Renewable Fuels
for Cross Border Transportation

ANNEX 1: Module sheets for primary energy sources

Overview:

Cultivation of Energy Plants (P)			
Oil Plants			
C1P1	Rape seed	**C1P2**	Olive tree
C1P3	Soy bean	**C1P4**	Sunflower
Other Plants			
C1P5	Sugar beet	**C1P6**	Cereals
C1P7	Triticale	**C1P8**	Hemp
C1P9	Fast growing trees	**C1P10**	Miscanthus
C1P11	Maize	**C1P12**	Potato

Renewable or Nuclear Electric Energy (E)	
Renewable electric energy	
C1E1	Hydropower
C1E2	Wind power
C1E3	Photovoltaic solar energy
C1E4	Solar thermal energy
Nuclear electric energy	
C1E5	Nuclear energy

Collection of Organic Residues (R)			
Straw and Similar Residues			
C1R1	Straw from cereals cultivation		
Wood			
C1R2	Logging residues		
Collection of Organic Waste			
C1R3	Used cooking oil	**C1R4**	Animal excrements
C1R5	Organic waste from households	**C1R6**	Vegetable residues from agriculture
C1R7	Organic commercial waste	**C1R8**	Wood residues from trade and industry

Fossil Fuels (F)	
C1F1	Crude oil
C1F2	Natural gas

ANNEX 1: Module sheets for primary energy sources

No.:	C1-P1	Rape Cultivation (Rape Seed)

class	1	input from:	-
category	Oil Plants	output to:	Module C2-O1

General description of the process

Rape is an annual C3 plant which originated from the Mediterranean region. It is a member of the *Cruciferae* family, and has both winter and spring forms. The plant germinates quickly, forming a deep growing tap root and a rosette of blue-green leaves from which emerge 7-10 lateral shoots. On the ends of the branched stems grow the gold-yellow flowered racemes. Each plant has approximately 120 long slender seed pods, each plant possesses 2000-3000 seeds. The winter rape vegetation period is about 330 days (August-July), spring rape vegetation period is about 180 days (April-September). Rape seed possesses many possibilities of the application, e. g. hydraulic oil, chain saw oils, fuel.

Ecological requirements

Rape is an ecologically demanding plant. A deep sandy loam rich in humus and nutrients and with an optimal lime content is the most appropriate soil for rape cultivation, followed by humic loam, loam and clayey loam in decreasing order of suitability. Humic and loamy soils can be appropriate when a sufficient water supply is guaranteed in April, though in general the success of the crop is greatly influenced by a sufficient water supply during the vegetation period. Because of spring rape's weaker root development it is more sensitive to water deficit than winter rape. After sowing winter rape, the plant should have about 100 days with temperatures over 2°C to reach the 8-10 leaf stage and develop the tap roots necessary for wintering. The winter can be moderately cold with a light snow cover. There should be very little spring frost, and the spring should be moderately warm. In late winter/early spring when the temperature remains constantly above 5°C the plant will begin leaf growth.

Crop management

Winter rape is sown in the middle of August to the beginning of September. The desired crop density is between 60 to 80 plants/m^2 which is achieved by using 3-4 kg of seed per hectare. The seed should be planted at a depth of 1.5-3.0 cm. Spring rape is sown from the end of March to the beginning of May. The double amount of seed (compared with winter rape) may be necessary to obtain the same desired crop density. Problem weeds are: chickweed, field foxtail grass, couch grass, camomile, blind nettle, pansy, annual wild oats and reappearing wheat, among others. Fungicides may also be used. Insecticides can be used to combat the variety of pest which infest rape crops. These pests include fleas, lice, snails, pollen beetles and weevils. Organic fertilisation using liquid manure is possible and recommended. Fertiliser levels as recommended in Germany,

for winter rape are: Nitrogen 0-50 kg/ha (in autumn), Nitrogen up to 100 kg/ha (vegetation start), Nitrogen 80-100 kg/ha (4 weeks later), Phosphorus 100 kg/ha, Potassium 220 kg/ha, Magnesium 25-30 kg/ha

for spring rape are: Nitrogen 80-100 kg/ha (with sowing), Nitrogen 60-80 kg/ha (at 6-8 leaf stage), Phosphorus 80 kg/ha, Potassium 120 kg/ha, Magnesium 40 kg/ha

Crop rotation

Crops coming before rape should be early harvested crops such as winter barley or peas. Because of the danger of nematodes infesting the crop, rape should not include e.g. sugar beets in its crop rotation. A break in rape cultivation of 4-5 years should be adhered to. The lowest yields were obtained when rape was grown in monoculture. It was found that in general the yields of oilseed rape increased with the length of the rotation and the length of the break between two rape crops.

Regional specifications in the EU
Summer rape is planted, usually in northern latitudes, where the winters are too severe for winter rape to survive the hibernation period.
Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.
Internal and external resources
(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover.pdf) (2) FEDERAL AGRICULTURAL RESEARCH CENTRE (FAL), Braunschweig, Germany (3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000 (4) Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001 (5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001 (6) REINHARDT, G..; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997 (7) EUROPEAN UNION (ED.): Ölsaatenanbau in der EU, (writer: Verhoog, A. D.), 2002 (www.eu-datashop.de/download/DE/sta_kurz/thema5/nn_02_06.pdf)

Description of the calculation to obtain the quantitative figures
Economy figure: The prices for rape seed were found in (7). **Ecology figure:** In (3), the yearly fossile CO_2-output per hectare induced by the rape production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was found out per ton of rape seed yield. **Efficiency figure:** In (3), the yearly fossile energy input per hectare induced by the rape production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the rape seed was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of rape seed.
Description of the calculation to obtain the availability data
In the EU the arable agriculture land according to (4) is used for food production in general. This led to the assumption, that an area of the extent of the land set-aside can be used for energy plants in each country. The average of the land set-aside in Europe is currently 10 % of the total arable land. So 10 % of the total arable land is assumed to be available for cultivating energy plants. To find out which plant can achieve the best technical potential it is assumed that the whole available area is cultivated with only one type of plant (in the case of this module it is rape seed). Depending on the geo-ecological conditions of each country the yields per hectare vary in a wide range. In this manner a specific yield per hectare (4) and plant is set for each country. For plants which cannot be cultivated at all or only in parts in a country (from module description "general description of the process – ecological requirements"), the extent of the available land is reduced. The specific yield per hectare and plant for each country is multiplied with the number of hectares, which represent the assumed 10% of the agricultural land (or the reduced land) of a country. The result is a total plant mass for each energy plant type and for each country in the EU. The entire energy plant mass of a plant type is multiplied with the specific net calorific value of the plant type (5). Thus a value for the technical potential in PJ results for each energy plant type and country. Data for the candidate countries have been estimated from agricultural conditions in EU countries with similar climatic conditions. Today, the real yield per hectare in these countries is often lower, but considering the potential means also to consider potential agricultural techniques like in the EU including irrigation and effective land use.
Description of the finding of some qualitative evaluations
Need of space: Less than 5 TJ energy content per km² in EU 15 average is bad compared to other crops. Readiness for market is very good, rape cultivation is broadly used. The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	169
Ecology:	
emission of CO_2 (kg) per output unit	252
Efficiency:	
GJ output energy per GJ of all input energies	4.0

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	0.5	0.2	1.5	-	19.5	25.6	-	-	-	-	-	-	-	0.2	2.0	49.5
technical potential	8	5	18	8	125	91	17	6	24	0	7	9	56	18	40	432
Country / primary energy origin	**CY**	**CZ**	**EE**	**HU**	**PL**	**SI**	**BG**	**LT**	**LV**	**MT**	**RO**	**SK**	**TR**	**CH**	**N**	**EU 30**
technical potential	1	18	7	27	113	1	13	18	11	0	54	9	164	2	3	873

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space		x			
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P2	**Olive Tree Cultivation**

class	1	input from:	-
category	Oil Plants	output to:	Module C2-O4

General description of the process

Olive tree is a member of the *Oleacee* family. The olive tree is an evergreen that can take on different shapes and sizes. Its lanceolate leaves are from 5 to 8 cm (2 to 3 in)long on average; they are green on the upper side and silver-gray on the lower, and last about 3 years. The trunk is gray-green and smooth till about the tenth year, then it becomes knotty, twisted, rough with deep furrows, and it takes on a dark colour, almost black. At the bottom a wide stump can grow sprouts even after the trunk has been cut, thus assuring the survival of the tree. The roots are fasciculate and with many surface ramifications which absorb most of the nourishment. They spread horizontally up to 2-3 times the height of the tree, and in the most fertile soils they run up to 1.5-2 meters deep.

Ecological requirements

The olive tree is very robust: in winter it can endure temperatures below – 6° C, and in summer long periods of drought. It is cultivated in areas with an average rainfall of 350-400 mm per year, and summer temperatures of 40 degrees centigrade. The cultivation area of the olive tree is between the 30° and 45° latitude. In order to obtain a good yield it is necessary to carry out a cultivation program.

Crop management

The olive tree life cycle is as follows. From 0 to 7 years of age the tree is unproductive. From 7 to 30 years of age the tree grows with a constant increase in productivity. From 35 to 150 years the tree reaches maturity and full production. At 150 years the olive tree starts aging with a remarkable productivity for centuries and sometimes for thousands of years. The olive trees production is cyclical with more production in one year and significantly less in the following year. This cycle is repeated throughout the life of the tree. In spring the soil around the tree must be fertilised and tilled for improved storage of water near the roots. The trees must also be pruned at this time. The spring fertilisation provides mineral and other necessary substances for blossoming, adjusts the ratio of those contained in the soil, or supplements them if they are scarce. It has been estimated that 100 kg of olives remove from the soil an average of 818 g of nitrogen, 182 g of phosphoric dioxide and 90 g of potassium. Organic fertilisers are often used. Trees are watered every 2-3 weeks during the summer months when the fruit is in its early stages of growth. In the summer period olives can be damaged due to exposure to harsh weather, disease and parasites. Olive Fly is the most feared enemy. In certain years this insect can destroy the entire crop. The larvae cause premature fruit drop and yield reduction. The use of antiparasitics, poisoned bait and certain parasites of the Olive Fly that attack its larvae during the summer. During autumn the olives grow ripe and they lose their green colour due increase in oil content and decrease in water content. In this period the olive tree requires a constant supply of minerals and other substances otherwise the tree's productivity can decrease in the following year. The soil surrounding the plant is treated at the maximum depth of 20 cm in order to avoid damaging surface root. This treatment allows the mixing of fertiliser with the soil and prepares the soil to receive rainwater and to maintain humidity as long as possible. During winter the olives must be harvested when they are ¾ violet and before they become fully ripe, accumulated oil in the fruit then starts to decrease.

Crop rotation

Because olive tree is a perennial crop, a crop rotation may not be necessary for more than 150 years.

Regional specifications in the EU
Olive trees do best in Mediterranean climate (Spain, Italy, Greece, South France) with hot, dry summer and a cool, wet winter.
Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
Implementation outside the Mediterranean area cannot be seriously considered. If cultivation areas have to be enlarged, the growing period of 30 years has to be taken into account. The availability of more olives cannot be increased in a short- or middle-term period for this reason.
Internal and external resources
(1) SUPERQUINN (http://www.superquinn.ie/nutrition/food_facts_olives.html) (2) REZEPTE UND COCKTAILS (www.rezepte-cocktails.de/ernaehrung_olivenoel.htm) (3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000 (4) ELIKI OLIVE OIL, Los Angeles (http://www.elikioliveoil.com) (5) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001 (6) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

Description of the calculation to obtain the quantitative figures
Economy figure: The prices for olives were found in (2). **Ecology figure:** The value was estimated by comparative values from (3) and related to estimated yields per hectare. **Efficiency figure:** The energy content of olives was found in (1), the energy input was calculated in the same way as the ecology figure.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed). Olive trees can only be cultivated in countries with an mediterranean climate, so the potential is zero for the other countries. In France, the useable land set-aside is reduced to 4 %.
Description of the finding of some qualitative evaluations
Need of space: Less than 1 TJ energy content per km² in EU 15 average is very bad compared to other crops. Readiness for market is very good, olive tree cultivation has a very long tradition. The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	280
Ecology:	
emission of CO_2 (kg) per output unit	61
Efficiency:	
GJ output energy per GJ of all input energies	3.4

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	-	-	-	-	1.9	-	0.7	-	2.4	-	-	0.5	3.2	-	-	9
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	-	-	-	-	-	-	1.3	-	-	-	-	-	6.6	-	-	17

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space	x				
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P3	Soy Bean Cultivation

class	1	input from:	-
category	Oil Plants	output to:	Module C2-O2

General description of the process

Soybean is an annual bush-like C3 plant originating from China. It grows to a height of up to 80 cm with all plant-parts being hairy. The plant produces a main root with smaller roots branching from it. The smaller roots possess numerous nodules inside of which develop the bacteria *Bradyrhizobium japonicum.* The bacteria is responsible for free nitrogen fixing. Above the cotyledonary nodes develop two single leaflets opposite each other. The plant's other leaves consist usually of three leaflets. Soybean is for the most part self-fertilisation. Numerous very small purple or white flowers are found in compact racemes in the leaf axils. These racemose inflorescences growing from the leaf axils are responsible for the production of the plant's fruit which develops in the form of pods. Although l-5 seeds per pod can be found, the usual number is 2 or 3. The seeds are round to oval with a whitish-yellow to brown/black-brown colour. Their composition ranges from approximately 38-43% protein, 18-25% oil and 24% carbohydrates. The crop has about a 4-5 month growing period. Soybeans currently have a very wide range of food and non food uses, e. g. soy milk, soy meal, emulsifier for pharmaceuticals and pesticides.

Ecological requirements

Soybean plants are adaptable to a wide range of environments, but this adaptability is possible because of the many different cultivars, each having its own characteristics and preferred conditions. Soybean has similar ecological requirements as maize. The plant desires high temperatures in the summer and autumn to facilitate ripening. Loamy soil or loess and black soil with a good ability to hold water are recommended. When enough water is present a light sandy soil can also be used. A constantly humid subtropic climate is most favourable for soybean crops. Although the temperatures 24-25°C are preferred for optimal growth, the range of 20-25°C is still excellent for all stages of plant growth. Frost tolerance is better than that of maize. The rainfall required for a good yield in warmer areas is 500-750 mm though less precipitation during ripening is preferred. The pH range of 6-6.5 has been shown to be the most desirable for soybean crops, with instances of certain cultivars performing better at slightly more acidic or basic levels. Rhizobium symbiosis is an important factor when it comes to crop growth and yield.

Crop management

Sowing should take place in the middle of April/beginning of May. The ground temperature at a depth of 5 cm should be at least 10°C. A sowing depth of 3-4 cm and a distance between rows of 25-30 cm is recommended. The desired crop density is 40-60 plants/m^2. This corresponds to a seed sowing amount of about 70-90 kg/ha. Because the N_2 binding potential of soybean's nodules is negatively affected by high soil temperatures, regions in southern Europe and the Mediterranean should use denser crop spacings, thus shielding the soil in hotter climates. Because of the nitrogen fixing bacteria most soils do not need supplementary nitrogen fertilisation, especially in the case of the previous crop having been abundantly fertilised. During the first few weeks after sowing weed control is essential. Drought or excessive dryness strongly affects crop yield in a negative fashion especially before flower formation and during granulation. Disease damage to soybean crops can be greatly reduced by proper cultivar and seed selection, maintaining sanitary practices and appropriate crop rotation. The most destructive diseases affecting soybean crops are, among others, frogeye leaf spot, stem canker and soybean mosaic virus. Some of the more damaging pests are the soya bean moth, the Japanese beetle and the soybean cyst nematode. If these pests are present, insecticides may be necessary. 15 kg phosphorus and 50 kg potassium are used from the soil for every ton of seeds produced.

Crop rotation

Soybean can be used with a large variety of crop rotation plans. Usually soybean comes between two grain or cereal crops. Possible rotation combinations are: maize-soybean-wheat, soybean-wheat-sorghum, millet-winter wheat-soybean, or maize-soybean-cotton.

