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PROJECT INNOREF SUB-PROJECT BRIE



TECHNICAL MANUAL FOR IMPLEMENTATION AND PILOT ACTIONS BIOMASS USE IN LOCAL SYSTEMS

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1. Introduction, Basic Information

Rise in prices of fossil fuels, raised emphasis on environment and its preservation, sustainable growth of regions and other factors push us to the considerations and practical steps towards the use of renewable energy sources. In the conditions of the Czech Republic, **biomass has the largest potential** among all types of biomass. We have to realise that the biomass sources or landscape ability for its production is limited. Also the practical biomass use has its problems and risks. It is important to identify the problems, assess its relevance and eliminate and solve all the troubles in the maximal possible way.

The **BRIE sub-project** is one of eight sub-projects of the INNOREF project. The goals of INNOREF are use of local sources in the efficient way and the sustainable growth of regions. The BRIE sub-project aims at the energy biomass use, energy savings and global solutions of energy tasks.

Persons concerned in energy biomass use meet **quite a number of problems and obstructions** regarding the consumption, transformation of biomass and its production as well. This document is focused on the questions of production and transformation of biomass. The Technical Manual should (together with other documents elaborated within the BRIE sub-project) make the **questions about biomass clearer and easier to understand**.

We will focus on **four basic forms of biomass for energy use**:

- pellets (especially of plants)
- lump wood
- woodchips
- waste wood

Lowering of energy intensity of buildings or technologies goes before the economic efficient use of biomass. Then the use of fossil fuels goes down, which has the positive impact on the environment. This was one of the focuses of the sub-project BRIE. The manual about the system of energy management and its practical use within organisations or buildings was published.

Each of outputs and other information are at disposal on the website of the Regional Energy Centre - www.regec.cz. The Regional Energy Centre supported by the Hranicko Region will continue on consultancy activities and services provided through the website after the end of the sub-project's realization also for persons concerned from other regions.

1.1 Target groups

The study is intended for all persons concerned in the energy biomass use, its effects and biomass resources providing in particular regions.

Target groups are (among others): municipalities, agricultural or forest companies, farmers, companies dealing with wood and rural products transformation but also those providing local maintenance and servicing.

Questions of biomass use for energy purposes consist of three basic parts:

- biomass production (source)
- biomass transformation and storage
- biomass consumption

1.2 Chosen forms of biomass for energy use

Two basic forms of biomass were chosen for the detailed analysis of the questions of fuel providing, long-term resources stability ensuring and economy and environmental aspects.

In the following chapters we will deal with **bio-pellets** (fytomass as the raw material) and later on also with the classical pellets of wood waste. We will also mention the **lump wood** and its use, because it is the most common form of biomass for family houses heating. Then the **wood-chips** – its sources - and other chosen forms of **wood waste** will get in the programme.

Above mentioned forms of biomass are already utilized in the Hranicko region or there is the adequate potential existing for its use. According to the experience from the Czech Republic, it is important in the initial phase of local bio-energetic cycles building to focus on the maximal (and economic) use of **waste biomass sources**, doesn't matter if it comes from the sector of agriculture, forestry, processing industry or others. This is considered as crucial because of the least economic demandingness with relative fast economic and environmental effects for the region.

With regard to the increasing number of questions about short rotation forestry (SRF), the brief information about its possibilities within the conditions of the Czech Republic is mentioned. This is supported by the study in Czech language for all persons interested in the topics.

2. Bio-pellets

The process of pelletization as a process of biomass modification for its further combustion in unmanned kettles is developing in the last 20 years in the Czech Republic. The former production of granulated feedstuff of fytomass (granulating machine) has been widely renovated on particular farms. The pellets production works under the same system.

We can recognize **two basic kinds of pellets**:

- **pelletes** (classical pellets, so called “white” pellets) – made of wooden saw-dust
- **bio-pellets** – made of fytomass (plants)

The production of classical wooden pellets is limited by the availability (but also quality) of raw material. That is why the production of this particular kind of pellet is markedly limited (we can add in this place that it also is the demanded exportable article). Despite of the proclaiming support of new pelletizing installations development it is obvious, that many of the facilities will focus also on the fytopenellets production because of the limited amount of raw material (wood).

Raw materials' base of bio-pellets is wide and not exploited so far. As the possible raw materials for bio-pellets production can be identified:

- waste after agricultural products processing (chaffs, plants segments, ...)
- post harvest residue (straw and other waste on the field after harvest)
- bio-pellets production of energy crops (sorrel Uteuša, ...)
- other waste of agricultural production or transformation

Main differences among classical wooden pellets and bio-pellets are stated in the following table:

Parameter	Classical pellets (wooden)	Bio-pellets*
Heating power [MJ.kg ⁻¹]	17,5	14,5 - 16,5
Ash content [%]	up to 0,6 – 1,0 %	5 – 13 %
Power density [kg.m ⁻³]	650	600 - 700
Humidity [%]	up to 10	8,5 – 12,5
Size – diameter [mm]	6, 8, 10, 12 mm	8, 10, 12 and more mm
Abrasion [%]	up to 2 %	variable
Price [CZK]	3 500 – 4 500	1600 – 2 400

** average values are presented, it always depends on the particular kind of fuel and its parameters*

Wooden pellets



Wooden saw-dust is the raw material for wood pellets production.

Bio-pellets (agro-pellets) – of fytomass



Different kinds of fytomass (waste or energy crops) are the raw materials for bio-pellets production.

