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Basic information regarding decentralised CHP plants based on biomass combustion in selected IEA partner countries

final report

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IEA Task 32 project performed in co-operation with the Institute for Resource Efficient and Sustainable Systems, Graz University of Technology

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1 Introduction, objectives and general information about the participating partners

The evaluations made in this report are related to “Questionnaire I – Basic information regarding decentralised CHP plants based on biomass combustion in selected IEA partner countries”, which has been sent by e-mail to the IEA Task 32 members at the 18th of April 2003.

The questionnaire has been sent to all task members, in total 14 persons and institutions. 7 partners or 50% of them answered the questionnaire. The partners who answered the questionnaire are shown in Table 1.1 with contact details. In addition, the contact details of all IEA Task 32 members are available at “http://www.ieabcc.nl/”.

Table 1.1: Participating IEA Task 32 members

Partner country	Institution	Person in Charge	E-mail
Austria	Graz University of Technology	Obernberger, Ingwald	obernberger@rns.tugraz.at
Belgium	Centre de Recherche Agronomiques	Delcarte, Jerome	delcarte@cragx.fgov.be
Denmark	dk-Teknik	Evald, Anders	evald@dk-teknik.dk
Finland	VTT Technical Research Centre of Finland	Kärki, Janne	Janne.Karki@vtt.fi
Netherlands	TNO Environment, Energy and Process Innovation	Koppejan, Jaap	j.koppejan@mep.tno.nl
Sweden	Swedish National Testing and Research Institute	Tullin, Claes	claes.tullin@sp.se
Switzerland	Verenum Research	Nussbaumer, Thomas	verenum@smile.ch

The seven questionnaires answered by the partners shown in Table 1.1 formed the basis for the evaluations made in this report.

The main focus of this project were on the collection, discussion and evaluation of information regarding economic, legal and general side constraints for decentralised biomass CHP plants in the countries of the project participants., e.g. amount of electricity produced from renewables and solid biomass, respective development targets, investment subsidies, feed-in tariffs for green electricity, emission limits. In addition, an overview of plants in operation and technologies applied in the participating partner countries has been gained.

Another main objectives of the project were to gain an overview of technological developments and demonstration activities regarding decentralised biomass CHP systems in IEA member states. Documentation as well as technological and economic evaluation of innovative small-scale biomass CHP technologies based on the information from the project partners have been done. The results of these activities are summarised in the report “Techno-economic evaluation of selected decentralised CHP applications based on biomass combustion in IEA partner countries - final report”.

As decentralised CHP applications based on biomass combustion are seen plants with nominal electric capacities below about 20 MW_{el}. Co-combustion applications can, however, also have higher nominal electric capacities, but the share covered by biomass is usually also in the capacity range (below about 20 MW_{el}). Only a few biomass CHP plants, especially in Scandinavia, exist with higher nominal electric capacities.

Due to different national framework conditions it is not possible to make a general definition for “solid biomass” valid for this report. The different biomass fuel fractions allowed to be used under the specific national regulations are defined for each country in section 2.2 (related to investment subsidies) and in section 2.3 (related to increased feed-in tariffs). Co-firing of biomass with other (fossil) fuels is also included in the evaluations made in this report (proportionate).

2 Framework conditions for decentralised CHP technologies based on biomass combustion in selected IEA partner countries

2.1 Amount of electricity produced from renewables and solid biomass as well as respective targets

Table 2.1 gives an overview of the electricity production from renewables and solid biomass as well as of respective targets defined. The highest amount of electricity from solid biomass is produced in Finland, followed by Sweden, the lowest amount in Switzerland. The production of electricity in Denmark will increase significantly in 2003 due to the start of operation of several new large-scale plants. The estimated total amount of electricity produced from solid biomass in Denmark in 2003 is 1,370 GWh/a (4% of the total electricity demand per year and 0.6% of the total primary energy demand per year).

Finland and Sweden show the highest amount of electricity produced from solid biomass in CHP plants based on biomass combustion. In Finland all the electricity produced from solid biomass is produced in CHP plants based on biomass combustion. In Denmark, an additional production of electricity of around 220 GWh/a is expected by the Herning CHP plant from 2003 on. This would lead to a total amount of electricity produced from solid biomass in CHP plants based on biomass combustion of about 720 GWh/a in 2003.

Three countries have defined targets regarding electricity production from solid biomass, i.e. Finland, Belgium and Denmark. The highest value is defined in Finland, however, from a very high starting level. Belgium has defined different targets for Flanders and Wallonia (see explanations in Table 2.1).

The absolute amount of electricity produced from renewables (excluding hydropower) is again the highest in Finland. Denmark, the Netherlands and Sweden show also very high values. The highest percentage, however, is shown by Denmark.

All countries have defined targets concerning electricity production from renewables. Austria’s target in this context is defined with 4% of the total electricity demand per year by the year 2008. This percentage is, however, related to approved green electricity generation plants, which produce currently 0.84% of the total annual electricity demand in Austria. Not included in this figure and for the achievement of the target are plants which do not supply the green electricity produced to the public grid (e.g. plants in the pulp and paper industry). Taking the green electricity produced from this industrial plants and the additional 4% from the approved green electricity generation plants into account, this would lead to a total target of about 7.1% of the total annual electricity demand.

Table 2.1: Electricity production from renewables and solid biomass as well as respective targets

Explanations: [1]…related to the total electricity demand per year; [2]…related to the total primary energy demand per year; [3]…related to the total primary energy demand per year used for electricity production; [4]…in Wallonia 150 GWh by 2005 and 350 GWh by 2010, in Flanders 350 GWh by 2004; [5]…0.6% by 2005, 1.2% by 2010; [6]…the estimate target is a total increase of renewables by approximately 10 TWh from 76 to 86 TWh until 2010 (including hydropower); [7]…2% by 1st January 2004, 3% by 1st January 2006 (percentage related to approved green electricity generation plants, producing currently (2003) 0.84% of the total electricity demand per year); [8]…including co-generation units using coal and heavy oil with solid biomass; [9]…6% by 2005, 9% by 2010; [10]…5% by 2010, 10% by 2020 (both for electricity and heat)

Unit	Austria	Switzerland	Finland	Belgium	Denmark	Netherlands	Sweden
Amount of electricity produced from solid biomass							
GWh/a	455.0	13.8	8,000	328.5[8]	667	2,053	3,700
%[1]	0.92	0.026	8.0	0.4	2.0	2.3	2.5
%[2]	0.12	0.0043			0.3		0.6
Amount of electricity produced from solid biomass in CHP plants based on biomass combustion							
GWh/a	412	1.3	8,000	112	497	164	1,500
%[1]	0.84	0.0024	8.0	0.10	1.5	0.18	1.0
%[2]	0.11	0.0004			0.22	0.026[3]	0.20
Targets concerning electricity production from solid biomass							
GWh/a			13,000	150 / 350[4]	2,500		
%[1]			14.0	0.6 / 1.2[5]	7.2		
%[2]					1.0		
until year			2010	[4] [5]	2005		
Amount of electricity produced from renewables (excluding hydropower)							
GWh/a	1,911	884	9,000	902	6,490	2,963	4,200
%[1]	3.9	1.64	11.0	1.13	21.1	3.1	2.8
%[2]	0.51	0.27			3.0		0.7
Targets concerning electricity production from renewables (excluding hydropower)							
GWh/a		1,352	14,000	5,500	9,400		
%[1]	2 / 3 / 4[7]	2.5	15	5	29	6 / 9[9]	
%[2]		0.42			3.86	5 / 10[10]	[6]
until year	2008	2010	2010	2010	2010		2010

The current and targeted values for the electricity production from solid biomass and from renewables are summarised in Figure 2.1. Figure 2.2 shows the ratio of the targeted to the current electricity production from solid biomass and renewables. Austria, Switzerland and the Netherlands have no specific targets defined for the electricity production from solid biomass and Sweden has not defined any target in this context. However, a total increase of electricity production from renewables (including hydropower) by approximately 10 TWh from 76 to 86 TWh has been defined in Sweden.