Regional specifications in the EU

Because the N_2 binding potential of soybean's nodules is negatively affected by high soil temperatures, regions in southern Europe and the Mediterranean should use denser crop spacings, thus shielding the soil in hotter climates.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources

(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover.pdf)

(2) FEDERAL AGRICULTURAL RESEARCH CENTRE (FAL), Braunschweig, Germany

(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001

(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(6) REINHARDT, G..; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997

(7) EUROPEAN COMMUNITY (ED.): Ölsaatenanbau in der EU, (writer: Verhoog, A. D.), 2002 (www.eu-datashop.de/download/DE/sta_kurz/thema5/nn_02_06.pdf)

Description of the calculation to obtain the quantitative figures

Economy figure: The prices for soy beans were found in (7).

Ecology figure:

Data for the CO_2-output of the soy bean production were not found. For getting an approximative value, the yearly fossile CO_2-output per hectare induced by the production of rape seed was taken from (3). The typical yield per ha has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was estimated per ton of soy bean yield was estimated.

Efficiency figure:

Data for the energy input of the soy bean production were not found. For getting an approximative value, the yearly energy input per hectare induced by the production of rape seed was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the soy bean was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity soy bean.

Description of the calculation to obtain the availability data

See Module C1-P1: Rape cultivation (rape seed).

Description of the finding of some qualitative evaluations

need of space: less than 5 TJ energy content per km² in EU 15 average is bad compared to other crops

readiness for market is very good, soy bean cultivation is broadly used.

The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	172
Ecology:	
emission of CO_2 (kg) per output unit	288
Efficiency:	
GJ output energy per GJ of all input energies	3.3

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	4.7	2.1	7.2	0.8	81.7	41.3	7.4	0.3	66.7	0.2	2.4	7.9	49.4	0.0	0.0	272

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.3	10.5	0.0	15.6	51.2	0.8	34.8	7.2	0.0	0.0	31.3	5.0	73.6	1.3	0.3	504

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space		x			
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P4	Sunflower Cultivation

class	1	input from:	-
category	Oil Plants	output to:	Module C2-O3

General description of the process

Sunflower is annual C3 plant which originated from America. Sunflower belongs to the genus *Helianthus* of the *Compositae* family. The inflorescence of the plants of this family are heads in which the fertile flowers are aggregated and bordered by rays, the corollas of sterile flowers. The genus *Helianthus* includes 67 annual and perennial species. The cultivated sunflower is an annual plant with the scientific name *of Helianthus annus*. It is an erect, unbranched, coarse annual, with a distinctive large, golden head, the seeds are often used for the production of sun oil. The plant having a well developed root system is considered as one of the most drought resistant crops suitable for the southern semi-arid countries. The vegetation period is about 150 days (April-August).

Ecological requirements

Sunflower is a well adapted crop under various climatic and soil conditions. Under moisture stress conditions the number and the size of the leaves are reduced. A satisfactory crop can be produced, without irrigation, even in winter rainfall regions of approximately 300 mm. Growth is satisfactory when temperatures do not fall below 10° C, but it can resist far lower temperatures. The young plants can withstand considerable freezing until they reach the 4 to 6 leaf stage, and the ripening seeds suffer little damage from slight frost. It requires ample sunlight and is considered insensitive to day length. Sunflower grows on a variety of soils ranging from sand to clay. In low fertility soils its performance is better in comparison with other crops such as maize, potato and wheat. The best pH range is between 6.5 to 8. It is considered slightly susceptible to salts.

Crop management

The seed should be placed in moist soil and rapid drying out of the seedbed should be avoided. Sunflower seeds are capable of germinating even at 5° C, but in practice more than 10° C are required for satisfactory germination and even higher for satisfactory emergence. Generally, it is possible to sow sunflower fairly early in spring. The desired crop density is between 35 to 60 plants per m^2 which is achieved by using 5-15 kg seeds per hectare. Usually early plantings lead to higher seed yields and higher oil content of seeds. Distances of 75 cm between rows are very common. In the early growth stages sunflower is sensitive to weed competition. A pre-emergence harrowing or pre-emergence herbicides are used for the control of the weeds. One of the most common fungal diseases of sunflower is rust, caused by *Puccinia helianthi*. Several other fungal diseases, of minor importance, attack sunflower. Among them are charcoal rot, downy mildew, powdery mildew and leaf spot wilt. Several insects attack sunflower, sunflower beetle, aphid grasshoppers. In non-irrigated fields sunflower response to fertilisers is very limited, as is the case with many other non-irrigated spring grown crops. In irrigated fields of low fertility nitrogen fertilisation response is positive. Nitrogen fertilisation rates from 50 to 80 kg/ha are recommended. Nitrogen application must be related to the availability of phosphate and potash. If these are deficient, nitrogen usually depresses yield and seed-oil content.

Crop rotation

Sunflowers can add diversity to a rotation and can be successfully used in annual cropping systems that utilize no-till. Crop rotation is important for preventing diseases such as white mold, Verticillium wilt, Phoma and premature ripening.

Regional specifications in the EU

Sunflower cultivation is limited to southern and central Europe, yields are different in each country.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources
(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover.pdf)
(2) FEDERAL AGRICULTURAL RESEARCH CENTRE (FAL), Braunschweig, Germany
(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000
(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001
(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001
(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997
(7) EUROPEAN UNION (ED.): Ölsaatenanbau in der EU, (writer: Verhoog, A. D.), 2002 (www.eu-datashop.de/download/DE/sta_kurz/thema5/nn_02_06.pdf)
(8) MONSANTO COMPANY, FARMSOURCE U.S. (http://www.farmsource.com/ConTill/contill_pl_summer.asp)

Description of the calculation to obtain the quantitative figures
Economy figure:
The prices for sunflower seed was found in (7).
Ecology figure:
Data for the CO_2-output of sunflower seed production were not found. For getting an approximative value, the yearly fossile CO_2-output per hectare induced by the production of rape seed was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was estimated per ton of sunflower seed yield.
Efficiency figure:
Data for the energy input of the sunflower production were not found. For getting an approximative value, the yearly energy input per hectare induced by the production of rape seed was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the sunflower seed was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of sunflower seed.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed).
Description of the finding of some qualitative evaluations
need of space: less than 5 TJ energy content per km² in EU 15 average is bad compared to other crops
readiness for market is very good, sunflower cultivation is broadly used.
The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	199
Ecology:	
emission of CO_2 (kg) per output unit	349
Efficiency:	
GJ output energy per GJ of all input energies	2.8

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	-	-	-	-	3.2	0.3	-	-	0.7	-	-	-	-	-	-	4.2
technical potential	9	5	16	2	117	72	8	5	48	0	5	3	38	3	8	339
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0	20	1	29	90	2	25	16	2	0	59	9	75	2	1	671

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space		x			
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P5	**Sugar Beet Cultivation**

class	1	input from:	-
category	Other Plants	output to:	Module C2-F1

General description of the process

Sugar beet is an C3 plant and a member of the *Chenopodiaceae* family. In the sowing year it forms a rosette from upward-arranged, large, fleshy leaves as well as for wedge-shaped carrot body. The yield organ, the carrot body, consists of the thickened primary root as well as a part of the leaf-rising up head. It grows only little from the soil. The sugar beet vegetation period is about 210 days (March-September). The main application of the sugar beet is the production of sugar.

Ecological requirements

Sugar beets rank among the cultures with the highest requirements to the soil quality. The ideal climate for sugar beet production is uninterrupted summer sunshine, temperatures between 22-28 °C, coupled with adequate reserves of available moisture. The presence of compacted layers in the soil profile creates conditions for poor rooting and inadequate plant growth. Compaction makes it difficult for plants to obtain sufficient water and nutrients, especially during dry periods. Sugar beet will grow under alkaline conditions, but prefers a neutral soil, taking up other crop nutrients most efficiently from most soils with a pH range of 6.5-7.0.

Crop management

The sugar beet crop requires a fine moist tilth at drill depth, permitting good seed to soil contact. The soil should be free of compaction to encourage deep rooting and maximum moisture extraction, as well as allowing free drainage. A progressive approach to soil preparation should lead by sowing time to, a level surface for efficient drilling operations, a compaction free moisture retentive seedbed to aid germination and crop establishment, with good seed to soil contact. The soil should be uncompacted to full rooting depth, to allow deep rooting and free drainage. Beet seedlings are slow to emerge and establish in cold or dry soil conditions. Slow emerging seedlings are most at risk from pest and disease attack. The aim should always be to encourage rapid and uniform emergence and is best achieved when soil temperatures are moving upward from a base of 5°C, with adequate seedbed moisture. The creation of a level, moist tilth without compaction can be arrived at by just cultivating the friable surface soil - the friable surface being created by the repeated wetting and drying, freezing and thawing of the soil surface. The treatment of seed with a fungicide and insecticide is essential, particularly when crops are drilled to a stand. European pelleted seeds usually incorporate a fungicide (thiram or hymexacol), plus an insecticide such as imidacloprid (Gaucho). Pelleting allows fungicides and insecticides to surround the seed in a more measured dose, offering much more effective control. The most destructive diseases affecting sugar beet crops are, among others, black leg, downy mildew, rhizomania. Some of the more damaging pests are seedling pest and wireworm. If these pests are present, insecticides may be necessary.

For high yields the use of fertilisers is recommended:

Nitrogen 120-160 kg/ha, Phosphorus 35–70 kg/ha, Potassium 170 kg/ha, Magnesium 35–50 kg/ha,

Crop rotation

The rotation is the basis of effective beet crop production. Pest, disease and weed control are all influenced by the rotation. To avoid the build-up of beet cyst nematodes cruciferous host crops, i.e. oil seed rape, cabbage, turnips etc. should also be avoided in the rotation, or at least have a three year break between these crops and beet. On no account should sugar beet be grown closer than every third year (2 year break).

Regional specifications in the EU
Sugar beet is not very frost resistant, so the use in countries with long winters is problematic.
Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.
Internal and external resources
(1) TACIS TECHNICAL DISSEMINATION PROJECT (TDP) (www.tacisinfo.ru/brochure/sugar_e/index_m.html) (2) RAPOOL RING GMBH (http://www.stichnoth.net/rapool/rapool.cfm?aktland=5) (3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000 (4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001 (5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001 (6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997

Description of the calculation to obtain the quantitative figures
Economy figure: The sugar beet price was found in (1). **Ecology figure:** In (3), the yearly fossile CO_2-output per hectare induced by the sugar beet production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was found out per ton of sugar beet yield. **Efficiency figure:** In (3), the yearly fossile energy input per hectare induced by the sugar beet production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the winter wheat was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of sugar beet.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed).
Description of the finding of some qualitative evaluations
need of space: more than 18 TJ energy content per km² in EU 15 average is the best value compared to other crops readiness for market is very good, sugar beet cultivation is broadly used. The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	46
Ecology:	
emission of CO_2 (kg) per output unit	15.6
Efficiency:	
GJ output energy per GJ of all input energies	13.6

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	29	17	49	27	465	242	49	17	143	1.1	17	46	321	46	111	1581

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	2	66	17	98	300	5	75	49	28	0.2	197	32	487	8	10	2957

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space					x
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P6	**Cereals Cultivation (e.g. Winter Wheat)**

class	1	input from:	-
category	Other Plants	output to:	Module C2-F3

General description of the process

The winter wheat is a member of the *Gramineae* family. It has a prostrate, semierect, or erect physical statue and possesses a fibrous root system. In environmental demand till 50 sprouts can be generate from the main sprout, usually 5 are generated. On the ends of the branched sprouts grow the spike. The vegetation period is about 330 days (October- August). The grains are a basic input for the food industry, also there is the possibility to regenerate fuel from the grains.

Ecological requirements

Winter wheat is the most ecological demanding plant under the cereals. It prefers deep, nutrient rich, soils, with a good water supply. Winter wheat can survive temperatures about –20 ° C. In the 3-5 leaf stage the winter wheat is very frost sensitive.

Crop management

Winter wheat is normally sown in September-November and grows just a little before going dormant in winter. The seed should be planted at a depth 2.5-3.5 cm, the distance between the rows should be 12-20 cm. The desired crop density is between 350-420 plants/m². After the floral initiation in January, the plants develop a number of tillers and are finally harvested in August. The weed combat are possible on mechanical or chemical way. Several diseases and pests have been known, e.g. Fusarium, Mildew, Fly etc. Against these diseases and pests, the application of fungicides and insecticides can be necessary.

The first fertilisation of 50-70 kg/ha Nitrogen is recommended during the spring, later another fertilisation of 30-50 kg/ha is recommended. Other fertilisers are Magnesium 12 kg/ha, Potassium 80 kg/ha and Phosphorus 28 kg/ha.

Crop rotation

Winter wheat should be planted in crop rotation, but not after cereal crops. Seeding it into stubble from broad-leaved crops, such as canola, mustard and peas, will reduce the risk of insect, disease and weed problems for all crops in the rotation.

Regional specifications in the EU

Differences result from ecological requirements and different yields.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources

(1) ALBERTA MINISTRY OF AGRICULTURE, FOOD AND RURAL DEVELOPMENT, Canada (http://www.agric.gov.ab.ca/agdex/100/12000221.html)

(2) RAPOOL RING GMBH (http://www.stichnoth.net/rapool/rapool.cfm?aktland=5)

(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001

(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig, Wiesbaden, 1997

(7) INFORMATION CENTRE FOR LOW EXTERNAL INPUT AND SUSTAINABLE AGRICULTURE (ILEIA) (http://www.ileia.org/2/16-4/13.PDF)

Description of the calculation to obtain the quantitative figures

Economy figure:

The wheat price was found in (1).

Ecology figure:

In (3), the yearly fossile CO_2-output per hectare induced by the winter wheat production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was found out per ton of wheat yield.

Efficiency figure:

In (3), the yearly fossile energy input per hectare induced by the wheat production is indicated. The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. The energy content of the wheat was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of winter wheat.

Description of the calculation to obtain the availability data

See Module C1-P1: Rape cultivation (rape seed).

Description of the finding of some qualitative evaluations

need of space: An energy content between 5 and 9 TJ per km² in EU 15 average is an medium value compared to other crops

readiness for market is very good, cultivation of winter wheat and other cereals are the most spread agricultural land use form in Europe.

The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	120
Ecology:	
emission of CO_2 (kg) per output unit	163
Efficiency:	
GJ output energy per GJ of all input energies	5.3

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	10.7	8.2	22.3	12.1	184	105	11.2	8.4	63.5	0.5	9.0	8.6	75.0	18.9	61.0	598

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.5	24.2	7.1	35.9	130	1.9	33.1	22.3	11.5	0.05	72.0	11.5	111	3.0	4.6	1067

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P7	**Triticale Cultivation**

class	1	input from:	-
category	Other Plants	output to:	Module C2-F3

General description of the process

Triticale is the secondary amphiploids of durum wheat and rye. Durum wheat, the donor of the A and B genomes, is known for its high yield potential and adaptation to relatively dry environments. On the other hand, rye, the R genome donor, has lower yield potential but is well adapted to extreme cold, drought, and acidic soils. Triticale cultivation around the world during the last 25 years indicates that it possesses the yield potential of wheat and the hardiness of rye. The yield potential of triticale under optimum crop production environments has reached the level of wheat while outperforming wheat in marginal environments. The plants vegetation period is about 330 days (September-July). The grain is mainly used for forage and feed, but also for unleavened bakery products.

Ecological requirements

It can grow in almost all geographic ranges, but with increasing soil quality the yields rise. Due to the high climatical adaptability of the plant, triticale can also build up in rougher exposures a sufficient stand density.

Crop management

Triticale is normally sown in September-Oktober and grows just a little before going dormant in winter. The seed should be planted at a depth 2-4 cm, the distance between the rows should be 12-20 cm. The desired crop density is between 250-380 plants/m². After the floral initiation in January, the plants develop a number of tillers and are finally harvested in July-August. The weed combat are possible on mechanical or chemical way. Several diseases and pests have been known, e.g. Fusarium, Mildew, Fly etc. Against these diseases and pests, the application of fungicides and insecticides can be necessary.

