chips is not the common practice due to the lack of installation using wood chips as fuel. An important parameter affecting the increment of biomass use is the low number of medium and large scale applications of bioenergy production, such as district heating and cooling, electricity generation and cogeneration. Biomass is mainly used in small systems in residential heating applications, so far. For further penetration of new bioenergy production systems, it is important the support of the market, for the replacement of systems using fossil fuels, through direct subsidies or tax reductions. The creation of reliable biomass supply schemes is important for further development of the bioenergy sector.

In Latvia, most small sized SRC plantations are owned by farmers and private persons. There are also larger fields that were planted by companies investing in “growing of green energy” for wood chip production. Since 2008 almost 91 ha of SRC plantations were planted with aspen, poplar, and grey alder, and 144 ha with these species are reported as naturally grown. The Latvian State Forest Research Institute "Silava" has experimental and demo plantations of aspen, alder, willow, poplar, birch and other species potentially used as SRC. Despite the promising first results after growing hybrid poplar plantations, until now there are no providers of poplar planting material operating in Latvia. Only lately the first company for SRC plantation establishment, management and harvesting named "SalixEnergi Baltic" started operating.

SRC production does not exist yet in Macedonia. Approximately 76% of the households in Macedonia use biomass for heating. More than 100 private sawmill companies are processing 160,000 m³ technical wood during one year period, mostly for heating and for producing pellets and briquettes. There is outstanding part of unused waste biomass which can be used for heat and electricity production. 60 producers have planted approximately 200 ha private land only with one type of species - paulownia. This production is committed only for export abroad as raw material for processing in the industry. Very small percentage of it (which is low quality) is used for heating private houses.