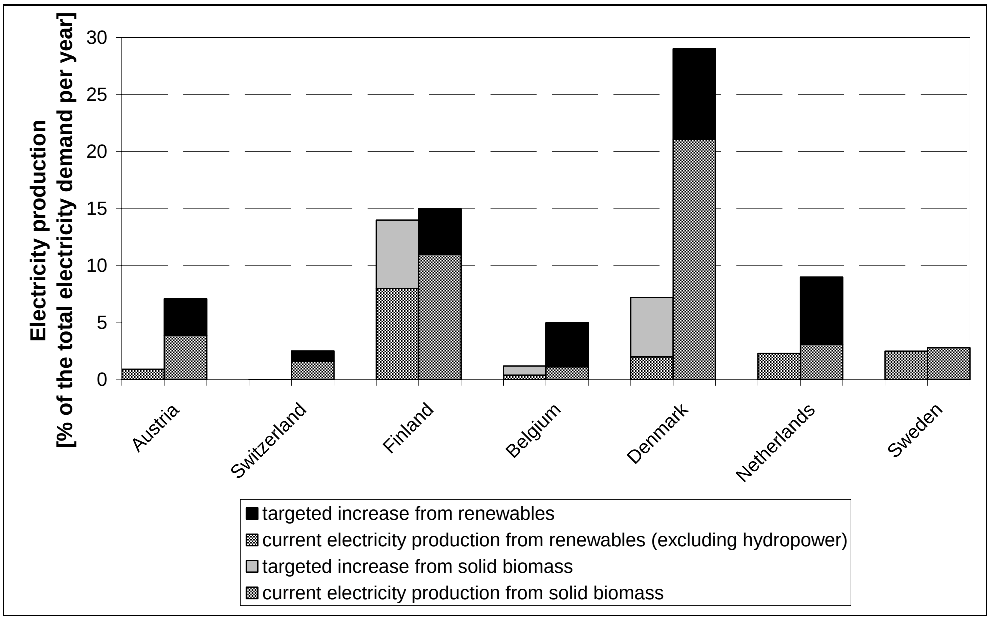

Figure 2.1: Current and targeted electricity production from solid biomass and from renewables

Explanations: for the year, until the targets should be achieved, see Table 2.1; current electricity production from Switzerland, Finland, Denmark and the Netherlands based on the year 2001, for Austria and Sweden on the year 2002 and for Belgium on the year 2003 (estimation); the targeted increase from renewables for Austria is related to an increase of the electricity production of approved green electricity generation plants from currently 0.84 to 4% in the year 2008 (without consideration of not approved green electricity generation plants, e.g. plants in the pulp and paper industry and other industrial plants, which do not supply green electricity to the public grid)

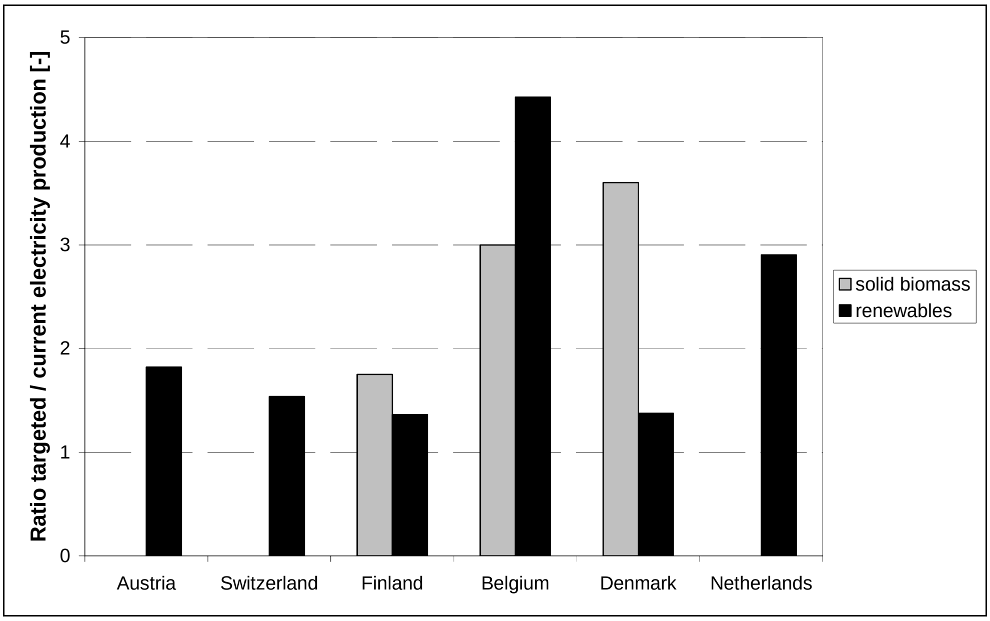

Figure 2.2: Ratio of the targeted to the current electricity production from solid biomass and renewables (excluding hydropower)

Explanations: for the year, until the targets should be achieved, see Table 2.1; current electricity production from Switzerland, Finland, Denmark and the Netherlands based on the year 2001, for Austria and Sweden on the year 2002 and for Belgium on the year 2003 (estimation)

2.2 Investment subsidies for CHP plants based on biomass combustion

Three countries indicated that investment subsidies for CHP plants based on biomass combustion are available, i.e. Finland, Belgium and the Netherlands. Table 2.2 summarises the respective regulations in the countries mentioned.

Table 2.2: Framework conditions for investment subsidies for CHP plants based on biomass combustion

Explanations: DEN…Duurzame Energie in Nederland (valid for first of their kind demonstration plants); EIA…Energie Investerings Aftrek (valid for all biomass CHP plants which achieve an efficiency higher than a defined target value); n.i.…no indication; 1)...total available funding budget for energy production (no indication regarding the achievable funding for a single application); 2)…minimum overall delivered annual energy efficiency of 40%, based on η_{el} + 0,66 * η_{th}; 3)…source separated recycled fuel (from municipal waste and industrial packaging waste, 60% is biodegradable); 4)…all biomass and waste derived fuels; 5)…impregnated wood (is hazardous waste); 6)…for investments up to 454,000 €, 25% for additional investments above that amount; 7)…no direct subsidy, 55% of the investment is tax deductible in the first year and average entrepreneurs pay some 35% tax (so this is comparable to an investment subsidy of about 19%, provided that enough profit is made to be able to subtract this amount of money from the income); 8)…5 to 15% are typical amounts granted for large units (reviewed case by case), 20% is the maximum for small-scale units

	Unit	Finland	Belgium	Netherlands (DEN)	Netherlands (EIA)
Investment subsidies	% of I	5 - 15 / 20 8)	15	40 6)	19 7)
Upper limit	€	12.1 M€ 1)		900,000	
Minimum efficiencies	yes/no	no	no	no	yes 2)
Allowed fuels:					
Untreated solid woody biomass		x	n.i.	x	x
Untreated solid herbaceous biomass		x	n.i.	x	x
Wood processing residues (untreated)		x	n.i.	x	x
Recycled waste wood (not contaminated)		x	n.i.	x	x
Wood processing residues (slightly treated)		x	n.i.	x	x
Waste wood according to EU-directive 2000/76/EC			n.i.	x	x
Other fuels		x 3)	n.i.	x	x
Excluded fuels:					
Meat and bone meal			n.i.		
Waste liqueur			n.i.		
Sewage sludge			n.i.		
Municipal waste			n.i.		x
Other fuels		x 5)	n.i.		x 4)

In Finland small-scale units usually receive an investment subsidy of up to 20%. Large-scale units are reviewed by each individual case. Typical amounts for the investment subsidies granted have been 5 to 15% recently. Only companies or associations can get investment subsidies, not individual persons. The total available funding budget for the sector "energy production" is 12.1 mio Euro. In addition, a special demonstration investment subsidy for large-scale units is available. Furthermore, investment subsidies can also be gained for wood harvesting equipment. Private consumers are excluded from this funding system. Only the Finnish regulation defines targets for renewable energy sources, which are shown in Table 2.3. Further demands which are essential to gain investment subsidies in Finland are, that a new technology should be applied and that a CO_2 mitigation can be achieved (such new technologies would have an advantage over other technologies).