The fertilisation of 40-60 kg/ha Nitrogen is recommended during the spring, later another fertilisation of 20-30 kg/ha is recommended. Other fertilisers are Magnesium 9 kg/ha, Potassium 85 kg/ha and Phosphorus 30 kg/ha.

Crop rotation

Triticale should be planted in crop rotation, but not after cereal crops. Seeding it into stubble from broad-leaved crops, such as canola, mustard and peas, will reduce the risk of insect, disease and weed problems for all crops in the rotation.

Regional specifications in the EU

Differences result from ecological requirements and different yields.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources

(1) OREGON STATE UNIVERSITY EXTENSION SERVICE (ED.): Barley, Oats, Triricale, Wheat, (writer: Sattell, R. et al), 1998 (eesc.orst.edu/AgComWebFile/EdMat/EM8692.pdf)

(2) RAPOOL RING GMBH (http://www.stichnoth.net/rapool/rapool.cfm?aktland=5)

(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001

(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997 - KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(7) THE WORLD BANK GROUP: Triticale: A reappraisal (Consultative Group on International Agricultural Research, writer: Varughese, G.; Pfeiffer,W. H.; Peña, R.J.) (www.worldbank.org/html/cgiar/newsletter/april97/8tritic.html)

Description of the calculation to obtain the quantitative figures

Economy figure:

Triticale prices were found in (2).

Ecology figure:

In (3), the yearly fossile CO_2-output per hectare induced by the triticale production is indicated. The typical yield per hectare was estimated according to (5) for all EU member countries and was taken in the European average. So the fossile CO_2-output was found out per ton of triticale yield.

Efficiency figure:

In (3), the yearly fossile energy input per hectare induced by the wheat production is indicated. The typical yield per hectare was estimated according to (5) for all EU member countries and was taken in the European average. The energy content of the triticale was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of triticale.

Description of the calculation to obtain the availability data

See Module C1-P1: Rape cultivation (rape seed).

Description of the finding of some qualitative evaluations

need of space: An energy content between 5 and 9 TJ per km² in EU 15 average is an medium value compared to other crops

readiness for market is good, cultivation of triticale is already used in Europe.

The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	100
Ecology:	
emission of CO_2 (kg) per output unit	170
Efficiency:	
GJ output energy per GJ of all input energies	5.0

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	11.2	5.8	20.3	12.0	189	113	12.2	8.8	70.2	0.5	9.3	10.0	83.9	20.1	63.4	630

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.5	25.3	7.6	37.6	140	1.9	36.6	20.3	12.2	0.0	75.4	12.1	121	3.2	4.5	1128

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market				x	
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P8	**Hemp Cultivation (Whole Crop)**

class	1	input from:	-
category	Other Plants	output to:	Module C2-F7

General description of the process

Hemp has its origins in Central Asia. It is an annual, short-day, C3 plant which is wind pollinated. It has a high cellulose and lignin content in its stems and a high fat and protein content in its seeds. The average height is about 2.5 m. The leaves are finger-like with serrated edges. The root system is dominated by a tap root. The plants vegetative period is about 100 days, with the main growth period in June and July, followed by flowering in August. Due to the presence of THC the cultivation of hemp is difficult. For THC to be used as a drug it needs to be present in an amount of over 2 %. Because of this the EU regulation makes it possible to cultivate hemp varieties with THC contents of 0.3 % or less. Hemp possesses many possibilities of the application: e.g. textile industry, fuel, machine oil and cosmetics.

Ecological requirements

Hemp exhibits optimal growth in a moderate climate, 13-22°C. Hemp is sensitive to frost during germination. Though the crop thrives on most soils, it prefers deep, humus rich, calcareous soils with a good water and nitrogen supply. Not as suitable are sand, heavy clay and excessively wet soils, as well as compacted soils. A pH value of 7 is recommended, though slightly basic soils are also appropriate. The soil should be well prepared to a fine tilth. The soil should be well supplied with water, but not excessively wet. A precipitation level of 700 mm is necessary for a substantial yield.

Crop management

Sowing should be performed between the middle of April and the end of May.

Approximately 35-50 kg/ha of seed should be planted at a depth of 2-4 cm. A normal crop density is about 200-350 plants/m². A higher crop density, about 300 plants/m², is used if the crop is grown for the production of long fibres. The higher density leads to a reduced production of undesired leaves. The seed has a germination period of 4 to 6 days. Herbicides may not even be necessary. Farms in England report that after drilling the seed there is no need for spraying or top-dressing. The next time the crop is regarded will be for checking its progress. Several diseases and pests have been known to attack hemp crops. The detrimental presence of *botrytis, fusarium* and *sclerotinia* has been observed, along with damage to germinating plants by snails and wire worms. The plant fibres may suffer damage from *Spherella cannabis* and *Phoma herbarum.*

Fertiliser levels as recommended by the Federal Agricultural Research Centre in Germany are:

Nitrogen 60- 100 kg/ha, (divided in two or three applications)

Phosphorus 70- 100 kg/ha

Potassium 150-180 kg/ha

Crop rotation

Because of its deep and extensive root system, hemp makes a good preceding crop in a crop rotation. In England a crop rotation of wheat and hemp has proved to be appropriate. Hemp can also follow itself in a crop rotation.

Regional specifications in the EU
Differences result from ecological requirements and different yields.
Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.
Internal and external resources
(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover) (2) Federal Agricultural Research Centre (FAL), Braunschweig, Germany (3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000 (4) Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001 (5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001 (6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997 (7) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL), Germany (http://www.verbraucherministerium.de/landwirtschaft/ab-2001/ab01/textband/tb-c1.htm)

Description of the calculation to obtain the quantitative figures
Economy figure: Prices for hemp were found in (7). **Ecology figure:** Data for the CO_2-output of hemp production were not found. For getting an approximative value, an average value between the yearly fossile CO_2-output per hectare induced by the production of rape seed and from winter wheat was taken from (3). The typical yield per hectare was estimated according to (5) for all EU member countries and was taken in the European average. So the fossile CO_2-output was found out per ton of triticale yield. **Efficiency figure:** Data for the energy input of the hemp production were not found. For getting an approximative value, an average value between the yearly fossile energy input per hectare induced by the production of rape seed and from winter wheat was taken from (3). The typical yield per hectare was estimated according to (5) for all EU member countries and was taken in the European average. The energy content of the sunflower seed was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of hemp.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed).
Description of the finding of some qualitative evaluations
need of space: An energy content of more than 9 TJ per km² in EU 15 average is a good value compared to other crops readiness for market is medium because cultivation of hemp is already known in Europe, but the delimitation towards drug cultivation induces some difficulties. The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	75
Ecology:	
emission of CO_2 (kg) per output unit	69
Efficiency:	
GJ output energy per GJ of all input energies	12.6

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	24.1	12.4	43.6	24.5	309	198	42.6	15.4	130	1.1	14.5	17.1	107	20.6	104	1064

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	1.9	54.4	7.7	80.8	246	4.2	68.0	43.6	12.5	0.2	162	26.0	423	6.8	9.2	2210

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market			x		
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P9	**Fast Growing Trees (Short Rotation Coppice, e.g. Willow)**

class	1	input from:	-
category	Other Plants	output to:	Modules C2-T1, C2-T2, C2-F5, C2-E1, C2-H2

General description of the process

A typical species for a fast growing tree is the willow. The willow is a member of the *Salicales* family. Their geographical origin (mainly UK, Germany and Scandinavia) and parental species are documented, but their precise parental provenance is not known. Willows possesses longish shaped leaves. In the first year the trunk has only one shoot, but in the second year many ramifications are generated. The twigs of the willow are used for rough wickerwork, fascines and fences. The bark has been employed for tanning purposes and as a salicin-containing drug.

Ecological requirements
Ecological sensitive areas such as heathlands, chalk downs, high moorland grazing, coastal dunes or estuarine margins are not suited to willow crops and are not likely to be planted. Commonly perceived as species adapted to river banks, wetland or even bogs, willows, although tolerant of a degree of waterlogging, are not constrained to these sites, and can be grown successfully on a wide range of soil types. However willows will not produce economically viable yields on very dry or alkaline soils. In general, sites considered as marginal for conventional agronomy, for instance, because of excessive winter waterlogging, will suit the Willow. A rule of thumb in selecting Willow sites might be those areas of a farm currently agriculturally less productive, which would be the first choice for permanent set-aside. The water requirement of willows has been estimated at 600 mm precipitation.

Crop management
For ease of planting, successful rooting and subsequent management, the site should be subsoiled if necessary, deep (250-300 mm) ploughed in autumn and then power-harrowed to produce a level, uncompacted tilth. The main determinants are suitable soil conditions and, *in extremis,* planting may be delayed to May, though with an increasing risk of losses due to drought. Northern or southern areas of Europe would need to adjust planting time to similar appropriate periods. Planting stock consists of unrooted cuttings from maiden (one-year-old) stems, 200 to 250 mm long and not less than 8 mm top diameter. A crop density of 10 /m² are recommended. Weed control in newly planted willows is important, otherwise the height growth can reduce to 50 %. The willow may be attacked by a wide range of leaf eating, stemsucking and wood-boring insect pests, but none has so far been more than an occasionally serious problem. Natural enemies and the immense number of leaves on a 1-3 year-old crop should ensure that normal levels of insect attack are not seriously damaging. The most serious disease is rust, caused by species of *Melampsora.* The following fertilisers are recommended:

Nitrogen 60 kg/ha, Phosphorus 15 kg/ha Potassium 35 kg/ha, Lime 18 kg/ha, Magnesium 3 kg/ha

Crop rotation
As previously mentioned, conventional forestry has little appeal for most farmers, because of the long maturation period. Densely planted, fast growing hard-woods may overcome this problem. The species chosen for SRC have, in common, the ability to make extremely rapid growth for the first few years following coppicing, with consequent very high yields. The optimum rotation (or harvest interval) is that which gives the highest yield of the most useable material for the least cost. In theory, therefore, rotations of 5 or 6 year intervals, when productivity is highest would be best. However, this would imply a long wait before any income was realised. Also, stems of this age are very thick and very tall, making both cutting/chipping operations and handling/stacking more difficult. In practice, the best compromise between maximising yield and minimising harvesting costs - at least for energy use – is likely to be with rotations of 3–4 years.

Regional specifications in the EU
Differences result from ecological requirements and different yields.
Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of forestry will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.
Internal and external resources
(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover) (2) Federal Agricultural Research Centre (FAL) Braunschweig, Germany (3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000 (4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001 (5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001 (6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997 (7) FORSCHUNGSINSTITUT FÜR SCHNELLWACHSENDE BAUMARTEN: Bewirtschaftung Schnellwachsender Baumarten auf landwirtschaftlichen Flächen im Kurzumtrieb (writer: Hofmann, W.), 1998 (www.fnr.de/veroff/schnellwbaeume.pdf)

Description of the calculation to obtain the quantitative figures
Economy figure: The prices for wood from fast growing trees were found in (7). **Ecology figure:** Data for the CO_2-output of the willow production were not found. For getting an approximative value, the yearly fossile CO_2-output per hectare induced by the production of rape seed was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was estimated per ton of soy bean yield was estimated. **Efficiency figure:** Data for the energy input of the willow wood production were not found. For getting an approximative value, the yearly energy input per hectare induced by the production of poplar wood was taken from (3). The typical yield per hectare was estimated for all EU member countries according to (5) and was taken in the European average.The energy content of the willow wood was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed). Dry woody biomass having an upper calorific value of 18,5 GJ/t and fresh wood containing about 25 % of water in the end of the winter leads to the figure of 14 GJ/t for fresh wood.
Description of the finding of some qualitative evaluations
need of space: An energy content of more than 9 TJ per km² in EU 15 average is a good value compared to other crops. Readiness for market is good because cultivation of different forms of wood is well known in Europe. The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	40
Ecology:	
emission of CO_2 (kg) per output unit	37
Efficiency:	
GJ output energy per GJ of all input energies	25.3

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	13.8	7.1	24.9	17.1	176	113	24.4	8.8	89.3	0.6	8.3	23.4	147	28.2	59.2	741

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	1.1	31.0	10.6	46.2	140	2.4	46.6	24.9	17.1	0.1	92.6	14.8	242	3.9	6.5	1421

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market				x	
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P10	**Miscanthus Cultivation**

class	1	input from:	-
category	Other Plants	output to:	Modules C2-T1, C2-T2, C2-F5, C2-E1, C2-H2

General description of the process

Miscanthus is a genus of woody, perennial, tufted or rhizomatous grasses which is related to sugar cane. It is high in lignin and lignocellulosc fibre and uses the C4 photosynthetic pathway. The erect stems arc slim, yet vigorous and are not usually branched. The solid pith stems are approximately 10 mm in diameter and can reach a height of a little over 2 m the first year and up to 4 m each consecutive year. The herbaceous leaves are usually cauline, flat and linear with a basal tuft which is only weakly developed. The flowers are arranged on the stem in abundant racemes which lie along a central axis. The rhizomes make up a highly branched storage system. The main goal for the utilisation of miscanthus is whole plant compaction to produce a solid fuel, with gasification as a large scale option.

Ecological requirements

The growing season temperature has a large effect on crop yield for miscanthus. Though the crop prefers warmer climates it has been shown that miscanthus can be grown with favourable results throughout Europe. Miscanthus has evolved in regions of the world that have large temperature fluctuations between summer and winter. Miscanthus does not create many demands on the soil, this being demonstrated by its ability to grow on many types of arable land. In order for the crop to establish itself in April and May it is necessary that the soil is sufficiently aerated and has a fine tilth, thus making soils of greater than 25% clay probably unsuitable. Soil with 70 to 95 mm of available water per 500 mm depth of soil is recommended for miscanthus. During the crop's growing season it is estimated that 600 mm of precipitation would be necessary to produce sufficient yields. Data from Denmark and the UK suggest that the optimum pH range is between 5.5 and 7.5 for growing miscanthus. This excludes soils which are very acidic or very chalky from the possibilities for optimum miscanthus growth.

Crop management

It is recommended that young plants and stored rhizomes be planted when the planting depth temperature of the soil is 10°C or greater. This corresponds to approximately late April to early June. The important factors are: sufficient soil moisture, fine tilth, and avoidance of young plant destruction from frost. The suggested spacings from Germany are 0.7-1.0 m between plants and 0.8-1.0 m between rows. Though new' shoots are quick to emerge after planting, the period of time until May or June is marked by slow growth. With the more favourable temperatures of summer comes rapid growth, with development of stalks over 2 m in the first year and 4 m the following years. Weed control is an important factor especially during the establishment and first two years of the crop. The best time for nutrient application is in the spring, before the new growth season, but after the previous harvest:

Nitrogen 50 kg/ha, Potassium 45 kg/ha, Phosphorus 21 kg/ha, Sulphur 25 kg/ha, Magnesium 13 kg/ha, Calcium 25 kg/ha

Crop rotation

Because miscanthus is a perennial crop, a crop rotation may not be necessary for more than 15 years. This possibility makes it important that the field is cleared of all perennial weeds before cultivation.

Regional specifications in the EU

Differences result from ecological requirements and different yields.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
Here, 11 tons per year and ha have been assumed for the most important countries in the temperate climate zone. In literature, yield data between 3 and 30 tons per year and ha have been published. It is probable, that a higher yield can be achieved in the long term development, if more experience has been made with miscanthus cultivation.

Internal and external resources
(1) FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) , REGIONAL OFFICE FOR EUROPE (REU) (www.fao.org/regional/europe/escorena/b46/cover.pdf)
(2) Federal Agricultural Research Centre (FAL) Braunschweig, Germany
(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000
(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001
(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001
(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997.
(7) PUDE, R.; BLIESENER, M.: Miscanthus.de (http://www.miscanthus.de/verwertung.htm)

Description of the calculation to obtain the quantitative figures
Economy figure: The prices for biomass from Miscanthus growing were found in (7).
Ecology figure:
In (3), the yearly fossile CO_2-output per hectare induced by the miscanthus production is indicated. The typical yield per hectare has been estimated according to (5) for all EU member countries and was taken in the European average. So the fossile CO_2-output was found out per ton of miscanthus wood.
Efficiency figure:
In (3), the yearly fossile energy input per hectare induced by the rape production is indicated. The typical yield per hectare has been estimated according to (5) for all EU member countries and was taken in the European average. The energy content of miscanthus was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of miscanthus wood.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed).
Data for actual use (1998) were found in (7).
Dry woody biomass having an upper calorific value of 18,5 GJ/t and fresh wood containing about 25 % of water in the end of the winter leads to the figure of 14 GJ/t for fresh wood.
Description of the finding of some qualitative evaluations
need of space: An energy content of more than 9 TJ per km² in EU 15 average is a good value compared to other crops.
readiness for market is rather bad because cultivation of Miscanthus is not so widespread so far.
The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	95
Ecology:	
emission of CO_2 (kg) per output unit	27
Efficiency:	
GJ output energy per GJ of all input energies	26.7

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A		DK	FIN		D	EL		I	L		P	E		UK	EU 15
actual use (for energy purposes)	-	-	0.00	-	-	0.02	-	-	-	-	0.00	-	-	-	-	0.03
technical potential	20.4	10.5	36.9	29.0	261	167	32.8	13.0	72.2	0.9	12.3	18.9	119	22.8	87.7	905
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	0.03	-	0.06
technical potential	1.5	46.0	8.6	68.4	208	3.5	37.6	36.9	13.8	0.1	137	22.0	326	5.8	11.0	1831

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market		x			
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P11	Maize Cultivation

class	1	input from:	-
category	Other Plants	output to:	Module C2-F2

General description of the process

Maize is an annual C4 plant which originated from America. It is a member of the *Gramineae* family and producing large, narrow, opposing leaves, borne alternately along the length of a solid stem. The plant produces male inflorescences (tassels) which crown the plant at the stem , and female inflorscences (ears) which are borne at the apex of condensed lateral branches protruding from leaf axis. Each plant produce till 4 ears. Maize is fertilized by wind-blown pollen. The vegetation period is about 130-180 days (May-September). Maize posses many possibilities of the application, e. g. maize meal, feed for animals, cornflakes etc..

Ecological requirements

Maize is very self-sufficient and therefore it can be grown as a monoculture. The crop, which is produced from 50° latitude N to 40° S, is adapted to desertic and high rainfall environments, and to elevations ranging from 0 to 4,000 meters above sea level.

Crop Management

Its demand for warmth during germination and early development (frost-sensitivity) leads to a late sowing from the end of April until mid-May, depending on the region. Depending on the harvesting technology and its use, the distance between the rows is normally 75 cm and the population density 9-13 plants/m2. If no mechanical weed control takes place, the distance between the rows can be reduced to 30 cm. The use of herbicides can be restricted by the use of time limits (permitted periods of time for its application). Young maize-plants are especially sensitive to competition between the 4 and 6-leaf-stage. Before and after this time, weeds can be tolerated to a greater degree. Later the maize-plants shade the ground so intensively that the growth of weeds is hindered. Maize is a relativley wholesome plant.

For high yield the use of fertilisers is recommended:

Nitrogen 160-200 kg/ha, Phosphorus 35-55 kg/ha, Potassium 125-170 kg/ha, Magnesium, 25-30 kg/ha

Crop rotation

The cultivation of catch crops, before maize is planted, primarily serves to cover the ground through the winter. Depending on the previous crop, the number of any hibernating catch crops can be considerable. With conservation tillage it is often useful to kill the catch crops and weeds with a non selective herbicide directly before the sowing of the maize. Catch crops planted after maize should guarantee the reception of remaining nutrients. The need of catch crops during their development can be catered for by sowing them as an underseed in maize. Thereby a higher catch crop mass can still be achieved in comparison to stubble seed in the autumn. The maize is sown into an existing turf with the technique of rotary sowing. The grass cover between the rows is usually kept short with mechanical methods. In addition, the reduction of the maize share in a crop rotation should be regarded as an important aspect with diverse environmentally relevant effects, above all if it is interconnected with the introduction of other plant cultures.

Regional specifications in the EU

Differences result from ecological requirements and different yields.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development
It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources
(1) IOWA STATE UNIVERSITY, COLLEGE OF AGRICULTURE (http://maize.agron.iastate.edu)
(2) RESEARCH CENTRE FOR AGRICULTURE AND ENVIRONMENT; GEORG-AUGUST-UNIVERSITY OF GÖTTINGEN DEPARTMENT OF FORAGE AND GRASS RESEARCH OF THE INSTITUTE FOR AGRONOMY AND PLANT BREEDING: The environmental impact of maize cultivation in the European Union: Practical options for the improvement of the environmental impact.- Case study Germany -, (writer: Finke, C. et al), 1999 (http://europa.eu.int/comm/environment/agriculture/pdf/mais_allemange.pdf)
(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000
(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001
(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001
(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997.
(7) RAPOOL RING GMBH (http://www.stichnoth.net/rapool/rapool.cfm?aktland=5)

Description of the calculation to obtain the quantitative figures
Economy figure:
Prices for maize were found in (7).
Ecology figure:
Data for the CO_2-output of maize production were not found. For getting an approximative value, an average value between the yearly fossile CO_2-output per hectare induced by the production of rape seed and from winter wheat was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was estimated per ton of maize yield.
Efficiency figure:
Data for the energy input of the maize production were not found. For getting an approximative value, an average value between the yearly fossile CO_2-output per hectare induced by the production of rape seed and from winter wheat was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the maize was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of maize.
Description of the calculation to obtain the availability data
See Module C1-P1: Rape cultivation (rape seed).
Description of the finding of some qualitative evaluations
need of space: An energy content of more than 9 TJ per km² in EU 15 average is a good value compared to other crops.
readiness for market is very good because maize cultivation is well known and widespread in Europe.
The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	125
Ecology:	
emission of CO_2 (kg) per output unit	50
Efficiency:	
GJ output energy per GJ of all input energies	8.3

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	15.5	7.5	-	-	199	127	22.3	-	94.3	0.6	8.8	19.8	124	-	-	619

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	1.0	35.0	-	-	158	2.7	49.2	-	12.0	0.1	104	16.7	221	-	1.3	1 220

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-P12	**Potato Cultivation**

class	1	input from:	-
category	Other Plants	output to:	Module C2-F4

General description of the process

The potato is part of the nightshade family and has its origins in America. The yield organs, the tubers, are generated at the underground tillers. The aboveground sprout parts gives the potato plant a herbal look. The bloom colour varied species typical from white unto red or blue. The potato vegetation period is about 140-180 days (April-September). Potatoes possess many possibilities of application, e.g. starch source for food industry, fuel source etc..

Ecological requirements

Most soils will grow potatoes. For starch potatoes the most appropriate soil are humus, loamy sand till soft-gloved loam. The potato loves easily warm up able, loose and well aired soils with good water supply. The soil should be free of stones to prevent the tubers from violations at the harvest. Potato will grow under alkaline conditions, the pH range should be between 4.5-7.5. While the formation of the tubers a sufficient and consistent water supply is necessary.

Crop management

Planting occurs from late April until early June depending on the weather and soil temperatures. Ideal soil temperature to deploy the potatoes are above 7°C with 70-80 % of available soil water. The potato tubers should be discarded at a depth of 4-6 cm. A crop density of about 40–42 plants/m² are appropriated. Often a combination of mechanical and chemical weed combat are used. Potatoes are strongly endangered by virus infestation. Several disease and pests have been known to attack potato crops are, e. g. Black Leg, Late Blight, Rhizoctonia Canker and Black Scurf, Potato Leafroll Virus an Gray Mold.

The use of fertiliser for potato plants are recommended: Nitrogen 100-150 kg/ha, Potassium 80-150 kg/ha, Phosphorus 50 kg/ha, Magnesium 40 kg/ha.

Organic fertilisation should be already deployed in the autumn.

Crop rotation

Crops coming before the potato plant are cereals and sugar beet, which leave behind a crowd of organic materials in the soil. A break in planting potatoes should be 4-5 years.

Regional specifications in the EU

Differences result from ecological requirements and different yields.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources

(1) GOVERNMENT OF CANADA, CANADA´S DIGITAL COLLECTIONS (http://collections.ic.gc.ca/potato)

(2) RAPOOL RING GMBH (http://www.stichnoth.net/rapool/rapool.cfm?aktland=5)

(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Ger-

many: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001

(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997

Description of the calculation to obtain the quantitative figures

Economy figure:

Potato prices were found in (2)

Ecology figure:

Data for the CO_2-output of potato production were not found. For getting an approximative value, the yearly fossile CO_2-output per hectare induced by the production of sugar beet was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average. So the fossile CO_2-output was estimated per ton of potato yield.

Efficiency figure:

Data for the energy input of the potato production were not found. For getting an approximative value, the yearly energy input per hectare induced by the production of sugar beet was taken from (3). The typical yield per hectare has been found for all EU member countries in (4) and was taken in the European average.The energy content of the potato was found in (6). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of potatoes.

Description of the calculation to obtain the availability data

See Module C1-P1: Rape cultivation (rape seed).

Description of the finding of some qualitative evaluations

need of space: An energy content of more than 9 TJ per km² in EU 15 average is a good value compared to other crops.

readiness for market is very good because potato cultivation is well known and widespread in Europe.

The other indicators give no relevant information about agricultural production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	80
Ecology:	
emission of CO_2 (kg) per output unit	30
Efficiency:	
GJ output energy per GJ of all input energies	7.6

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	12	9	31	17	206	145	14	7	66	1	11	9	111	25	70	732

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	1	27	9	40	180	2	34	31	15	0	80	13	134	3	7	1.309

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-R1	**Straw from Cereals Cultivation (e.g. Winter Wheat)**

Class	1	input from:	-
Category	Straw and Similar Residues	output to:	Modules C2-F5, C2-E2

General description of the process

The winter wheat is a member of the *Gramineae* family and has been described in module C1-P6. After harvesting the wheat, the straw is a residue from the agricultural production of grains. In principle the whole straw can be used as an energy source. But the agricultural praxis has shown that a certain part of the straw must be used to close the nutrient cycle of the soil. A further part of the straw is used for animal production as intersperse or fodder. After this material use it will be partly worked into the nutrient cycle of the soil as a form of muck. The rest of the straw can be taken out of the nutrient cycle of the soil and thus be used as an energy source.

Ecological requirements

Winter wheat is the most ecological demanding plant under the cereals. It prefers deep, nutrient rich, soils, with a good water supply. Winter wheat can survive temperatures about –20 ° C. In the 3-5 leaf stage the winter wheat is very frost sensitive (see C1-P6).

Crop management

Straw is only a residue from wheat cultivation, so it will be not regarded in the crop management.

Crop rotation

Winter wheat should be planted in crop rotation, but not after cereal crops. Seeding it into stubble from broad-leaved crops, such as canola, mustard and peas, will reduce the risk of insect, disease and weed problems for all crops in the rotation (see C1-P6).

Regional specifications in the EU

Straw is also used for other purposes, e.g. horse rearing or strawberry plantations. The technical potential is not completely available where such competing purposes have a considerable importance.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

It is assumed that the development of agriculture will not lead to other yields than today in the EU 15 countries and that it will lead to comparable yields in the candidate countries like in the EU 15.

Internal and external resources

(1) THRÄN, D.; KALTSCHMITT, M.: Stroh als biogener Festbrennstoff in Europa, IE, Leipzig, 2001

(2) EUROPEAN COMMISSION, JOINT RESEARCH CENTRE, INSTITUTE FOR PROTECTION AND SECURITY OF THE CITIZEN, Monitoring Agriculture with Remote Sensing (MARS) (mars.aris.sai.jrc.it/documents/stats/ bulletin/mars-05-1997.pdf)

(3) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(4) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Münster, 2001

(5) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, Berlin, 2001

(6) REINHARDT, G.; KALTSCHMITT, M.: Nachwachsende Energieträger, Vieweg Verlag, Braunschweig; Wiesbaden, 1997

Information from web pages:

(7) EMBASSY OF THE REPUBLIC OF POLAND, Vienna, Austria (www.brh-gov-pl.or.at/monograf/plland02.htm) (for Poland)

(8) U.S. DEPARTMENT OF AGRICULTURE, NATIONAL SOIL EROSION RESEARCH LABORATORY (http://topsoil.nserl.purdue.edu/nserlweb/isco99/pdf/ISCOdisc/SustainingTheGlobalFarm/P212-Gangu.pdf) (for Romania)

(9) NEW AGRICULTURALIST ONLINE (http://www.new-agri.co.uk/00-3/countryp.html) (for Turkey)

(10) INTERNATIONAL WHEAT AND MAIZE IMPROVEMENT CENTRE (CYMMIT) (http://www.cimmyt.org/Research/economics/map/facts_trends/wft9596/htm/wft9596Sheet12.htm) (for Switzerland and Norway)

Description of the calculation to obtain the quantitative figures

Economy figure:

For residues accrue no costs. The only fact is that the soil loses some nutrients that can compensated by more fertilisers in the following crop, but in the frame of this rough survey, this cost is neglected.

Ecology figure:

In (3), the yearly fossile CO_2-output per hectare induced by the removal of winter wheat straw is indicated. The typical yield per hectare of cereals has been found for all EU member countries in (4) and was taken in the European average. The corn-straw-relation of 1 : 1,1 leads to the straw mass. So the fossile CO_2-output was found out per ton of straw biomass.

Efficiency figure:

In (3), the yearly fossile energy input per hectare induced by the removal of winter wheat straw is indicated. The energy for cultivating the wheat is not taken into account because it is attached to the wheat yield (see C1-P6). Only some supplementary fertilizers for the following year are taken into account. The typical yield per hectare of cereals has been found for all EU member countries in (4) and was taken in the European average. The corn-straw-relation of 1 : 1,1 leads to the straw mass. The energy content of straw was found in (1). So it was possible to calculate the relation between the primary energy input and the energy content for the same quantity of corn straw.

Description of the calculation to obtain the availability data

The available potential of straw is restricted by the condition of closing the nutrient cycle of the soil. Thus only 30 % (1) of the whole straw mass is available for further applications like an application as an energy source. Via known acreage in the EU 15 countries (1), the average yields per hectare (1) and known corn/straw proportion of each country (1) it is possible to calculate the incidental straw mass of each country. 30 % of the straw mass in each country is multiplied with the net calorific (1) value and that way obtains the technical straw potential of each country in PJ.

For the 15 other European countries, the most important source was the wheat production data for 1996, from FAO statistics, quoted in (2). Total cereal crop and typical yield per hectare for other countries in the same time period was found out by different internet sources (7, 8, 9, 10). This led to an synoptical estimation of yearly cereal crops (for all cereals excepting maize) for these countries, the transformation into a technical potential was calculated like in (1) for the EU15. An important annotation is the fact, that cereal yields in some candidate countries are very low compared with the EU 15 countries. Using irrigation systems and other agricultural techniques, the yield per hectare could be two- or three-fold higher in some countries (e. g. Romania, Bulgaria). The technical potential as shown below was calculated from the existing yield between 1995 and 1999. This method was chosen because the residues accrue from existing cultures, there is no influence on their yield, while the technical potential for energy plants can be estimated higher (see module C1-P1).

Description of the finding of some qualitative evaluations
readiness for marketing: Very good because collecting of straw is well known in all countries
need of space: very good because residues need no supplementary area
The other indicators give no relevant information about straw production and have been left out.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	23
Efficiency:	
GJ output energy per GJ of all input energies	40

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	0.2	0.0	13.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.6	5.3	22.0
technical potential	22.0	11.7	43.2	12.8	316	206	20.0	8.6	90.1		7.2	5.9	99.8	26.3	105	974.5

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.5	32	1.4	51	116	1.4	13.9	11.6	4.6	0.0	26.8	16.2	139	4.2	4.6	1 397

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space					x
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-R2	**Logging Residues**

class	1	input from:	-
category	Wood	output to:	Modules C2-T1, C2-T2, C2-F5, C2-E1, C2-H2

General description of the process

Logging residues accrue from the slash when cutting down trees, such as tops and large limbs. It will chaffed or worked up to short wood and/or logs or - if an appropriate market available it will be regenerated also to hogged wood. Generally, leaves and roots should be left in the forest to preserve a healthy forest environment.