Table 2.3: Targets for renewable energy sources in Finland according to the proposal of the working group for a revised Action Plan for Renewable Energy

Explanations: [1]…not included in the Action Plan, estimation of the Finnish Ministry of Trade and Industry; [2]…number includes only a biodegradable share of recovered fuels, which is estimated to be about 60%. Demolition and construction wood is not included in REF. They are part of the industrial wood residues. Numbers are not targets, only estimations of the energy recovery that waste management targets will achieved; [3]…preliminary target, which will be specified later; [4]…new investments to large scale hydro are not included in the Action Plan, estimation of the electricity producers; data source "Renewable Energy Sources in Finland 2002 - OPET Report 9", available at "http://www.tekes.fi/opet/pdf/OPET_report9.pdf"

	1995	**2001**	**2005**		**2010**		**2025**	
	PJ	PJ	PJ	Increase from year 2001,%	PJ	Increase from year 2001,%	PJ	Increase from year 2001,%
BIOENERGY BY SECTORS	**209**	**267**	**305**	**14**	**349**	**31**	**414**	**55**
Industry	156	202	215	6	230	14	268	33
District heating	8	16	30	88	44	175	61	4
Firewood (households)	45	49	59	21	72	46	76	55
Transport								
BIOENERGY TOTAL BY FUELS	**208.6**	**267.2**	**304**	**14**	**349**	**31**	**414**	**55**
Spent liquors from forest industry[1]	109.0	133.7	143	7	154	15	167	25
Industrial wood residues	51.8	76.6	80	4	84	9	92	20
Firewood (excl. forest chips)	43.7	45.8	50	8	54	19	59	28
Forest chips	3.1	9.4	22	133	38	4 times	63	7 times
REF[2]	0.36	1.01	5	5 times	10	10 times	10	10 times
Biogas	0.65	0.75	2.3	3 times	4.2	6 times	8	11 times
Agrobiomass	0.00	0.00	0.9		2.1		5	
Liquid biofuels (for transport sector)[3]	0.00	0.00	1.4		3.1		9	
HYDROPOWER	**46.0**	**46.9**	**49**	**5**	**52**	**12**	**58**	**23**
of which >10 MW[4]	41.8	42.8	44	2	45	4	46	8
of which < 10 MW	4.2	4.1	6	39	8	88	11	175
WIND POWER	**0.04**	**0.25**	**1.2**	**5 times**	**4.0**	**16 times**	**17**	**70 times**
SOLAR ENERGY	**0.013**	**0.021**	**0.16**	**8 times**	**0.33**	**16 times**	**3.3**	**200 times**
PV	0.004	0.008	0.08	10 times	0.17	20 times	1.7	200 times
Solar heat	0.008	0.013	0.08	6 times	0.17	147	16	6 times
HEAT PUMPS	**1.84**	**2.73**	**4**	**55**	**7**	**147**	**16**	**6 times**
TOTAL	**256**	**317**	**359**	**13**	**412**	**30**	**508**	**60**

Two regulations exist in the Netherlands. The regulation DEN (Duurzame Energie in Nederland) is valid for first of their kind demonstration projects. The regulation EIA (Energie Investerings Aftrek) is valid for all biomass CHP plants which achieve an efficiency higher than a defined target value (see Table 2.2). In the Netherlands, the regulation is issued annually with a fixed budget. Following, due to the increasing number of proposals the chances of funding are only good for innovative projects with a high replication potential. In the Netherlands the project applications within the DEN regulation are ranked based on their ratio of contribution to CO_2 mitigation to requested subsidy. In addition, the innovative character and the market potential for replications are important parameters. The budget available for the EIA regulation is 209 M€.

In Belgium utilities are not entitled to get subsidies from this funding system. Changes of the regulation are planned. The regulation should change to a rate of 40% of the additional investment costs compared to standard power plants with the same energy output. In addition, utilities should be entitled to get access to investment subsidies.

2.3 Increased feed-in tariffs for electricity from biomass

2.3.1 Specification of the feed-in tariffs

Six countries indicated, that increased feed-in tariffs (or other support for electricity production from renewable energy sources) for electricity from biomass are available, i.e. Austria, Finland, Belgium, Denmark, the Netherlands and Sweden. The feed-in tariffs of Austria, Denmark and the Netherlands can directly be compared and are summarised in Table 2.4. In addition, information available from Germany and Italy are also shown in this table. The systems in Finland, Belgium and Sweden are different and will be explained in more detail later in this section.

The Austrian feed-in tariffs depend both on the electric capacity of the CHP plant and on the biomass fuel used. Taking these framework conditions into consideration, the feed-in tariff for green electricity in Austria varies in a broad range between 6.63 and 16.0 €Cent/kWh$_{el}$. A detailed overview of the Austrian feed-in tariffs for electricity from solid biomass is given in Figure 2.3. If fuel mixtures are used, a proportional feed-in tariff based on the proportional fuel energy input must be applied.

Table 2.4: Feed-in tariffs for electricity from biomass in selected countries

Explanations: [1)]...lower limit valid for plants > 10 MW$_{el}$ fired with contaminated fuels like particle board wastes, demolition wood, salt impregnated wood, etc., upper limit for plants < 2 MW$_{el}$ fired with fuels like forest wood chips, for details see Figure 2.3; [2)]…including basic market based price for CHP plants, subsidy granted for electric power generation from straw, wood chips or other solid biomass fuels and the refunded CO_2 tax (valid for plants built before 2002); [3)]…including the basic price for grey electricity, the contribution for biomass CHP plants and the value of green certificates for biomass CHP, lower limit valid for plants > 50 MW$_{el}$, upper limit for plants < 50 MW$_{el}$; [4)]…lower limit valid for plants with an electric capacity between 5 and 20 MW fired with biomass, upper limit valid for plants < 75 kW fired exclusively with plants or parts of plants or with liquid manure according to the EU directive 1774/2002; [5)]…additional information about countries not included in the questionnaire survey; [6)]…market based basic price between 4.5 and 5.0 €Cent/kWh$_{el}$, additional price for tradeable certificates between 6 and 8 €Cent/kWh$_{el}$

	Austria	Denmark	Netherlands	Germany[5)]	Italy[5)]
Feed-in tariff [€Cent/kWh$_{el}$]	6.63 - 16[1)]	8.5[2)]	8.7 - 10.7[3)]	8.4 - 15.5[4)]	10.5 - 13.0[6)]

In Denmark there are no standard increased feed-in tariffs available for decentralised CHP plants based on biomass combustion built after 2002. Existing CHP plants built before 2002, however, receive an increased feed-in tariff, consisting of different components. Biomass CHP plants receive a market based price. The average payment according to this price is about 4.9 €Cent/kWh$_{el}$. In addition, a subsidy is granted for electric power generation from straw, wood chips or other solid biomass fuels, which amounts to 2.3 €Cent/kWh$_{el}$. Finally, the CO_2 tax of 1.3 €Cent/kWh$_{el}$ is refunded which results in a total increased feed-in tariff for electricity from biomass in Denmark of about 8.5 €Cent/kWh$_{el}$. This tariff is independent from the plant size and the fuel used.