The process includes the cutting down of the trees with chainsaws, the transportation of the logging residues to the outskirts of the forest and an interim storage in a container till the transportation to the user of the wood residues begins (possible users are described in class 2).

The water content of wood varies somewhat with the season, it is smallest from January to March with approximately 50%, for impact the spring is therefore most favourable. All firewood contains water. Freshly cut wood can be up to 50% water, while well seasoned firewood generally has a 20-25% moisture content. The density of dry wood varies from 800 kg/m³ for hard leafy wood (e.g. beech) to 600 kg/m³ for coniferous (e.g. pine).

Regional specifications in the EU

The techniques for wood production vary broadly. In Scandinavia, a lot of wood is cut by harvesters, in the other parts of Europe more manual methods (chainsaws) are used.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

Actually, the felling in European forests is sustainable. In certain countries, a sustainable forest culture would even enable a higher wood production. So the long term wood production in Europe will be higher, if a balance between growing and felling is supposed.

If modern harvester technologies are used, wood plantations are felled earlier than in today's average. The share of branches in the total mass for younger trees is higher, so the logging residues will have a higher share if these technologies are used.

Both facts are reasons to assume a long-term growing potential of logging residues.

Internal and external resources

(1) WORLD ENERGY COUNCIL (WEC) (http://www.worldenergy.org/wec-geis/publications/reports/ser/wood/wood.asp)

(2) RES PUBLICA (www.res-publica.de/stats/stat011.htm)

(3) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Leitfaden Bioenergie (http://www.fnr.de/de/Leitfaden/)

(4) UNIVERSITY OF MISSOURI, SCHOOL OF NATURAL RESOURCES (http://muextension.missouri.edu/xplor/agguides/forestry/g05450.htm)

(5) HARTMANN, H.; KALTSCHMITT, M.: Biomasse als erneuerbarer Energieträger – eine technische, ökologische und ökonomische Analyse im Kontext der übrigen erneuerbaren Energien (unpublished)

(6) KALTSCHMITT, M.; REINHARDT, G.: Nachwachsende Energieträger, Vieweg Verlag, 1997

(7) Central Intelligence Agency (CIA) (Ed.): World Factbook 2002, 2002

(8) ZMP GMBH (ED.): Agrarmärkte in Zahlen – Europäische Union 2002, Bonn, 2002.

(9) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung Landwirtschaft und Forsten 2001, Münster 2001

(10) REINHARDT, G.; ZEMANEK, G.: Ökobilanz Bioenergieträger, Erich Schmidt Verlag, Berlin, 2000

(11) NILL, M.; KALTSCHMITT, M.: Ökobilanzierung zukünftiger Techniken zur Nutzung regenerativer Energien. Energie Innovativ 2002 „Integration von Energiesystemen zur Effizienzsteigerung“ Nürnberg, June 2002, VDI-Verlag

Description of the calculation to obtain the quantitative figures

Economy figure:

The cost for cutting and chaffing the wood as well as an interim storage at the outskirts of the forests was found in (5). Normally, for residues accrue no costs, but the logging residues can only be used if they are brought to a point where the usual transport chain (lorry) can start. Other sources give values between 2.20 € and 6.34 € depending on the complexity of the used technique (3).

Ecology figure:

Own calculation in preparation of (11) referring to the use of harvesters, the chaffing of the wood and the transport of the logging residues from the cutting point to the outskirts of the forest.

Efficiency figure:

Own calculation in preparation of (11) referring to the use of harvesters, the chaffing of the wood and the transport of the logging residues from the cutting point to the outskirts of the forest.

Description of the calculation to obtain the availability data

<u>Actual use:</u> The World Energy council has published data about the fuelwood production per country in 1999 (1). These include not only logging residues but also other forms of wood used as fuelwood. There is no reliable database about the acutal use of logging residues per country. One of the reasons for this lack of data is the alternating use of wood from different sources as firewood and the decentral use in small domestic heatings.

<u>Technical potential:</u> The technical potential depends on the forest area per country, found in (7) and on the wood production, found for all EU member countries in (8). The typical value for wood production per forest area was transferred from the EU member countries to the candidate countries with similar conditions to estimate the wood production in these countries because only forest area was known. The proportion of hardwood and softwood per country among the wood production was found in (9). The logging residues were calculated depending on the heating value, the percentage of dry matter in the wood and the typical logging residue percentage.

Description of the finding of some qualitative evaluations

As different technical concepts are possible, the qualitative evaluation (such as complexity or health risk) varies depending on the used technique. A general qualitative evaluation was not made for these reasons.

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	3.85 €
Ecology:	
emission of CO_2 (kg) per output unit	0.48 kg
Efficiency:	
GJ output energy per GJ of all input energies	0.0072

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B / L	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)																
technical potential	21.3	7.0	2.9	86.2	91.7	68.5	5.1	3.7	24.3	see B	2.0	18.5	28.7	94.9	12.5	467

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)																
technical potential	0.2	14.5	7.2	9.7	55.8	2.8	10.6	7.7	11.3	0.0	16.8	11.1	29.0	9.1	31.7	685

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space					
Availability					
readiness for market					
Other indicators					
hazardousness (health risk)					
complexity of technique					
output standardisation					

No.:	C1-R3	Collection of Used Cooking Oil

class	1	input from:	-
category	Organic Residues	output to:	Module C2-S2

General description of the process

Within the commercial and private sector great quantities of cooking oil are used during the food preparation. The part of oils which are not eaten, must be recycled as a residual substance. Up to now used cooking oil was converted almost exclusively to animal feeds.

The module of used cooking oil can be sectional based on their sources in six groups:

- fry fats and drippings from catering and canteens
- fry fats and drippings from households
- fry fats from food industry
- slaughter waste fats
- waste fats from food
- fats from grease separators

For the technical utilisation of used cooking oil the content of solids, water, salts, free fatty acids and polymers are problematic. Depending upon the origin the consistence of the fats differs. Generally the quality requirement applies a pure fat as possible. The group of slaughter waste fats and the fats from grease separators are ill-suited for chemical and technical utilisation. The used cooking oil possess many possibilities of application, e.g. animal feeds production, basic material for the chemical industry, basic material for fuel production and for fermentation in fermentation gas installations.

Regional specifications in the EU

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The potential of used cooking oil in Europe depends on alimentation habitudes. A long-term forecast is not possible, so it can be assumed that the potential will stay at its actual level.

Internal and external resources

Information from web pages:

(1) RES PUBLICA (www.res.publica.de/stats/stat011.html)

(2) www.hollerith.de/altfett.pdf

Description of the calculation to obtain the quantitative figures
Economy figure: For used cooking oil accrue no costs. **Ecology figure:** For used cooking oil accrues no $CO2$-emission. **Efficiency figure:** Regarding that costs and emissions don't accrue, no input energy can be found, thus this figure can not be calculated.
Description of the calculation to obtain the availability data
The mass of used cooking oil which is useable as an energy source varied in depending on food industry density, use of mass in households and use of mass in canteens and catering. Up to now no data basis was found, which considers the differences in the accumulation of each country. So that an average value (mass per inhabitant and year) of Germany (2) is used for all European Countries. On the assumption of the partially use of used cooking oil as basic material for chemical industry and as basic material for animal feed the average value is reduced to 80 %. The reduced value is multiplied with the number of inhabitants per country (1), so that an entire used cooking oil mass results for each country. The entire used cooking oil mass of each country is multiplied with the net calorific value used cooking oil, found in (2). Thus a value in PJ results for the technical potential of used cooking oil.
Description of the finding of some qualitative evaluations
Need of space: For collection of used cooking oil, no large machinery is necessary. Readiness for market: Some cases of using the used cooking oil for energy production have been made, but there is no significant market penetration so far. Standardisation has not been made so far.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	0.7	0.9	0.5	0.4	5.1	7.1	0.9	0.3	4.9	0.0	1.4	0.8	3.4	0.8	5.0	32.3

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.1	0.9	0.1	0.9	3.3	0.2	0.7	0.3	0.2	0.0	1.9	0.5	5.4	0.6	0.4	47.9

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market		x			
Other indicators					
hazardousness (health risk)				x	
complexity of technique				x	
output standardisation		x			

No.:	C1-R4	Collection of Animal Excrements

class	1	input from:	-
category	Organic Residues	output to:	Module C2-F7

General description of the process

Excrements from the keeping of domestic cattle are accumulated essentially in the agriculture. The basic materials for this biomass fraction-group are dejection, that accrued more or less firmly, and the urine are accrued liquid. As a function of animal-husbandry either the both basic materials as well as the interspersing material (slurry) or excrement and urine without other additives (manure) accrue. The amount and consistence of the excrements range significant in depending on feeding and other parameters. All animals produce excrements, but for the biomass potential only the excrements from cows, pigs and chicken are utilisable. This is founded in the different kinds of the animal-husbandry. Animals like sheep and goats are mainly on the outside during the year, and so there is no possibility for collecting their excrements.

Pig slurry

Up to six varieties of different types of animal housing are commonly in use, resulting in large variations of total solids (2-10 %) and organic dry matter content in manure. The excrements from pigs, particularly in units with more than 1000 animals, are commonly collected as a liquid manure. In most cases, pigs are kept in feedlots with open floors, where the excrements are collected through slots with high amounts of liquid.

Cow slurry

Cow slurry is typically collected from feedlots by a scraper system. Straw is often added in the feedlots resulting in slight variations of total solids. Commonly little water is added for cleaning and rinsing of the cattle walkway, hence dilution with water is minimal. As for pig slurry, cow slurry also exhibits large variations in total solids contents, depending on the animal housing system. Depending on the location and operational tradition cows often spend long periods of time grazing on pastures.

Chicken manure

Chickens are usually kept in large scale units holding up to several hundred thousand animals. Chicken manure is characteristically high in TS contents (~ 20 %) and NH_4- N concentrations (the NH_4^+-N concentration of animal slurries is generally rather high). In most cases, water dissolved ammonia is excreted. Since chickens excrete little liquid, ammonia may be found in crystalline form in the excrements. The resulting high ammonia content can lead to inhibitory effects during digestion, causing high NH_4 - emissions during manure storage in the feedlots.

Excrements from animal housing are often used as fertiliser and so the nutrients can be repatriated on the agricultural areas. The digestion of the excrements, before it will be repatriated on the agricultural areas, poses no problem for closing the nutrient-cycle of the solid.

Regional specifications in the EU

There are no relevant specifications concerning the collecting of animal excrements in barns.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The development depends on agricultural policy in the EU: If ecological farming is more supported, the animals will live not all the times in housings (like cows do often today). Outside, a systematic collection of the manure is not possible – so the availability of the total potential will drop. Another reason for a decreasing potential could be a decrease of meat production caused by a trend to healthier diet or caused by rising meat import from the world market.

Internal and external resources

(1) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten, Münster, 2001

(2) NATIONAL STATISTICAL INSTITUTE, Bulgaria (http://www.nsi.bg/Stat_e/Bulgaria-World/Agr2-e.htm)

(3) UNIVERSITY OF WESTERN ONTARIO, DEPARTMENT OF STATISTICAL AND ACTUARIAL SCIENCES (http://www.stats.uwo.ca/computing/datasets/datasets/CLEVELAN/EGDATA/LIVESTOC)

(4) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, 2001

(5) THE ANAEROBIC DIGESTION NETWORK (http://www.ad-nett.org/assets/images/Feednw1.pdf)

Description of the calculation to obtain the quantitative figures

Economy figure:

For animal excrements accrue no costs.

Ecology figure:

For animal excrements accrues no CO_2-emission.

Efficiency figure:

The energy and emissions linked with livestock farming is attached to the meat, milk and egg production. So no input energy is calculated for the generation of residues.

Description of the calculation to obtain the availability data

The available potential of animal excrements depends on the number of animals per country and their animal-husbandry. The number of animals for EU 15 was found in (1). In (2) these data were found for the 8 most important of the 15 remaining countries. For Norway and 7 smaller countries, older data from (3) and estimations, based on the proportion of arable land and population of each country were used. The estimations do not constitute more than 3,5 % of the total EU figure. The animal excrements is only collectable inside. Pigs and Chicken are inside the whole year, so that their total dung are collectable. Cows often spend long periods of time grazing on pastures This led to the assumption, that only 50 % of their animal excrements are collectable. The number of pigs and chicken of each country are multiplied with a specific value for dung production (4) during a year. The number of cows of each country is multiplied with 50% due to long stay outside, and then is also multiplied with a specific value for excrement production (4) during a year. Thus a value results for the total excrement production of an animal per country. The dung of pigs, chicken and cows have specific energy contents (5), these specific values are multiplied with the total dung production of everyone animal group. Thus a value results for the technical potential of an animal group. The technical potential of animal excrements in PJ results of the entire sum. 70 % of the technical potential can be considered as available.

Description of the finding of some qualitative evaluations

readiness for market: There is no real market for animal excrements but the in situ use of biogas reactors is a existing and approved technological possibility to transform these excrements into biogas.

The collection technique is not very complex (good), but there is no standardisation of the excrements at all.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	13.1	22.5	23.6	6.3	113	89.1	5.7	23.6	47.8	0.7	40.9	10.2	47.4	9.3	58.6	512
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.3	13.4	2.3	13.2	50.0	2.7	5.4	6.1	4.1	0.1	28.5	6.5	47.8	7.5	4.3	704

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market			x		
Other indicators					
hazardousness (health risk)					
complexity of technique				x	
output standardisation	x				

No.:	C1-R5	**Collection of Organic Waste from Households**

class	1	input from:	-
category	Organic Residues	output to:	Module C2-F8

General description of the process

Organic waste generated by households can be divided into two groups:

- kitchen slops, leftovers, residues from fruits and vegetables, grass residues, kitchen paper etc., these are materials which could be fermented
- wood and herbal residues, eggshell, soil from flowerpots etc., these are organic materials which can be used for composting

The consistency of the organic waste varies depending on place, season, type of settlement and the social standard of the inhabitants. At other places and under other frame conditions a significant variation can result in another consistency of the household waste. One-third of the organic residues from households can be fermented easily and one third can be fermented with difficulties. As a result more than 50 % of the household waste is composed of organic materials from different sources. An average value for fermentable residues is 100 kg per inhabitant. De facto the effectively collected amount is significantly lower than this value in almost all EU countries.

Regional specifications in the EU

The collection systems are varying not only from country to country but also from city to city. This is the reason why the technical potential is really collected in some regions whilst in other regions people are even not used to collect organic waste in separate dust bins.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The share of collected organic waste will rise when the demand for the collected materials will rise.

Internal and external resources

(1) Res Publica (www.res.publica.de/stats/sat011.html)

(2) KALTSCHMITT, M.; HARTMANN, H. : Energie aus Biomasse. Springer Verlag, Berlin, 2001

(3) BILITEWSKI; HÄRDTLE; MAREK: Abfallwirtschaft. Springer Verlag, Berlin, 1990

Description of the calculation to obtain the quantitative figures
Economy figure: For organic waste from households accrue no costs. **Ecology figure:** For organic waste from households accrues no CO_2-emission. **Efficiency figure:** No input energy is calculated because the collection of all household disposals has to be carried out in any way.
Description of the calculation to obtain the availability data
The consistent and mass of the organic waste from households varied in depending on place, season, type of settlement and the social standard of the inhabitants. Up to now no data basis was found, which considers the differences in the accumulation of each country. So that an average value (mass per inhabitant and year) of Switzerland (2) is used for all European Countries. The value is multiplied with the number of inhabitants per country (1), so that an entire organic waste mass results of each country. The entire organic waste mass of each country is multiplied with the net calorific value of organic waste from households (3). Thus a value in PJ results for the technical potential of organic waste from households.
Description of the finding of some qualitative evaluations
The need of space is regarded as the sum for the need of space for the dust bins in all households and for all buildings. It can be a problem in very densely populated quarters. The market for organic waste is not a market wiht positive prices, today the producers of the waste pay for the removal. There is some health risk linked to the storage and removal of dust bins containing mixtures of organic residues.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	1.3	1.6	0.8	0.8	8.9	12.5	1.6	0.5	8.7	0.1	2.4	1.5	6.1	1.4	8.9	57.0
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.1	1.6	0.2	1.5	5.9	0.3	1.3	0.6	0.4	0.1	3.4	0.8	9.6	1.1	0.7	84.5

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market			x		
Other indicators					
hazardousness (health risk)			x		
complexity of technique				x	
output standardisation		x			

No.:	C1-R6	**Collection of Vegetable Residues from Agriculture**

class	1	input from:	-
category	Organic Residues	output to:	Module C2-F7

General description of the process

During the agricultural plant production accrue relative moistly harvest residues. For example, only a part of the grown biomass from producing of vegetables like green peas and bush beans are useable for human food. Also when harvesting root crops (e.g. sugar beets, potatoes), residues and by-products accrue. During the harvesting of sugar beets accrues a significant leaf mass (40-50 t/(ha a)), in practice the leaf mass is used for fodder. Considering the cultivation of potatoes, the grown biomass useable as an energy source is small. As a result of the high water content of the leaf mass, the use of the relative moistly harvest residues as solid fuel is not possible. The use of vegetable residues is only conceivable for the production of fermentation gas.

Regional specifications in the EU

No relevant specifications are known.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The amount of residues depends mainly on the prevailing cultures. A forecast of agricultural policy is not possible, the crops to be cultivated can even be influenced by the results of this study. So it is assumed to have a constant potential of agricultural residues.

Internal and external resources

(1) ECOFYS: Landwirtschaftliche Reststoffe, Ruhrgas Studie

(2) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2001, Landwirtschaftsverlag Münster-Hiltrup

(3) EMBASSY OF THE REPUBLIC OF POLAND, Vienna, Austria (http://www.brh-gov-pl.or.at/monograf/plland02.htm)

(4) NEW AGRICULTURALIST online (http://www.new-agri.co.uk/00-3/countryp.html)

(5) BILITEWSKI; HÄRDTLE; MAREK: Abfallwirtschaft, Springer Verlag, 1990

(6) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, 2001

Description of the calculation to obtain the quantitative figures

Economy figure:

For vegetable residues from agriculture accrue no costs.

Ecology figure:

For vegetable residues from agriculture accrues no CO2-emission.

Efficiency figure:

No input energy is calculated because the collection of agricultural residues has to be carried out in any way.

Description of the calculation to obtain the availability data
The mass of the vegetable residues from agricultural which are useable as an energy source varied in depending on cultivated plants, season, use as fertiliser and animal feed. Up to now no data basis was found, which considers the differences in the accumulation of each country. So that an average value (total mass per year) of Germany (1) was used and related to the typical total yield of sugar beet and vegetables in the European Countries. For the EU 15, the total yield of vegetables and of sugar beet was found in (2), for Poland it was found in (3), sugar beet for Turkey in (4). For the other countries, a relation between the arable land and the vegetables-plus-sugar-beet yield in comparable countries (e. g. Austria and Switzerland) was used to estimate the total yield. Based on the assumption of the partially use of vegetable residues as animal feed and as nutrient for closing the nutrient cycle the average value is reduced to 50 %. The entire vegetable residue mass of each country is multiplied with the net calorific value of vegetable residues from agriculture (5). Thus a value in PJ results for the technical potential of vegetable residues from agriculture.
Description of the finding of some qualitative evaluations
The situation is similar to the collection of animal excrements: The space demand is limited to some containers, the technique is not complex and a market doesn’t exist, excepted the in situ biogas plants.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
technical potential	6.0	14	6.0	2.3	65	50	10	3.2	48	0.01	18	5.0	32	4.8	21	285
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
technical potential	0.4	7.9	1.8	20	36	1.0	19	6.3	2.9	0.04	24	3.8	53	1.7	0.9	463

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market			x		
Other indicators					
hazardousness (health risk)				x	
complexity of technique				x	
output standardisation	x				

No.:	C1-R7	Collection of Organic Commercial Waste

class	1	input from:	-
category	Organic Residues	output to:	Module C2-F8

General description of the process

Organic commercial waste originates in industry and trade. Residues with organic origins accrue in various sectors of the food-industry, chemical-industry, pharmaceutical-industry as well as various sectors of the trade. Waste of the trade is sometimes collected with the waste of the household, but sometimes separately. The mentioned waste from trade consists of unsold and spoiled fruits and vegetables from distribution organisations as well as restaurant waste. The organic industry waste consists of materials which cannot deployed for animal feeding and composting. At present these organic materials are burned, respectively deposited. An average value for the organic commercial waste are 38 kg per inhabitant and year.

Examples for sources of organic commercial waste:

Sugar production. 17 % of the primary weight of the sugar beet are crystal sugar. The residual rest are sugar beet residues and molasses, at present these residues are used for animal feeding.

Coffee- and tea processing. On the processing of tea and coffee also accrue organic residues, these residues are partly used for feeding cows or composting.

Production and Processing of fruits. To this a multitude products are to name: drinks (fruit juice, alcohol), vinegar, dry fruits, pectin, flavours... These products with agricultural origins are mostly processed in larger factories of the food industry. The withal evolved waste and waste water are heavily used by organic materials. At present such organic materials are used for feeding, composting, dumping, fermentation, and combustion.

Meat processing. The slaughter house residues are limited usable for pig feeding. Supplementary heavily organic used waste water accrues, this is cleaned in a sewage plant on location.

Beer production. During the beer production malt develops. The malt contains nitrogen and vegetable fat, on this account it is favoured for animal feeding. During the end cleaning of the beer yeast accrues.

Wine production. The remaining residues after alcohol fermentation and distillation (mash) can be transformed in energy. The mash can be used for feeding or for fertilisation agricultural areas.

Milk processing. The whey can be used for production of biogas, if it is not used for other purposes (Feeding for pigs, whey powder, production of drinks).

Regional specifications in the EU

The amount of organic commercial waste per inhabitant is assumed to be equal in all EU countries.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The most important sources are found in the food-industry. The inputs and outputs of the most food industrie processes can not be easily influenced, the demand of foods depends on the population. So a constant potential of residues can be supposed.

Internal and external resources

(1) RES PUBLICA www.res.publica.de/stats/sat011.html

(2) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, 2001

(3) BILITEWSKI; HÄRDTLE; MAREK: Abfallwirtschaft, Springer Verlag, 1990

Description of the calculation to obtain the quantitative figures
Economy figure: For organic commercial waste accrue no costs. **Ecology figure:** For organic commercial waste accrues no CO2-emission. **Efficiency figure:** No input energy is calculated because the collection of agricultural residues has to be carried out in any way.
Description of the calculation to obtain the availability data
The consistency and mass of the organic commercial waste varies depending on place, kind of manufacturing industries and technical standards of the industrial processes. Up to now no data basis was found, which considers the differences in the accumulation for each country. So that an average value (mass per inhabitant and year) of Switzerland (2) is used for all European Countries. The value is multiplied with the number of inhabitants per country (1), so that an entire organic commercial waste mass results for each country. The entire organic commercial waste mass of each country is multiplied with the net calorific value of organic commercial waste (3). Thus a value in PJ results for the technical potential of organic waste from households.
Description of the finding of some qualitative evaluations
Compared with the collection of agricultural residues, the situation is similar, but the hazards are a little more important, that’s why biogas reactors need a pre-treatment.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	0
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)																
technical potential	0.7	0.9	0.5	0.5	5.3	7.4	1.0	0.3	5.2	0.04	1.4	0.9	3.6	0.8	5.3	33.9

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)																
technical potential	0.1	0.9	0.1	0.9	3.5	0.2	0.7	0.3	0.2	0.03	2.0	0.5	5.7	0.7	0.4	50.2

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market			x		
Other indicators					
hazardousness (health risk)			x		
complexity of technique				x	
output standardisation	x				

No.:	C1-R8	Collection of wood Residues from Trade and Industry

class	1	input from:	-
category	Organic Residues	output to:	Modules C2-T1, C2-T2, C2-F5, C2-E1, C2-H2

General description of the process

The wood residues of the trade mostly are parts of finished wood products, which arrived the end of their use. In contrast, the wood residues from industry are residues that accrue during the working and processing procedure.

Wood residues from trade

Wood residues from trade accrue in many ranges of the national economy, where wood from the use process is separated; this is the case by industrial manufacturing processes (e.g. building demolitions, new buildings, refurbishment) and at the end of a certain material use (e.g. old furniture, packing materials). Due to the very different use history such material can be loaded with many kinds of pollutants. Untreated wood residues can be reduced to small pieces and cleaned of contaminant used for material recycling. Under present economical boundary conditions this is the preferred recycling way for untreated wood residues. In principle treated wood residues from trade are used as an energy source. The quantitative accumulation of wood residues from trade varies locally within very large ranges, it depends on the density of inhabitants and their respective prosperity and also at a multitude of further parameters.

Wood residues from industry

In the wood working and processing industry, wood residues accrue from domestic or imported wood, beside the actual desired main product (e.g. furniture) and/or the by-products intended for a material use (e.g. particle boards), usually further wood by-products, residues or wastes. These residues are available for energy recovery. Withal mostly it concerns wood in form of chips, segments, rinds, dust, bark pieces and splints. For the most wood residues from industry a material use at present is preferred for economical reasons. This led to the assumption, that only a part of wood residues from industry are useable for energy recovery. Nevertheless, a part of the biomass energy is used at present for the drying chambers of the wood industries. The energy use ratio of wood residues from industry depends on market conditions for wood basic materials, fossil energy competitor and disposal costs.

Regional specifications in the EU

The amount of wood residues depends on the importance of wood in each countrie's economy.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

If the wood production will rise, the wood residues from industry will also rise.

The amount of used wood depends mainly on the building industry and construction habitudes: In regions with a high share of wooden buildings or in regions with a lot of demolitions and reconstructions, the potential of used wood will be higher. In Germany, e. g., there was a construction boom in the former GDR which led to more demolition wood in the 1990s, since then, the amount of used wood is decreasing.

Internal and external resources
(1) RES PUBLICA (www.res.publica.de/stats/stat011.html)
(2) internal database of IE, Leipzig
(3) KALTSCHMITT, M.; HARTMANN, H.: Energie aus Biomasse, Springer Verlag, 2001
(4) CENTRAL INTELLIGENCE AGENCY (CIA) (Ed.): World Factbook 2002, 2002
(5) ZMP GMBH (ED.): Agrarmärkte in Zahlen – Europäische Union 2002, Bonn 2002.
(6) FEDERAL MINISTRY OF CONSUMER PROTECTION, FOOD AND AGRICULTURE (BMVEL) (ED.), Germany: Statistisches Jahrbuch über Ernährung Landwirtschaft und Forsten 2001, Münster, 2001
(7) IER; IPG; IVD; TFZ; TLL; TLUG: Standardisierung biogener Festbrennstoffe, Az.:97NR055, final report from october 2002 for FNR and the technical committee „Solid Biofuels“ (CEN TC 335)

Description of the calculation to obtain the quantitative figures
Economy figure:
Costs depend from offer and demand. Wood residues of different categories (rough, steamed, contaminated, ...) have partially negative prices (because the avoiding of disposal costs for contaminated wood), but growing demand has led to positive prices for the most common wood residues in 2001. In Germany, the prices of electric current entry from wood are defined by the renewable energies law (EEG) and determinate the long-term market prices for wood residues. It is estimated that they will reach an average of about 20 € per ton (2). If current entry prices are lower, wood based power stations cannot afford wood prices of 20 € per ton, market prices will be lower.
At an European level, the average between no price (avoiding of disposal and benefit for the buyer are equal) and the German price estimation is taken, so the figure is fixed at 10 € per ton.
Ecology figure:
For wood residues from trade and industry accrues no CO_2-emission.
Efficiency figure:
The energy and emissions of wood processing is not attached to the residues.

Description of the calculation to obtain the availability data
The mass of the wood residues from trade and industry which are useable as an energy source depends on the wood industry density, trade density and the use of wood residues as further basic material. Up to now no data basis was found, which considers the differences in the accumulation for each country.
In Germany, about half of the potential accrues as tradable residues to remove. Due to a lack of reliable data, the average value (mass per inhabitant and year) of Germany (2) is used for all European countries, because the residues depend mainly on the population (demolition of housing, used furniture etc.). The above mentioned average value is multiplied with the number of inhabitants per country (1), so that an entire wood residue mass results for each country. The entire wood residue mass of each country is multiplied with the net calorific value of wood residues from trade and industry (3).
The other part of wood residues accrues in the wood processing industry, such as edgings, saw dust, and wood shavings. It is completely used today, either for energy purposes or for a substantial use. The actual use of wood residues from trade and industry in Germany was a finding of a recent non-published study (2). For other countries, comparable data were not found. So it was assumed, that the amount of these residues depends mainly on the wood production, found for all EU member countries in (5), and this depends on the forest area, found in (4). The typical value for wood production per forest area was transferred from the EU member countries to the candidate countries with similar conditions, because only the forest area of the candidate countries was known. The proportion of hardwood and softwood per country among the wood production was found in (6). The wood residues

from the wood processing industy were calculated depending on the heating value and the percentage of dry matter in the wood as a fixed percentage of the wood production. Both values together (traded wood residues depending on the number of inhabitants and industrial wood residues depending on wood production per country) were added to get the potential data. In most countries with lower industrialisation (most of the candidate countries) the potential of wood residues is already used, but not traded: If wood residues accrue, the owners retain them for a later use for firing (heat production). So the calculated potential is not really free for new forms of use, e. g. thermochemical processing. In fact, the share of the available potential depends on the demand for material use of wood residues (e. g. paper industry) and the demand for wood as energy source and the market price of each segment. An availability of 80 % of the technical potential like in Germany is a rather high share, for Poland it was found out that almost no share of the technical potential was available because it was not traded. The availability will rise if prices rise.
Description of the finding of some qualitative evaluations
The readiness for market is generally good, the standardisation of solid biomass is actually done for the European Union (CEN TC 335), see (7), the relevance of the other indicators for an evaluation is very limited.

Quantitative assessment of the module for the present state	
Output unit:	t
Economy:	
costs (€) per output unit	10.0 €
Ecology:	
emission of CO_2 (kg) per output unit	0
Efficiency:	
GJ output energy per GJ of all input energies	-

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)						117										
technical potential	56	29	13	181	243	255	23	14	120	1	28	44	108	213	117	1 445
Country / primary energy origin		**CZ**	**EE**	**HU**	**PL**	**SI**	**BG**	**LT**	**LV**	**MT**	**RO**	**SK**	**TR**	**CH**	**N**	**EU 30**
technical potential	2	43	16	34	164	8	32	20	25	1	66	29	152	28	66	2 131

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space					
Availability					
readiness for market				x	
Other indicators					
hazardousness (health risk)					
complexity of technique				x	
output standardisation			x		

No.:	C1-E1	**Hydropower**

class	1	input from:	-
category	Renewable Electricity	output to:	Module C2-H1, C3-E1

General description of the process

Generation of electrical energy using the potential and kinetic energy of water.

There are three main types of hydropower facilities:

Storage systems impound water behind a dam, forming a reservoir. Water from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water storage and release cycles can be relatively short, for instance, storing water at night for daytime power generation. Or the cycles can be long, storing spring runoff for generation in the summer when air conditioner use increases power demand. Some projects operate on multi-year cycles carrying over water in a wet year to offset the effects of dry years.