The feed-in tariff for electricity from biomass in the Netherlands depends on the capacity of the CHP plant. The feed-in tariff consists of three components. The basis forms the price of grey electricity of about 2.9 €Cent/kWh$_{el}$. The contribution to the feed-in tariff for CHP plants based on biomass combustion for plants < 50 MW$_{el}$ is 6.8 €Cent/kWh$_{el}$, for plants > 50 MW$_{el}$ this contribution amounts to 4.8 €Cent/kWh$_{el}$. In addition, the value of green certificates for CHP plants based on biomass combustion is about 1 €Cent/kWh$_{el}$. This results in a total feed-in tariff between 8.7 and 10.7 €Cent/kWh$_{el}$ in the Netherlands.

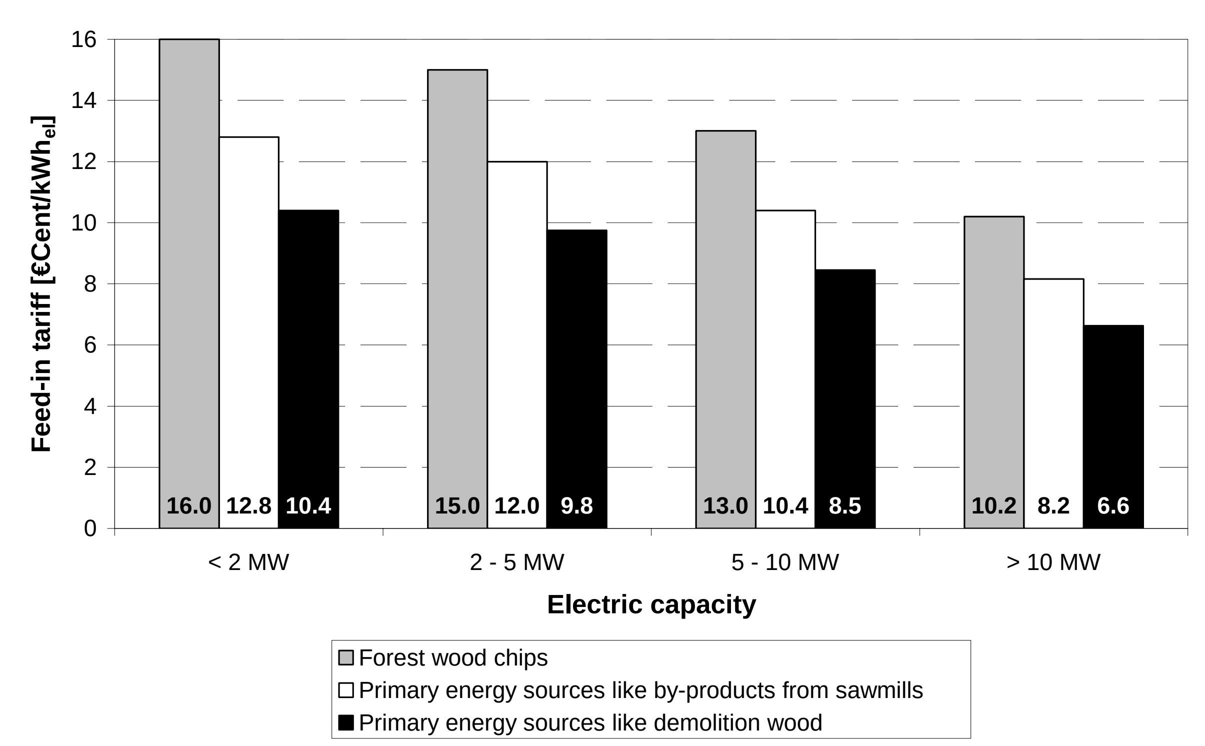

Figure 2.3: Feed-in tariffs in Austria for electricity from solid biomass

A tax subsidy for electricity production from renewable energy sources was introduced in 1997 in Finland. According to this subsidy, the tax paid by the consumer on the electricity produced with wood-based fuels, biogas, small hydro (< 1 MW) and for peat fuelled CHP plants (< 40 MVA) is refunded as subsidy to the producer. This refund amounts to 0.42 €Cent/kWh$_{el}$. For forest wood chips and wind power the subsidy is 0.69 €Cent/kWh$_{el}$.

The support of electricity production from biomass in Belgium is based on certificates for green electricity and is different in Flanders and in Wallonia. In Flanders 1 certificate per MWh green electricity is granted. The value of one certificate amounted to 100 € in 2003 and to 125 € from 2004 on, which is equal to a feed-in tariff of 10 and 12.5 €Cent/kWh$_{el}$, respectively. The percentage of green electricity that a supplier has to deliver amounted to 0.8 in 2002 and will increase to 5% by 2010. In Wallonia τ certificates per MWh$_{el}$ are granted, where τ is the relative saved CO_2 quantity per year with respect to the same electricity production with a standard natural gas combined cycle power plant (STAG) with an efficiency of 55%. The value per certificate is 100 €. Values for τ for different energy sources are shown in Table 2.5. The percentages to be achieved for green electricity amounted to 3% in 2003 and will increase to 12% by 2010.

Table 2.5: Values for τ for the Wallonian support system for green electricity

Energy source	τ
Wind and hydro	1.0
CHP power plants firing natural gas	0.2 - 0.3
Biomass plants generating electricity only	0.8 - 1.0
CHP plants firing biomass or biogas	> 1

The increased feed-in tariffs for electricity from biomass in Sweden are market based. The principal of the system applied in Sweden for introducing renewable electricity is to legislate an increasing fraction of renewable electricity. The same market based price for renewable energy applies to all renewables. Special rules apply to hydropower for bigger plants (installed capacity > 1,500 kW_{el}).

2.3.2 Additional demands to gain increased feed-in tariffs

In Flanders (Belgium) a minimum of 5% primary energy must be spared compared to separate heat and electricity production (in the same amount) with a hot water or steam boiler and a combined cycle power plant to gain increased feed-in tariffs. In Wallonia (Belgium) spared CO_2 must deliver a τ factor of at least 0.1. In Denmark a minimum total efficiency of CHP plants based on biomass combustion of 80% is required to gain increased feed-in tariffs. The total efficiency of CHP plants based on biomass combustion is defined according to Equation 2.1. The other countries having increased feed-in tariffs have not defined such demands.

Equation 2.1:
$$\eta_{tot} = \frac{P_{el} + P_{th}}{Q_{fuel(NCV)}}$$

Explanations: η_{tot}…total efficiency; P_{el}…net electric power produced; P_{th}…thermal power output; $Q_{fuel(NCV)}$…fuel power input related to the net calorific value

2.3.3 Fuels allowed to be used in CHP plants based on biomass combustion benefiting from the increased feed-in tariffs

The fuels allowed to be used in CHP plants based on biomass combustion benefiting from the increased feed-in tariffs are shown for the respective countries in Table 2.6.

In Flanders (Belgium), additionally to the fuels stated in Table 2.6 the following “other fuels” are allowed to be used:

- Biogas generated through fermentation of organic biological matter either in landfills or in biogas plants.
- Animal matter including the biogas that it can generate.
- Biomass according to the definition given by the European Incineration Directive 2000, including the biogas that it can generate, if it is not treated together with solid waste.

- The following organic waste streams that are not part of the biomass definition, including the biogas that they can generate, and if they are not treated together with solid waste:
  - animal waste,
  - road cleaning waste,
  - green, fruit and vegetables,
  - green waste,
  - organic biological waste that is sorted out of municipal solid,
  - sewage sludge,
  - deep-fry oil.

The "other fuels" allowed to be used in Denmark according to Table 2.6 have been stated according to the annex of the Statutory order from the Ministry of Environment and Energy no. 638 of 3rd July 1997 on biomass waste, which specifies the following fuels as approved:

- Raw wood, including bark, whole tree chips and unprocessed sawmill chips.
- Clean wood (including chips and sawdust) without any content of glue, varnish, impregnating agents, paint (apart from sawmill stamps and similar), film, laminates, nails, screws, fittings, etc..
- Wood waste from the production and processing of clean plywood and similar glued wood products with a content of glue (phenol resorcinol glue, polyvinyl acetate glue, urea formaldehyde glue, polyurethane glue and melamine urea-formaldehyde glue) not exceeding 1%, measured as percentage by weight of dry matter.
- Straw (including twine from bales).
- Seeds and stones from fruit and berries.
- Fruit residues (dry fruit fractions).
- Nutshells and husks (including screenings from corn and seeds).
- Untreated cork.
- Untreated corn and seeds.
- Untreated cotton and flax.
- Ice-cream sticks containing paraffin approved as food, not exceeding 1‰, measured as percentage by weight of dry matter.
- Greenfeed pellets.
- Mash.
- Thatch.
- Tobacco waste in the form of whole or shredded tobacco leaves, stems etc..
- Fuel pellets and briquettes exclusively produced from waste featuring in this list.

Table 2.6: Fuels allowed to be used in CHP plants based on biomass combustion benefiting from increased feed-in tariffs or other support for electricity production from renewable energy sources

Explanations: 1)...source separated recycled fuel (from municipal and industrial packaging waste, 60% is biodegradable); 2)...see explanations in the text

Fuel	Austria	Finland	Belgium	Denmark	Netherlands	Sweden
Untreated solid woody biomass, e.g. forest wood chips	x	x	x	x	x	x
Untreated solid herbaceous biomass, e.g. straw	x	x	x	x	x	x
Wood processing residues (untreated), e.g. industrial wood chips, sawdust, bark	x	x	x	x	x	x
Recycled waste wood (not contaminated), e.g. pallets	x	x	x	x	x	x
Wood processing residues (slightly treated), e.g. particle board wastes	x	x	x	x	x	x
Recycled waste wood (contaminated), e.g. demolition wood, salt impregnated wood, wood containing halogenorganic compounds, railway sleepers (waste wood according to EU-directive 2000/76/EC)	x		x		x	x
Other fuels		x1)	x2)	x2)		

Meat and bone meal, waste liqueur and sewage sludge are explicitly excluded from the support systems for green electricity in Austria, Denmark and Sweden. In Denmark and Sweden municipal waste is additionally excluded. In Sweden, e.g., waste wood fractions, which are sorted out from municipal waste, are, however, included in this support system. In the Netherlands only sewage sludge is explicitly excluded.

2.3.4 Validity of the increased feed-in tariffs

Apart from Finland, where the support for electricity is based on yearly decisions since 1995 in the state budget, all countries with increased feed-in tariffs secure them for a specific period of time.

The Austrian feed-in tariffs are secured for a period of 13 years after start-up of the plant. Concerning the present regulation, the plant must be approved between the 1st of January 2003 and the 31st of December 2004 and must start-up before the 30th of June 2006.

In Flanders (Belgium) the amount of granted CHP certificates decreases according to lifetime, being zero after 20 years. In Wallonia (Belgium) the certificates are granted during a maximal period of 10 years.

The feed-in tariffs in Denmark are secured for 10 years, but valid only for plants put into operation before 2002. In the Netherlands the feed-in tariffs are secured for 10 years, except for very large plants (>50 MW_{el}) for which three years apply.

In Sweden the government will secure a minimum price for five years, starting at approximately 6 €/MWh going down linearly to 2 €/MWh in the year 2007.

2.4 Emission limits for CHP plants based on biomass combustion

An overview of the emission limits for CHP plants based on biomass combustion in Austria, Finland, Belgium, Denmark and Sweden is shown in Table 2.7. The parameters for which emission limits are defined, are dust, CO, NO_x, SO_x, total organic carbon (TOC) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F). However, not all countries have defined emission limit for all parameters mentioned. No emission limit exists for CO in Finland and Denmark. Emission limits for SO_x are only defined in Belgium, Denmark and Sweden. An emission limit for total organic carbon only exists in Austria and the emission of PCDD/F are only regulated in Belgium.

The emission limits in the Finnish regulation are expressed in mg/MJ. The re-calculation to mg/Nm^3 (see Table 2.7) has been done according to Equation 2.2, taking a wood fuel with a water content of 50 wt.% and a reference oxygen content in the dry flue gas of 13 vol.% (valid for small-scale applications) as well as of 6 vol.% (valid for large applications) into consideration.

Equation 2.2:

$$C\left[\frac{\mathrm{mg}}{\mathrm{Nm}^3_{\mathrm{FG_{dr}},\mathrm{O_{2,ref}}}}\right]_i = C\left[\frac{\mathrm{mg}}{\mathrm{MJ}}\right]_i \cdot \frac{\mathrm{NCV}.\left[\frac{\mathrm{MJ}}{\mathrm{kg_{fuel\,(w.b.)}}}\right]}{\frac{\mathrm{kg_{fuel\,(d.b.)}}}{\mathrm{kg_{fuel\,(w.b.)}}} \cdot V_{\mathrm{FG,spec}}\left[\frac{\mathrm{Nm}^3_{\mathrm{FG_{dr}}}}{\mathrm{kg_{fuel\,(d.b.)}}}\right]_{\lambda=1} \cdot \lambda_{\mathrm{O_{2,ref}}}}$$

Explanations: C...concentration; i...component; FG...flue gas; dr...dry; $O_{2,ref}$...reference oxygen content; d.b....dry base; w.b....wet base; NCV...net calorific value; $V_{FG,spec}$...specific volume of the flue gas (between 3.7 and 4.7 depending on the biomass, for woody biomass an average value of about 4.6 can be considered); λ...air ratio; $\lambda_{O2,ref} = 2.6$ (guiding value for wood)

Table 2.7: Overview of the emission limits in the participating partner countries (except the Netherlands)

Explanations: PCDD/F...dioxins and furans; FEI…fuel energy input; r.c.o.…range covered otherwise; W…woody biomass; S…straw; P…peat; BM…biomass; WW…waste wood; ex.…existing plant; new…new plant; TEQ…toxicity equivalent; [1)]…expressed in ng TEQ/Nm^3; [2)]…for plants built before the 12th of February 1987 to be calculated using emission limit [mg/MJ] = 85 – 4 x (FEI – 5) / 3; [3)]…higher value valid for peat using burners, lower value valid for peat (other techniques) and wood or straw; [4)]…valid for biomass; [5)]…200 mg/Nm^3 from 1st of January 2016; [6)]…6% O_2; [7)]…daily / hourly average

Country		Austria	Finland$_{ex.}$	Finland$_{new}$	Belgium	Denmark	Denmark	Sweden
Fuel		W	W, S, P	BM / peat	BM	W, WW / S	BM$_{ex.}$/BM$_{new}$	BM
Parameter	FEI [MW]	mg/Nm$^3_{13\%O2}$	mg/Nm$^3_{13\%O2}$	mg/Nm$^3_{6\%O2}$	mg/Nm$^3_{11\%O2}$	mg/Nm$^3_{10\%O2}$	mg/Nm$^3_{6\%O2}$	mg/Nm$^3_{6\%O2}$
Dust	< 0.12	150	-	-	150	-	-	350
	0.12 - 1	150	-	-	150	300[4)]	-	100
	1 - 2	150	265	-	150	40	-	100
	2 - 5	50	265	-	150	40	-	100
	5 - 10	50	397[2)]	-	30	40	-	100
	10 - 30	50	159[2)]	-	30	40	-	35
	30 - 50	50	79[2)]	-	30	40	-	35
	50 - 100	50	50[6)]	50	10	-	100 / 50	35
	100 - 300	50	50[6)]	30	10	-	100 / 30	30
	300 - 500	50	30[6)]	30	10	-	100 / 30	30
	> 500	50	30[6)]	30	10	-	50 / 30	30
CO	0.1 - 0.12	250	-	-	250	-	-	-
	0.12 - 1	250	-	-	250	500[4)]	-	-
	1 - 5	250	-	-	250	500 / 625	-	250 / 500[7)]
	5 - 50	100	-	-	200	500 / 625	-	250 / 500[7)]
	> 50	100	-	-	100	-	-	250 / 500[7)]
NO_x	< 0.1	-	-	-	r.c.o.	400 / -	-	-
	0.1 - 5	250	-	-	r.c.o.	400 / -	-	200 - 300
	5 - 10	250	-	-	r.c.o.	300	-	200 - 300
	> 10	200	-	-	r.c.o.	300	-	200
	> 100	200	199 / 238[3)]	-	r.c.o.	300	-	200
	< 30	r.c.o.	-	-	400	r.c.o	-	200
	30 - 50	200	-	-	200	300	-	200
	50 - 100	200	373[6)]	400	200	300	600 / 400	150 - 200
	100 - 300	200	373[6)]	300	200	300	600 / 300	150 - 200
	300 - 500	200	124[6)]	150	130	300	600 / 200	150 - 200
	> 500	200	124[6)]	150	130	300	500[5)] / 200	150 - 200
SO_x	< 50	-	-	-	300	-	-	-
	50 - 100	-	-	200 / 400	50	-	200	200
	> 100	-	-	200 / 200	50	-	200	200
TOC	> 0.1	50	-	-	-	-	-	-
PCDD/F[1)]	> 5	-	-	-	0.1	-	-	-