Run-of-river systems typically use relatively low dams where the amount of water running through the powerhouse is determined by the water flowing in the river. Because these plants generally do not hold back water behind storage dams, they tend to have less effect on upstream water levels and downstream stream flow than storage projects. Electricity generation from these plants will vary with changes in the amount of water flowing in the river.

Pumped-storage systems use electricity during off-peak periods of lower demand to pump water from a lower reservoir to an upper reservoir for storage. During periods of high electrical demand, the water is released back to the lower reservoir. This spins the turbines forward, activating the generators to produce electricity. As this last kind of hydropower facility is rather a power storage than an electricity generating system it will not be analysed here.

Regional specifications in the EU

The possibility to generate electricity in hydropower facilities strongly depends upon the local situation: available amount of water, altitude difference, etc.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

There are no great technological changes to expect.

Internal and external resources

(1) NEUBARTH, J.; KALTSCHMITT, M.: Erneuerbare Energien in Österreich, Springer Verlag Wien; New York, 2000

(2) WORLD ENERGY COUNCIL (WEC) : Survey of Energy Resources, 1998, Chapter 7, Hydropower

Description of the calculation to obtain the quantitative figures
Economy figure: Cost data from (1) have been used. It is hereby assumed, that the situation in Austria can be generalized for the whole of Europe. The costs of power generation strongly depend upon the local situation and it is therefore hard to give precise cost estimates. To partly overcome this problem for the two types of power facilities storage systems and run-of-river systems the average value of four different facilities examined by (1) is taken. The interest rate is 4.5 %, the lifetime is assumed to be 70 years for construction work and 40 years for engineering work. **Ecology figure:** LCA data from (1) have been used. Again, the average value of four different facilities for the two types of power facilities storage systems and run-of-river systems is calculated. **Efficiency figure:** LCA data from (1) have been used. The efficiency is thereby given by the reciprocal value of the cumulated energy demand. The latter value describes the fossil primary energy needed to produce electricity using hydropower. Again, the average value of four different facilities for the two types of power facilities storage systems and run-of-river systems is calculated.
Description of the calculation to obtain the availability data
Actual use and technical potential taken from (2).
Description of the finding of some qualitative evaluations
Hazardousness: The health risks consist in the risks of a dam failure. It is assumed that these risks are higher for storage systems than for run-of-river systems. Readiness for market: technology already widely used

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	21 (run-of-river) 17 (storage)
Ecology:	
emission of CO_2 (kg) per output unit	2.5 (run-of-river) 1.5 (storage)
Efficiency:	
GJ output energy per GJ of all input energies	33.3 (run-of-river) 45.5 (storage)

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	128	0.7	0.1	42.1	226	65.5	15.5	2.5	157	0.2	0.4	49.3	146	184	11.9	1 029
technical potential	194	3.6		72	259	90	72		378			90	252	468	10.8	1 890

Country / primary energy origin	CY	CZ	EST	H	PL	SLO	BG	LT	LV	M	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)		6.8	0.01	0.2	2.2	4.9	3.3	0.4	2.8	0	22.7	17.6		136	464	>1 936
technical potential		11		18	43	32	54	14	18	0	144	25		148	720	>3 118

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space		x			
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)		x (storage)	x (river)		
complexity of technique				x	
output standardisation					x

No.:	C1-E2	**Wind Power**

class	1	input from:	-
category	Renewable Electricity	output to:	Modules C2-H1, C3-E1

General description of the process

The kinetic energy of wind can be transformed into electrical energy using wind power converters. The electrical yield of a wind power converter depends strongly on the wind speed, for this reason wind turbines are situated at sites with a high average wind speed. Nowadays most wind turbines are situated in coastal areas, on hilltops or other onshore areas with a high average wind speed. As wind blows above the surface of the sea with a higher speed and less turbulences, offshore installations promise to be an efficient way of power generation. The nominal power of commercial wind turbines ranges from some hundred kilowatts to several megawatts for offshore installations

Regional specifications in the EU

As in the northern parts of the EU the average wind speed is higher than in the southern parts, the power generation by wind turbines is favoured in northern Europe.

Actually, Germany, France and Spain have energy feeding input rules which give a higher price to wind electricity for favoring its development.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The technology of wind power converters has progressed a lot in the last decade. By now onshore wind power can be seen as a mature technology. For offshore installations there is still some technological progress to come. There is a certain trend towards systems with a higher normal power and higher hub heights. Following (6), prices will go down about 25 % (from 2000 to 2010) resp. 50 % (2000 – 2020).

Internal and external resources

(1) KALTSCHMITT, M.; WIESE, A.; STREICHER, W.: Erneuerbare Energien. 3rd Ed. Springer-Verlag, 2003 (In preparation)

(2) NILL, M.; KALTSCHMITT, M.: Ökobilanzierung zukünftiger Techniken zur Nutzung regenerativer Energien. Energie Innovativ 2002 „Integration von Energiesystemen zur Effizienzsteigerung“ June 2002 in Nürnberg, VDI-Verlag

(3) EUROBSERV’ER N° 148: Le bilan 2001 des énergies renouvelables, 2002 (www.energies-renouvelables.org)

(4) WORLD ENERGY COUNCIL (WEC) (www.worldenergy.org/wec-geis/publications/reports/ser/wind/wind.asp)

(5) EUROPEAN WIND ENERGY ASSOCIATION (EWEA) (www.ewea.org/src/europe.htm)

(6) EUROPEAN WIND ENERGY ASSOCIATION (EWEA): Windstärke 10, 1999 (study about how to cover 10 % of the world electricity supply by wind power untill 2020)

(7) LLOYD, G.; HASSAN, G.: Study of Offshore Wind Energy in the EC, Joule I, 1994

Description of the calculation to obtain the quantitative figures

Economy figure:

Data for the costs of wind power generation are taken from (1). These cost figures are based on a 1.5 MW onshore turbine under the conditions given in Germany. The interest rate is 4.5 %, the technological lifetime is assumed to be 20 years. As the costs strongly depend on the average wind speed given at the turbine site, cost figures are given for 5.5, 6.5 and 7.5 m/s in 50m above ground. A average wind speed of 5.5 m/s describe sites of medium quality, whereas a wind speed of 6.5 and 7.5 m/s are given at sites of good or very good quality.

Following (6), prices will go down about 25 % (from 2000 to 2010) resp. 50 % (2000 – 2020).

Ecology figure:

LCA data from (2) have been used. To adapt the data to the different wind speed classes (5.5, 6.5 and 7.5 m/s in 50 m above ground) they are scaled by factor which is given by the full load hours (5.5 m/s: 1550 h/a, 6.5 m/s: 2200 h/a; 7.5 m/s 2900 h/a). The values of the full load hours for the different wind speed classes are taken from (1).

Efficiency figure:

LCA data from (2) have been used. The efficiency is thereby given by the reciprocal value of the cumulated energy demand. The latter value describes the fossil primary energy needed to produce electricity using wind power converters.To adapt the data to the different wind speed classes (5.5, 6.5 and 7.5 m/s in 50 m above ground) they are scaled by factor which is given by the full load hours (5.5 m/s: 1550 h/a, 6.5 m/s: 2200 h/a; 7.5 m/s 2900 h/a). The values of the full load hours for the different wind speed classes are taken from (1).

Description of the calculation to obtain the availability data

Sources:

actual use: Considering the strong rise of wind energy in the last years, it was tried to find the most actual data for each country. For the EU 15, the most actual data (end of 2001) for the installed capacity were found in (3). They were multiplied by the typical yearly yield indicated in (4) for 1999, supposing that the typical yield per installed MW did not undergo such strong changes. For other european countries, data were found in (5) and (4), dating mostly from 2000.

technical potential onshore: For the EU 15 and Norway, source (6) was taken. For other European countries, the approach was made to use 2,5 % of the total country surface, where 5 turbines (750 kW capacity each) per km² are installed. The yield per installed MW corresponds to the assumptions of (6). The method corresponds in principle to (1) and gives a comparable result to the data from (6) if applied to EU 15 (as a whole) or Norway.

technical potential offshore: (7) was taken, the assumptions have been used there: one 6 MW wind turbine per square kilometer, hub height 60 meters, maximum water- depth 40 meters and maximum distance from land 30 kilometers. For Sweden, Finland and the 15 not-EU-member countries, there was no figure available.

The technical potentials on- and offshore are added up.

Description of the finding of some qualitative evaluations

Need of space interpreted as area of sealed land. This is very small for wind power as the ambient area of the turbines can be used for agriculture.

Quantitative assessment of the module for the present state			
Output unit:	GJ		
Economy:	**5.5 m/s**	**6.5 m/s**	**7.5 m/s**
costs (€) per output unit	23	16	12.5
Ecology:			
emission of CO_2 (kg) per output unit	10.4	7.3	5.5
Efficiency:			
GJ output energy per GJ of all input energies	6.7	9.5	12.5

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	0.60	0.16	14.9	0.38	0.68	52.4	1.47	1.33	4.36	0.05	2.75	0.76	32.1	1.63	4.45	**116.5**
onshore potential	10.8	18	36	25.2	306	86.4	158	158	248		25.2	54	310	148	410	1 994
offshore potential	0	86	1980		1714	857	331	662	554	0	493	173	504		3550	>10 904
total technical potential	**10.8**	**104**	**2016**	**25.2**	**2020**	**943**	**490**	**821**	**803**	**0**	**518**	**227**	**814**	**148**	**3960**	**>12 899**
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)		0.07			0.02				0.01		0.00		0.16	0.01	0.09	**116.9**
onshore potential	6.2	53	31	63	211	13.7	75	44	44	0.2	161	33	526	27.9	274	3 556
offshore potential		0.0		0.0								0.0		0.0		>10 904
total technical potential		**53**	**31**	**63**	**211**	**14**	**75**	**44**	**44**	**0**	**161**	**33**	**526**	**28**	**274**	**>14 454**

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space				x	
Availability					
readiness for market			x (offshore)	x (onshore)	
Other indicators					
hazardousness (health risk)				x	
complexity of technique			x		
output standardisation					

No.:	C1-E3	**Photovoltaic Solar Energy**

class	1	input from:	-
category	Renewable Electricity	output to:	Modules C2-H1, C3-E1

General description of the process

Conversion of global radiation to electric power by photovoltaic systems. The global radiation is defined as the sum of diffuse sky radiation and direct radiation. Photovoltaic modules can be made of different cell materials. Most common are cells based on multi- and mono-crystalline silicon.

Regional specifications in the EU

The global radiation increases from north to south in EU. Whereas in the northern part of Finland the global radiation is 800 kWh/m2a it can reach up to 1800 kWh/m2a in southern part of Greece. The output of a photovoltaic module rises linearly with rising global radiation. So PV power generation is more efficient in southern Europe than in northern Europe.

Actually, Germany, France and Spain have energy feeding input rules which give a higher price to photovoltaic electricity for favoring its development.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

Higher cell efficiencies, better production technologies and new cell technologies (thin film) will lead to considerable cost reductions and better ecological data.

Internal and external resources

(1) UIL; IE: Evaluierung des 100.000-Dächer-Solarstrom-Programms, for BMWi, Leipzig, 2002

(2) WORLD ENERGY COUNCIL (WEC), following (www.energie-atlas.ch)

(3) KALTSCHMITT, M.; WIESE, A.: Erneuerbare Energien 3rd Ed. Springer-Verlag (In preparation)

(4) NILL, M.; KALTSCHMITT, M.: Ökobilanzen zukünftiger Techniken zur Nutzung regenerativer Energien, VDI-Verlag (In preparation)

(5) KALTSCHMITT, M.,WIESE, A.: Erneuerbare Energien-Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, Springer-Verlag, Berlin; Heidelberg, 1997

(6) NEUBARTH, J., KALTSCHMITT, M.: Erneuerbare Energien in Österreich, Springer-Verlag, Wien, 2000

(7) EUROBERSV'ER N° 149: Le baromètre du photovoltaïque, 2001 (www.energies-renouvelables.org)

Description of the calculation to obtain the quantitative figures

Economy figure:

Data for the costs of PV power generation are taken from (3). These cost figures are based on a 5 kW rooftop systems connected to the grid with an global radiation of 1000 kWh/m^2*a. The cell material is multi crystalline silicon. An interest rate of 4.5 % and a technological lifetime of 30 years are assumed.

As the costs strongly depend on the global radiation, three cost figures are given for typical conditions in northern (1000 kWh/m^2*a), central (1200 kWh/m^2*a) and southern Europe (1500 kWh/m^2*a). To adapt the cost data from /1/ to the different sites (northern, central and southern Europe) they are scaled by factor which is given by the full load hours (northern 800 h/a, central 960 h/a, southern Europe 1200 h/a).

Ecology figure:

LCA data from (4) have been used. The PV system is the same as described above. To adapt the data to the different sites (northern/central, central and southern Europe) they are again scaled by factor which is given by the full load hours.

Efficiency figure:

LCA data from (4) have been used. The efficiency is thereby given by the reciprocal value of the cumulated energy demand. The latter value describes the fossil primary energy needed to produce electricity using PV systems.

Description of the calculation to obtain the availability data

Sources:

actual use: For the 15 EU member countries (Ireland and Luxembourg excepted), acutal data, referring to 2001 were found in (7), for other countries, some data referring to 1999 were found in (2).

technical potential: potential of installed capacity multiplied by typical yield yearly (full load hours), depending on the average of global radiation per country, following (2).

potential of installed capacity (GW): technical area potential divided by 9 (need of space for good poycrystalline or average monocristalline cells: 9 m^2 per kW, following (1))

technical area potential (km^2): in regard to inhabitants of the countries, number of inhabitants divided by 90 000 (values after (5) and (6), only roof areas are taken into account)

Description of the finding of some qualitative evaluations

Need of space is assumed to be “very good” for rooftop systems. If the PV modules are installed on open plain the need of space is rather big and therefore assumed to be “very bad”.

Quantitative assessment of the module for the present state			
Output unit:	GJ		
Economy:	Central Europe		Southern (Mediterranean) Europe
	northern	southern	
costs (€) per output unit	150	125	100
Ecology:			
emission of CO_2 (kg) per output unit	35	29	23
Efficiency:			
GJ output energy per GJ of all input energies	1.7	2.0	2.5

Availability																
Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)																
Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	0.019	0.001	0.004	0.007	0.043	0.544	0.005		0.093		0.056	0.006	0.066	0.007	0.007	0.858
technical potential	29	35	18	15	229	292	57	12	271	1	53	48	209	27	197	1 493
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)		0.000				0.000					0.000		0.001	0.045	0.014	>0.918
technical potential	4	37	4	38	131	7	36	13	7	2	87	20	330	29	13	>2 253

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space	x (plain field)				x (rooftop)
Availability					
readiness for market				x	
Other indicators					
hazardousness (health risk)				x	
complexity of technique			x		
output standardisation					

No.:	C1-E4	Solar Thermal Energy

class	1	input from:	-
category	Renewable Electricity		Modules C2-H1, C3-E1

General description of the process

Solar thermal power plants generate electricity from the heat produced by the sunlight.

There are various types of solar thermal power plants, as an example the parabolic trough power plants are described more in detail: A number of large cylindrical parabolic mirrors are installed so that they concentrate the sunlight on a line of focus to form an collector. Several of these collectors are installed in rows about a hundred metres long and the total solar field is composed of many of such parallel rows. All the collectors track the path of the sun on their longitudinal axes. The mirrors concentrate the sunlight more than 80 times on a metal absorber pipe in the line of focus. This pipe is embedded in an evacuated glass tube to reduce heat loss. A selective coating on the absorber tube surface lowers emission losses. Either water or a special thermal oil runs through the absorber tube. The concentrated sunlight heats it up to nearly 400°C, evaporating water into steam that drives a turbine and an electrical generator. After passing through the turbine, the steam condenses back into water that is returned to the cycle.

In periods of bad weather or at night, a fossil-fired burner can drive the water-steam cycle if the solar thermal power plant should guarantee capacity. This option increases the quality of planning distribution over the grid. Thermal storage can complement or replace the fossil-fired burner so that the power plant can be run with neutral CO_2-emissions. The systems operate only in the MW range (30 MW till 200 MW), so they need a grid-connection.

Between 1984 and 1991, nine trough power plants were built in the Californian Mojave Desert with a total capacity of 354 MW_{el}, feeding about 800 GWh yearly into the grid and need a space of more than 7 km². The total investment in all of the systems was more than $1.2 * 10^9$ US-$.

Regional specifications in the EU

Solar thermal power plants need direct irradiance for power generation, while photovoltaic systems can use diffuse irradiance as well. So the systems can be installed in areas where the direct irradiance dominates, e. g. in the Mediterranean countries.

In August 2002, Spain decided to pay 0,16 € / kWh for electricity from solar thermal power plants.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

Three power stations of 50 MW capacity each will be soon realized in Southern Spain. For the long-term development, the technology will become more spread and may allow higher performances.

Internal and external resources

(1) QUASCHNING, V.: Solar power – Photovoltaics or Solar Thermal Power Plants?, in: VGB Power Tech 6/2002

(2) FORSCHUNGSZENTRUM JÜLICH, SYSTEMFORSCHUNG UND TECHNOLOGISCHE ENTWICKLUNG:: Perspektiven der solaren Stromerzeugung, (writer: Nitsch, J.; Staiß, F.; Trieb, F.)

(3) KLAIß; STAIß, F. (German Aerospace Center): Solarthermische Kraftwerke für den Mittelmeerraum, Vol. 2, Springer Verlag, Berlin, 1992

(4) WEINREBE, G.: Technische, ökologische und ökonomische Analyse von solarthermischen Turmkraftwerken. IER-Forschungsbericht, Vol. 68, Stuttgart, 2000.

Description of the calculation to obtain the quantitative figures
Economy figure: (1) has calculated levelised electricity costs in Euro per kWh for solar power plants in latitudes between 35°N and 45°N corresponding to the Mediterranean region in Europe. The value of 0.2 € is an upper value in this range. Divided by 0.0036, the costs per GJ are resulting. **Ecology figure:** The only data available concerning solar thermal power plants were found in (4) and refer to solar tower power plants (among three examples, the plant in Almería, Spain, was considered). In general, the amount of material and energy for the construction of solar thermal power plants are comparable, so for a rough orientation they can be used for solar thermal power plants in general. The data taken refer to a pure solar system (without thermal storage at 1921 full load hours p.a.). They refer to a operating time of 30 years or 57 630 full load hours and were converted in values referring to 1 GJ of electricity. Only the greenhouse effect as a whole, calculated in CO_2-equivalents was found, the real CO_2-output figure is lower. Nevertheless, compared with other modules it becomes clear, that CO_2-emissions are lower than for photovoltaic electricity or wind energy but higher than for hydropower. If the plant is run in a hybrid way, the energy input is by far higher. **Efficiency figure:** The only data available concerning solar thermal power plants were found in (4) and refer to solar tower power plants (among three examples, the plant in Almería, Spain, was considered). In general, the amount of material and energy for the construction of solar thermal power plants are comparable, so for a rough orientation they can be used for solar thermal power plants in general. The data taken refer to a pure solar system (without thermal storage at 1921 full load hours p.a.). The given energy input (MJ per kWh) was converted into GJ per GJ.
Description of the calculation to obtain the availability data
For the actual use in Europe, only the Plataforma Solar de Almería in Spain was found, but it is a R&D installation and not a commercial power plant, it produces much less than 1 PJ yearly. For calculating the potential, (3) has been used as source. Only countries in the Mediterranean zone with a domination of direct irradiation were selected. The potential has been estimated in (3) for the Mediterranean region, supposing 3 600 full load hours, a thermal energy storage and a capacity of 20 MW per km² in non-used areas (badlands, stony deserts). In California, 50 MW had been installed per km², but the yearly yield was 2260 MWh of electricity per MW, among this output 25 % can be produced by non-regenerative sources (without thermal energy storage). It is not mentioned in the table, that a very large potential has been found at the southern side of the Mediterranean region (especially in Egypt, Maroc and Libya). All European countries can produce about 10 400 PJ, but at the other side of the Mediterranean region, 146 800 PJ can be generated yearly, most of this can be exported to Europe because energy demand is far lower in these countries.
The need of space is estimated as medium, considering the necessary areas and the fact that they are actually not used. The readiness for market is seen as good due to the experiences in California.

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	55
Ecology:	
emission of CO_2-equivalents (kg) per GJ	4.9
Efficiency:	
GJ output energy per GJ of all input energies	17

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK		F	D	EL	IRL	I	L	NL	P	E	S	UK	
actual use (for energy purposes)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
technical potential	0	0	0	0	0	0	648	0	1 050	0	0	259	3 162	0	0	5 119
Country / primary energy origin	**CY**		**EE**	**HU**	**PL**		**BG**	**LT**	**LV**	**MT**		**SK**	**TR**	**CH**	**N**	**EU 30**
actual use (for energy purposes)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
technical potential	26	0	0	0	0	0	0	0	0	1	0	0	5 236	0	0	10 382

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market				x	
Other indicators					
hazardousness (health risk)					
complexity of technique			x		
output standardisation					

No.:	C1-E5	**Nuclear Energy**

class	1	input from:	-
category	Nuclear Electricity	output to:	Modules C2-H1, C3-E1

General description of the process

A nuclear reactor produces and controls the release of energy from splitting the atoms of certain elements. In a nuclear power reactor, the energy released is used as heat to make steam to generate electricity. The principles for using nuclear power to produce electricity are the same for most types of reactor. The energy released from continuous fission of the atoms of the fuel is harnessed as heat in either a gas or water, and is used to produce steam. The steam is used to drive the turbines which produce electricity (as in most fossil fuel plants). The most spread reactor types in Europe are the pressurised water reactor and the boiling water reactor, the third type of importance is the gas cooled reactor which is only used in Great Britain, following (1).

Fuel: Usually pellets of enriched uranium oxide (UO_2) arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core.

The nuclear fuel reprocessing is not considered because the fast breeder reactor technology was given up in Europe for economical, technical and political reasons and nuclear weapons are not considered in this study.

Regional specifications in the EU

8 of the EU 15 countries use nuclear power plants for electricity generation: Belgium (7 reactors operating), Finland (4), France (59), Germany (19), Netherlands (1), Spain (9), Sweden (11), Great Britain (31). 8 of the considered candidate countries also use nuclear power plants. Actually, a supplementary reactor is planned only in Finland (among the EU 15), in the Czech and Slovak Republics, there are 3 reactors under construction, in Romania one reactor is planned. All other countries have no concrete plans to expand nuclear power production, some have decided to back out of the nuclear energy programme.

7 of the EU 15 countries don't use nuclear power production technology: Austria, Denmark, Greece, Ireland, Italy, Luxembourg, Portugal. 7 of the candidate countries don't use it either.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

All three types of reactors are well developped technologies, the fast breeder technology has been given up in Europe, so there are no important developments to expect.

Internal and external resources

(1) WORLD NUCLEAR ASSOCIATION (www.world-nuclear.org)

(2) BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE, Germany: Die weltweiten Reserven der Energierohstoffe: Mangel oder Überfluß?, (writer: Stahl, W.), (http://www.bgr.de/b4/aktthema/reswww/reswww98.htm)

(3) MARHEINEKE, T.: Lebenszyklusanalyse von Stromerzeugungstechniken. Institut für Energiewirtschaft und rationelle Energieanwendung, Universität Stuttgart, 2001, using data from „Ökoinventare für Energiesysteme", ETH Zürich, 1996

Description of the calculation to obtain the quantitative figures
Economy figure: The World nuclear association (global industrial association promoting the use of nuclear power) indicates Finnish data of 0.024 €/kWh (= 6.67 € / GJ) as the electricity generation costs (on the basis of 91% capacity factor, 5% interest rate, 40 year plant life), including fuel costs and (very dominating) capital costs of the technology. In fact, nuclear energy can be bought for such a price at the market. However, the price of long term nuclear waste management is not included, considering that an ultimate disposal place must be found. Underground repository plants must be used for several 10.000 years, data for ensuring such an ultra-long run of such repository plants and their long term costs have not been found. The price of public financed R&D activities is not included either. **Ecology figure:** There is no CO_2-emission arising from the run of nuclear power plants, only the transport of the nuclear fuel will generate some CO_2-emission. This value was found in the LCA database (3). **Efficiency figure:** This value was found in the LCA database (3). The calculation of the uranium input corresponds to the method of energy bilancing (in Germany): The primary energy content of uranium is assumed to be three times as high as the electricity output. Thus, more than 98 % of the energy input needed for nuclear power production are assumed to be in the uranium, all transport energies are included in the remaining share.
Description of the calculation to obtain the availability data
Actual use: Word Nuclear Association (1) Technical Potential: The technical potential in this study is given as an yearly value. Nuclear power production is no regenerative energy source because the availability of uranium is limited. Admong the limited sources, only 2 % of all uranium deposits world-wide have been found in the European Union. The nuclear electricity production of the EU countries in 2001 was 33,3 % of the worldwide nuclear electricity production, including the considered candidate countries, it was 37,6 %. The known recoverable resources of uranium orebodies reasonably (assured Resources plus Estimated Additional Resources – category 1, up to US$ 80/kg U, following (1)) can supply the actual run reactors of the world for about 50 years, so the EU resources can run the European reactors for only 3 years. So the technical potential in Europe is low, the renewable yearly technical potential is zero.
Description of the finding of some qualitative evaluations
The environmental impact in the mining areas is very high, not only because of radiation, but also because of the low uranium content of the orebodies: Most of the excavation residues have to be deposited on large heaps in situ. So, the need of space is estimated as “bad”. Another risk is the maximum credible accident during the run of a nuclear power plant (example Chernobyl accident in 1986). The probability is very low, but the impact is higher than for any other known energy production technology. Together, the hazardousness is estimated as “very bad”.

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	6.67
Ecology:	
emission of CO_2 (kg) per output unit	3.5
Efficiency:	
GJ output energy per GJ of all input energies	0.32

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

energy origin	A	B	DK	SF	FIN	D	EL		I	L		P	E	S	UK	EU 15
actual use (for energy purposes)	-	159	-	79	1444	584	-	-	-	-	13	-	220	249	296	3 045
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH	N	EU 30
actual use (for energy purposes)	-	53	-	51	-	18	66	41	-	-	18	62	-	91	-	3 444
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space		x			
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)	x				
complexity of technique		x			
output standardisation					x

No.:	C1-F1	Crude Oil

class	1	input from:	-
category	Fossil fuel	output to:	Module C2-R1

General description of the process

Supply of crude oil in Europe. Conventional energy source, data used for comparison purposes.

Regional specifications in the EU

Most of the EU countries have no own crude oil resources and import them.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The European crude oil sources, mainly in the North Sea, will be depleted earlier than those of the Middle East. The long-term development will lead to higher prices like for all fossil energy sources.

Internal and external resources

(1) FEDERAL MINISTRY OF ECONOMICS AND LABOUR (BMWA) (ED.), Germany: Energiedaten 2000

(2) FRISCHKNECHT, R.; HOFSTETTER, P.; KNOEPFEL, I.; DONES, R.; ZOLLINGER, E.: Ökoinventare für Energiesysteme, 3. Ed., Zürich, 1996

(3) EU; DG TREN: Transport in figures

Description of the calculation to obtain the quantitative figures

Economy figure:

Import prices for crude oil for 1999 from (1) are used; the lower heating value is 42.7 MJ/kg.

Ecology figure:

LCA-data for the crude oil supply in Europe are used from (2).

Efficiency figure:

The data go back to the LCA data. The efficiency in this class of primary energy provision means only the relation between the energy content of the crude oil and the energy demand for its exploration and transportation.

Description of the calculation to obtain the availability data

Actual use: The final energy demand of the transport sector is found in (3). As more than 99 % of this demand corresponds to mineral oil products, these data are taken here for giving an idea of the mineral oil demand. They refer to 1999 for EU 15 and to 1998 for the candidate countries. In fact, the losses within the refineries are not included, but the energy demand of the transport sector for electricity, natural gas and biofuels is included.

Technical Potential: The technical potential in this study is given as an yearly value. Mineral oil production is no regenerative energy source because the availability of mineral oil is limited. So the yearly renewable potential is zero.

Description of the finding of some qualitative evaluations

hazardousness: The hazardousness is estimated high because of the risks of dangerous pollution during the sea transport as well during pipeline transports outside of the EU.

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	2.86
Ecology:	
emission of CO_2 (kg) per output unit	5.92
Efficiency:	
GJ output energy per GJ of all input energies	0.911

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin		B	DK	FIN	F	D		IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)	260	402	205	184	2 110	2 797	314	155	1 717	71	578	251	1 336	322	2 110	12 812
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT		SK	TR	CH	N	EU 30
actual use (for energy purposes)	33	159	17	130	398	59	80	54	29	13	163	54	473	285	197	14 955
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Qualitative assessment of the module for the present state

	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)		x			
complexity of technique					
output standardisation					

No.:	C1-F2	**Natural Gas**

class	1	input from:	-
category	Fossil Fuel		Modules C3-P3, C2-H3

General description of the process

Supply of natural gas in Europe. The natural gas is originating from Russia, the North Sea and some domestic sources onshore. Natural gas is a fossil energy source that can be used for transportation in a transition period. Data are necessary for comparison purposes.

Regional specifications in the EU

Most of the EU countries have no own natural gas resources and import them.

Foreseeable intermediate (5-10 years) and long-term (25-30 years) development

The long-term development will lead to higher prices like for all fossil energy sources.

Internal and external resources

(1) FEDERAL MINISTRY OF ECONOMICS AND LABOUR (BMWA) (ED.), Germany: Energiedaten 2000

(2) FRISCHKNECHT, R., HOFSTETTER, P.; KNOEPFEL, I.; DONES, R.; ZOLLINGER, E.: Ökoinventare für Energiesysteme, 3. Ed., Zürich, 1996

(3) EUROPEAN NATURAL GAS VEHICLES ASSOCIATION (http://www.engva.org/view.phtml?page=160.phtml)

Description of the calculation to obtain the quantitative figures

Economy figure:

Import prices for natural gas for 1998 are used; the lower calorific (=heating) value is 31.7 MJ/m³.

Ecology figure:

LCA-Data for the natural gas supply in Germany are used. They are based on (2) with some corrections concerning the supply mix. It is assumed that the data will not change a lot for other European countries.

Efficiency figure:

The data go back to the LCA data. The efficiency in this class of primary energy provision means only the relation between the energy content of the unburned natural gas and the energy demand for its exploration and transportation.

Description of the calculation to obtain the availability data

Actual use: The use of natural gas in the transport sector has no significant importance compared with mineral oil. The most important demand is in Italy following (3) with about 340 000 natural gas vehicles. This leads to an estimated energy demand of 15 PJ yearly. All other European countries are assumed to have the same demand together.

Technical Potential: The technical potential is given as an yearly value. Natural gas production is no not regenerative because of the limited availability. So the yearly renewable potential is zero.

The need of space is higher than for other fuels due to the lower density of gasses. The readiness for market is good, gas vehicles are used in Europe. The other qualitative evaluations are less important.

Quantitative assessment of the module for the present state	
Output unit:	GJ
Economy:	
costs (€) per output unit	2.10
Ecology:	
emission of CO_2 (kg) per output unit	4.53
Efficiency:	
GJ output energy per GJ of all input energies	0.876

Availability

Quantitative potential of primary bioenergy / primary waste energy / electric power production (PJ/a)

Country / primary energy origin	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK	EU 15
actual use (for energy purposes)									15							
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Country / primary energy origin	CY	CZ	EE	HU	PL	SI	BG	LT	LV	MT	RO	SK	TR	CH		EU 30
actual use (for energy purposes)																30
technical potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Qualitative assessment of the module for the present state					
	very bad	bad	medium	good	very good
Ecology					
need of space			x		
Availability					
readiness for market					x
Other indicators					
hazardousness (health risk)		x			
complexity of technique			x		
output standardisation					