Table 2.8 provides an overview of the current emission standards that may apply to bioenergy installations in the Netherlands. These standards are the general Netherlands Emission Guidelines (Nederlandse Emissierichtlijn, NER), a special arrangement under the NER for combustion of clean waste wood (NER-BR for clean waste wood), a special arrangement under the NER for biomass pyrolysis (NER-BR for pyrolyse), the emission standards for large combustion units (Besluit Emissie Eisen Stookinstallaties, BEES A) and the degree for airborne emissions from waste incineration units (Besluit Luchtemissie Afvalverbrandingsinstallaties, BLA).

The fuel and the size of the installation determine which emission limits apply. For industrial combustion of clean waste wood in an installation owned by the producer of the wood with an installed capacity not exceeding 5 MW$_{th}$, the NER-BR for clean waste wood applies. For other combustion units, the BEES A or the NER apply. The NER needs to be interpreted with the typical oxygen content under standard process conditions: for biomass combustion this is about 11 vol.% O_2, for gas engines 3 vol.% O_2 and for gas turbines 15 vol.% O_2.

For gasification, the BEES A applies sometimes in combination with the NER or the Bijzondere Regeling Pyrolysis. The limits mentioned are guidelines issued by the national government; in practice, the local permit-issuing authority (e.g. the municipal government) may decide which exact limits apply.

Table 2.8: Overview of the emission limits for CHP plants based on biomass combustion for clean fuels in the Netherlands

Explanations: VOS…volatile organic substances; NER...Nederlandse Emissierichtlijn; BLA...Besluit Luchtemissie Afvalverbrandingsinstallaties; BEES A...Besluit Emissie Eisen Stookinstallaties; PCDD/F...dioxins and furans; TEQ...toxicity equivalent; 1)...valid for combustion of clean waste wood; 2)...valid for pyrolysis; 3)...if it is possible to apply a filtration system such as a cloth filter; 4)…the limit is 200 $mg/Nm^3_{11\%O2}$, but in practise the limit for manure combustion is applied for all forms of bioenergy, which is 5 $mg/Nm^3_{11\%O2}$; 5)…only if larger than 250 kW_{th} and with more than 80% particle board in the fuel; 6)…< 0.5 MW_{th}; 7)…0.5 – 1.5 MW_{th}; 8)…1.5 – 5 MW_{th}; 9)…> 300 MW_{th}; 10)…< 300 MW_{th}

Parameter	Unit	Regulation				
		NER	NER-BR 1)	NER-BR 2)	BLA	BEES A
NO_x	$mg/Nm^3_{11\%O2}$	200	400 5)	39	70	133 9) 67 10)
Dust	$mg/Nm^3_{11\%O2}$	10 3)	100 6) 50 7) 25 8)	2.8	5	13
SO_2	$mg/Nm^3_{11\%O2}$	200	-	22	40	133
Cd+TI	$mg/Nm^3_{11\%O2}$	0.2	-	0.02	0.05	-
Hg	$mg/Nm^3_{11\%O2}$	0.2	-	0.02	0.05	-
Total heavy metals	$mg/Nm^3_{11\%O2}$	25.4	-	0.6	1	-
HCl	$mg/Nm^3_{11\%O2}$	30	-	5.6	10	-
HF	$mg/Nm^3_{11\%O2}$	5	-	-	1	-
PCDD/F	ng TEQ/Nm^3	minimisation	-	0.05	-	-
VOS	$mg/Nm^3_{11\%O2}$	20-150	-	6	10	-
NH_3	$mg/Nm^3_{11\%O2}$	200 4)	-	5	-	-
CO	$mg/Nm^3_{11\%O2}$	-	250 8)	-	50	-

To reduce the complexity of the various existing guidelines for energy from biomass in the Netherlands, a new emission limit guideline was drafted. This guideline, which is based on the EU proposal for large combustion plants, is provided in Table 2.9. As in the proposed EU guideline, clean and contaminated biomass fuels are distinguished. At the moment, it is not clear whether there will be a minimum size above which the limit will apply. For an installation with an electricity-equivalent efficiency exceeding 40%, the NO_x emission value is less strict than it is for a less efficient installation.

Table 2.9: Overview of proposed emission limits for large stand-alone biomass combustion and CHP plants in the Netherlands

Explanations: PCDD/F...dioxins and furans; VOS…volatile organic substances; TEQ...toxicity equivalent; [1]…> 20 MW_{th}; [2]…< 20 MW_{th} and $\eta_{el\text{-}eq}$ < 40%; [3]…< 20 MW_{th} and $\eta_{el\text{-}eq}$ > 40%

Parameter	Unit	Clean biomass 6 % O_2, dry	Contaminated biomass 11 % O_2, dry
NO_x	mg/Nm^3	NO_x emission trade[1]	NO_x emission trade[1]
		100[2]	70[2]
		200[3]	130[3]
SO_2	mg/Nm^3	200	40
Dust	mg/Nm^3	20	5
Cd + Tl	mg/Nm^3	-	0.05
Hg	mg/Nm^3	-	0.05
Total heavy metals	mg/Nm^3	-	0.5
HCl	mg/Nm^3	-	10
HF	mg/Nm^3	-	1
PCDD/F	ng TEQ/Nm^3	-	0.1
VOS	mg/Nm^3	-	10
CO	mg/Nm^3	-	50

3 Overview of CHP plants based on biomass combustion in operation in selected IEA partner countries

3.1 Development of CHP plants based on biomass combustion and current situation

An overview of CHP plants based on biomass combustion already in operation in the participating countries is shown in Table 3.1. Finland is the country with both the highest number of CHP plants installed and the highest electric and thermal capacity installed. In spite of the relatively high number of CHP plants based on biomass combustion in Austria, the total electric capacity installed is low. This is due to the fact that the Austrians applications are usually decentralised CHP plants in the low or medium capacity range. Whereas Denmark and Sweden with a smaller number of installed plants reach a similar total capacity installed, because medium and large-scale application are commonly applied. The majority of the plants (as far as known) are operated heat controlled. An overview of the development of CHP plants based on biomass combustion in Austria, Switzerland, Finland, Denmark and the Netherlands is shown in Table 3.2. From Belgium and Sweden no respective data are available.

Table 3.1: Overview of CHP plants based on biomass combustion in operation

Explanations: 1)…exclusive of central CHP units (large CHP plants > 100 MW_{el}, located near larger cities); 2)…including the fuel capacity of 2 plants co-firing biomass: with natural gas generating 89 MW_{el} and with coal 19.6 MW_{el}; 3)…including the fuel capacity of 2 plants co-firing biomass: with natural gas generating 174 MW_{th} and with coal 60 MW_{th}, figure is exclusive of thermal capacity delivered as industrial steam in 3 CHP units in the wood industry; 4)…the plants indicated have been built with governmental support, several others without support have been built but there is no total number of them available; 5)…for the 15 plants above

	Unit	Austria	Switzerland	Finland	Belgium	Denmark	Netherlands	Sweden
Total number	-	62	3	80	1	16 1)	3	15 4)
Total electric capacity installed	MW_{el}	310		2,000	27	209.4 2)	27	340 5)
Total thermal capacity installed	MW_{th}		15.7	5,000		416.1 3)	5.3	1,000 5)
Heat controlled operation	%			90		88	33	100
Electricity controlled operation	%			10		12	67	0

Table 3.2: Development of CHP plants based on biomass combustion installed in the participating countries

Explanations: no data from Belgium and Sweden available; n.i....no indication; 1)…outlook

Year	Austria	Switzerland	Finland	Denmark	Netherlands
Number of plants installed					
1990	22	0	n.i.	6	n.i.
1995	25	2	50	9	n.i.
2000	32	3	70	14	2
2003 1)	62	n.i.	80	16	3
Electric capacity of the plants installed [MW_{el}]					
1990	212	n.i.	n.i.	31	n.i.
1995	223	n.i.	n.i.	79	n.i.
2000	234	n.i.	n.i.	120	n.i.
2003 1)	310	n.i.	2,000	209	n.i.
Thermal capacity of the plants installed [MW_{th}]					
1990	n.i.	n.i.	n.i.	49	n.i.
1995	n.i.	n.i.	n.i.	179	n.i.
2000	n.i.	n.i.	n.i.	242	26
2003 1)	n.i.	n.i.	5,000	416	27

Table 3.3 provides an overview of technologies applied for CHP plants in the participating countries and their power range. Thus, the most common CHP technology is the steam turbine with a power range between 600 kW and almost 700 MW (co-firing plants). All other technologies are, related to the number of plants already installed, of minor importance. However, especially for decentralised CHP plants based on biomass combustion (small and medium-scale applications) other technologies become more and more relevant. A common application in the range between 400 and 1,500 kW_{el} is the ORC process. The ORC process has been successfully introduced in the market in 1999. Other emerging technologies are the Stirling engine and the steam screw-type engine, where market introduction can be expected in the near future (most probably 2004). Steam piston engines are also applied for CHP plants based on biomass combustion. In addition, in the field of combined heat and power production from biomass in decentralised plants also plants based on biomass gasification are potential options. In this respect, fixed and fluidised bed gasification plants combined with gas engines are further technologies applied for CHP plants.

The number of CHP units based on steam turbines indicates this technology to be a well proven state-of-the-art technology in this field of application with installations in all participating countries, i.e. in Austria, Belgium, Denmark, Finland, the Netherlands, Switzerland and Sweden. The use of steam turbines is most common for co-combustion units, but their application in decentralised CHP plants based on biomass combustion is also well proven. However, there are several emerging technologies for smaller capacity ranges.

The two plants based on a steam piston engine are located in Finland. Due to several technical problems, the steam piston engine has been thrown back in his development.

A biomass CHP plant based on a steam screw-type engine cycle with a nominal electric capacity of 800 kW_{el} has recently (November 2003) been put in operation in Hartberg in Austria in the framework of an EU demonstration project (No. NNE5/2000/467). The nominal thermal capacity of the plant amounts to 7,000 kW_{th}. The plant is the first biomass CHP plant based on steam screw-type technology worldwide.

Table 3.3: Overview of the technologies applied for CHP plants in the participating countries and their capacity range

Explanations: n.i.…no indication; 1)…in addition to plants in the selected IEA partner countries investigated, 5 plants in Germany and 1 plant in Italy are in operation; year of observation: 2003

CHP technology	Number	Capacity range [MW_{el}]
Combustion based systems		
Steam turbine	127	0.6 - 697
Steam piston engine	2	1
Screw-type engine	1	0.8
ORC process	7 1)	0.4 - 1.5
Stirling engine	3	0.035 - 0.075
Directly fired gas turbine	n.i.	n.i.
Indirectly fired gas turbine	n.i.	n.i.
Gasification based systems		
Fixed bed gasification + gas engine	2	0.115 - 1.4
Fixed bed gasification + Stirling engine	1	0.031
Fluidised bed gasification + gas engine	3	< 1 - 10
Fluidised bed gasification + gas turbine	n.i.	n.i.

Seven CHP plants based on biomass combustion on the basis of an ORC process are already in operation in the participating partner countries, 5 in Austria and 2 in Switzerland. In addition to these plants in the partner countries, 5 plants based on an ORC process in Germany and 1 plant in Italy are in operation. The first ORC process in Europe in combination with biomass combustion was realised within an European demonstration project (EU THERMIE project „Biomass fired CHP plant based on an ORC cycle“ - BM/120/98/AT/IT) in the wood manufacturing company STIA in Admont (Austria). This plant with a nominal electric capacity of 400 kW is in operation since October 1999 [1; 2; 3; 4]. In Lienz in Austria the second ORC process in combination with biomass combustion has been installed in the framework of an EU demonstration project (project no. NNE5-475-2000) [3; 5]. The nominal electric capacity of the plant amounts to 1,000 kW_{el}, the nominal thermal capacity of the plant amounts to 5,000 kW_{th}. The plant was put into operation in February 2001. Based on the good experiences with these ORC processes, several further biomass CHP plants based on ORC processes have been installed in Austria, Germany, Italy and

Switzerland. The capacity range of the ORC process has in the meantime been expanded to about 1,500 kW_{el} and further installations are expected in the near future.

The three CHP plants based on biomass combustion on the basis of Stirling engines are located in Austria (2) and Finland (1). The first commercial demonstration of a biomass fired Stirling engine worldwide has been done in Oberlech, Austria, with a 4 cylinder Stirling engine with a nominal electric capacity of 35 kW_{el} and a nominal thermal capacity of 700 kW_{th} in the framework of a national demonstration project [6]. In Hard in Austria an EU demonstration project with a newly developed 8 cylinder Stirling engine process with a nominal electric capacity of 75 kW_{el} and a nominal thermal capacity of 500 kW_{th} has been realised. This is the first development and demonstration of a biomass fired 8 cylinder Stirling engine worldwide. The biomass fuels allowed to be used for the operation of biomass CHP plants based on a Stirling engine are at the moment confined to biomass fuels with low ash and chlorine content.

The decentralised biomass CHP systems based on gasification processes have not reached market introduction yet. All the plants already installed are pilot plants. The plants based on fixed bed gasification are installed in Denmark, i.e. in Ansager, Harboøre and Høgild. The plants in Harboøre (1.4 MW_{el}) and Høgild (115 kW_{el}) use the producer gas in gas engines. The plant in Ansager is based on a Stirling engine with 31 kW_{el}. The fluidised bed gasification systems based on gas engines are located in Austria, Finland and the Netherlands. The plant in Austria is located in Güssing and has a nominal electric capacity of 2.0 MW_{el} and a nominal thermal capacity of 4.5 MW_{th} [7]. The Finnish plant in Lahti has a total electric capacity of 167 MW where biomass covers about 15% of the fuel energy input [8]. Biomass is gasified in a circulating fluidised bed gasifier. The product gas is fed to a coal combustion power plant where complete burn-out of gas and char particles takes place. Another co-firing gasifier in combination with a gas engine is located in Amer in the Netherlands.

3.2 Potential and technological evaluation of the different technologies

The summarised estimation of the participating partners regarding important fields of application for different biomass CHP technologies is shown in Table 3.4. From the combustion based systems steam turbines, steam piston engines, screw-type engines, ORC processes and Stirling engines are already applied in one or more fields of application. Directly and indirectly fired gas turbines are seen as promising future options.

In the field of gasification based systems fixed and fluidised bed gasification in combination with gas engines and Stirling engines are already applied in pilot plants. In addition, fluidised bed gasification in combination with gas turbines is seen as a promising future options.

Steam turbines as well as ORC processes have already achieved their breakthrough in the fields of application stated. Decentralised biomass CHP plants based on the steam screw-type engine and the Stirling engine are expected to achieve a breakthrough in the near future (for both technologies demonstration units are already in operation). Almost all technologies (except steam turbine and steam piston engine systems) show a considerable potential concerning further technological development and the reduction of costs. This potential should be utilised within the next years in order to increase the competitiveness of biomass CHP systems.

Special focus concerning micro-scale biomass CHP plants should be put on Stirling applications (< 150 kW_{el}). Regarding small-scale systems between 400 and 1,500 kW_{el} ORC and screw-type engine processes are of special interest. Steam turbines are of special interest regarding larger applications above 2 MW_{el}.

Biomass CHP systems based on biomass gasification have not yet achieved a level of development which allows market introduction, but several demonstration plants are existing. The future will show whether a breakthrough for biomass CHP plants based on gasification can be achieved.

Table 3.4: Important fields of application for different biomass CHP plant technologies

Explanations: summary of the estimations of the participating partners for their respective country (i.e. Austria, Finland, Belgium, Denmark, the Netherlands, Sweden); x…already applied; o…promising future option

	Field of application					
Technology	District heating	Wood processing industry	Agriculture / forestry / farmers	Residential heating (small-scale)	Other industrial areas	Central CHP
Combustion based systems						
Steam turbine	x	x			x	x
Steam piston engine	o	x			o	
Screw-type engine	x	o				
ORC process	x	x		o		
Stirling engine	x	o	o	x	o	
Directly fired gas turbine	o	o				o
Indirectly fired gas turbine	o	o	o			o
Gasification based systems						
Fixed bed gasification + gas engine	x	o	o	o	o	
Fixed bed gasification + Stirling engine	x		o	o	o	
Fluidised bed gasification + gas engine	x	x		o	o	o
Fluidised bed gasification + gas turbine	o	o				

4 Conclusions

7 of the 14 IEA Task 32 members participated in this questionnaire survey providing an overview regarding decentralised CHP plants (usually < 20 MW_{el}) based on biomass combustion in selected IEA partner countries, i.e. Austria, Belgium, Denmark, Finland, the Netherlands, Sweden and Switzerland (the biomass allowed to be used within the framework of the respective national regulations is defined in the sections 2.2 and 2.3). All participating countries have defined different targets concerning electricity production from renewable energy sources, three countries (Belgium, Denmark and Finland) have additionally defined targets concerning electricity production from solid biomass.

Investment subsidies for CHP plants based on biomass combustion are granted in Finland, Belgium and the Netherlands (in an amount between 5 and 40% of the total investment costs). Six countries indicated, that increased feed-in tariffs (or other support for electricity production from renewable energy sources) for electricity from biomass are available, i.e. Austria, Finland, Belgium, Denmark, the Netherlands and Sweden. Except Finland, in all countries the feed-in tariffs are secured for a specific period of time.

Emission limits for CHP plants based on biomass combustion are defined for the following parameters in the respective countries:

- Dust: all participating countries
- CO: Austria, Belgium, Denmark, Netherlands, Sweden
- NO_x: all participating countries
- SO_x: Belgium, Denmark, Finland, Netherlands, Sweden
- TOC: Austria
- PCDD/F: Belgium, Netherlands

Several decentralised CHP plants based on biomass combustion are already in operation in the participating countries, most of them in Finland and Austria. The technology predominantly applied are steam turbines with nominal electric capacities of up to 700 MW_{el}. The steam turbine process is a well proven state-of-the-art technology in this field of application. ORC processes have successfully been demonstrated within two EU demonstration projects (Admont and Lienz in Austria) and have recently achieved market introduction in a capacity range between 400 and 1,500 kW_{el}. The worldwide first two demonstration projects for Stirling engines in biomass CHP plants are already ongoing in Austria with 4 and 8 cylinder Stirling engines (35 and 75 kW_{el}, respectively). A small series production of Stirling engines is planned to be launched in the years 2004/2005. Further CHP technologies based on biomass combustion are steam piston engines and steam screw-type engines. Due to several technical problems, the steam piston engine has been thrown back in his development. A biomass CHP plant based on a steam screw-type engine cycle with a nominal electric capacity of 800 kW_{el} has recently (November 2003) been put in operation in Hartberg in Austria in the framework of an EU demonstration project and show a promising performance.

Decentralised biomass CHP systems based on gasification processes have not reached market introduction yet. There are, however, several pilot plants already in operation. The future will show whether a breakthrough for biomass CHP plants based on gasification can be achieved.

5 Literature

1 HAMMERSCHMID Alfred, OBERNBERGER Ingwald, 2000: Biomasse-Kraft-Wärme-Kopplungen auf Basis des ORC-Prozesses am Beispiel des realisierten EU-THERMIE-Projektes in Admont (Österreich). In: Tagungsband zum 9. Symposium „Festbrennstoffe und umweltfreundliche Energietechnik“, Kloster Banz, Deutschland, ISBN 3-934681-09-3, OTTI Energie-Kolleg (Hrsg.), Regensburg, Deutschland, pp. 48-58

2 OBERNBERGER Ingwald, HAMMERSCHMID Alfred, BINI Roberto, 2001: Biomasse-Kraft-Wärme-Kopplungen auf Basis des ORC-Prozesses - EU-THERMIE-Projekt Admont (A). In: Tagungsband zur VDI-Tagung „Thermische Nutzung von fester Biomasse“, Salzburg, Mai 2001, VDI Bericht 1588, ISBN 3-18-091588-9, VDI-Gesellschaft Energietechnik (Hrsg.), Düsseldorf, Deutschland, pp. 283-302

3 OBERNBERGER Ingwald, 2003: Biomasse-Kraft-Wärme-Kopplung auf ORC-Basis – Vorstellung der EU-Demonstrationsprojekte Holzindustrie STIA/Admont und Fernheizkraftwerk Lienz in Österriech: In: Tagungsband zum 12. Symposium „Energie aus Biomasse – Biogas, Flüssigkraftstoffe, Festbrennstoffe“, Kloster Banz, Deutschland, ISBN 3-934681-28-X, pp. 204-210, Ostbayerrisches Technologie-Transfer-Institut e.V. (OTTI) (Hrsg.), Regensburg, Deutschland

4 Obernberger Ingwald, Bini Roberto, Neuner Helmut, Preveden Zvonimir: Biomass fired CHP plant based on an ORC cycle – project ORC-STIA-Admont, final report of the EU-THERMIE project No. BM/120/98, European Commission, DG TREN (ed.), Brussels, Belgium, 2001

5 OBERNBERGER Ingwald, THONHOFER Peter, REISENHOFER Erwin, 2002: Description and evaluation of the new 1,000 kWel Organic Rankine Cycle process integrated in the biomass CHP plant in Lienz, Austria. In: Euroheat & Power, Volume 10/2002, pp.18-25

6 BIEDERMANN Friedrich, CARLSEN Henrik, SCHÖCH Martin, OBERNBERGER Ingwald, 2003: Operating Experiences with a Small-scale CHP Pilot Plant based on a 35 kWel Hermetic Four Cylinder Stirling Engine for Biomass Fuels. In: Proc. of the 11th International Stirling Engine Conference (ISEC), Nov. 2003, Rome

7 HOFBAUER Hermann, RAUCH Reinhard, 2003: Biomasse Kraft-Wärme-Kopplung mit Wirbelschichtvergasung. In: Euroheat / Power, Volume 32/2003, pp. 50-55

8 KURKELA E. Solid recovered fuel gasification for co-combustion in pulversised coal-fired-boilers – Lahti case study, presented at the gasification workshop of the 12th European Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, June 2002, Amsterdam