If we compare building's demand with classical pellets and bio-pellets heating at the average annual demand of 80 GJ for heating, we will find the following results:

Parameter	Classical pellets (wooden)	Bio-pellets *
Fuel mass needed [kg/year]	4 568	5 163
Ash production [kg/year]	32	465
Fuel content [m ⁻³]	7,0	7,9
Price [CZK]	18 271	10 326

** kettle servicing and fuel transportation costs are not included*

Higher consumption of bio-pellets is evident because of the lower rate of heating power and higher rate of ash production.

The price of classical wooden pellets (and the price levels of other fuels) influences the price of bio-pellets. Nowadays the average price of bio-pellets moves between 1 600 – 2 400 CZK/t, depends on the suppliers, season, way and volume of demand.

2.1 Sources

Economic success of the plan or project for pellets production depends on the long-term availability and quality of sources for its production (incl. supplies timing). These are the main parts that generate the final price of pellets.

The price of bio-pellets for the ultimate consumer depends on:

- price of pellets from supplier (mind the seasonal variations)
- cost of transportation
- storage costs

One of the essential success factors is the precious analysis of the intention for building the manufacturing capacities for bio-pellets production – all this from the view of availability, quality and long-term resources stability. It is possible to find procedures and steps for risks elimination if the risks of the whole project are well identified. Sources of suitable biomass are the waste after agricultural products processing or manufacturing industry or energy crops production (sorrel, miscanthus ...).

By sight of consumer it is important to focus on local bio-pellets producers. The number of producers is not high so far and their dislocation is not balanced neither. This causes the more intensive use of biomass. The experience shows that the significant change of conditions on the regional market of bio-pellets can essentially influence success and economic efficiency of the project of energy biomass use – consumption part of the bio-energetic cycle.



Waste after wheat processing (chaffs) can act as the raw material for bio-pellets production. Argotech Poličná.

Number of available and workable raw material should respond to the processing capacity of the local pelletizing installation. Examples of usable sources and raw materials for pellets production are introduced in the following table:

Choice of some sources of raw materials for bio-pellets production



Waste after wheat processing



Straw – post harvest residue



Corn straw



Sorrel – energy crop



Rape straw



Feterite – energy crop



Hay

Particular kinds of raw materials suitable for pelletizing demand specific proofed and advised procedures.

Summary of production of choice plant energy yield included (assumed from 5). Presented data are roughly only. They can differentiate depending on place, soil quality, silvicultural techniques, etc.

Plant	Dry weight production [t/ha]	Energy yield [GJ/ha]
cannabis	9,8 - 12,6	178 - 229
surghum	9,6 - 10,8	175 - 197
triticale	9,4 - 13,2	171 - 240
rye	8,6 - 11,8	156 - 215
oat grass	3,37 - 4,31	52 - 66,5
hair-grass	4,74 - 8,06	91,2 - 155
sorrel	14,2 - 16,2	258 - 295
scorpion shell	30 - 54	546 - 983

2.2 Transformation

Spending on raw material transformation is influenced not only by the price of raw material (cost of production or purchase of fytomass) but also by other factors. The transport charge and humidity of input material entering the process of transformation belong among the important ones. High rate of humidity means the necessity of final drying before the pelletizing process. All additional processes push the total cost up.

The way and time needed for the crop or material gathering also influences the quality of the final output - pellets. There is a risk of wetting or pollution of the post harvest residue which can cause the growth of non-combustible matters (ashes).

Building-up manufacturing capacities is not always connected to high investments. Large installations have the advantages in the form of economies of scale. On the other hand the increasing transportation costs and thus the final pellets price are grossing up.



Small granulator for fytomass pellets production. Farmers' cooperation, Argotech Poličná.

If we want to process only a limited amount of the input material, we can follow the system of small manufacturing capacities. That means to use granulators that were used for granulation of feeding for livestock in the past in many farmers' co operations.

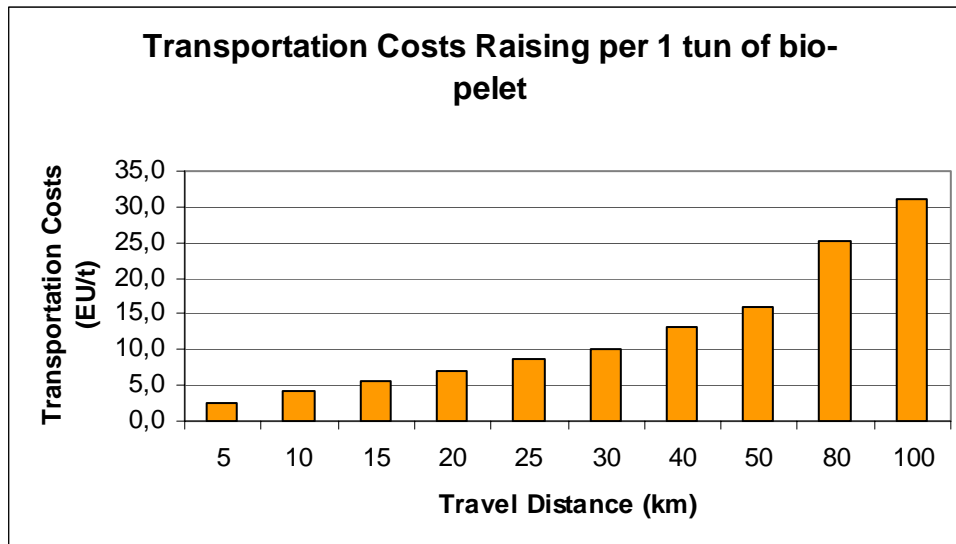
Smaller manufacturing capacities are able to operate a local market without any greater troubles and with a lower investment. In the case of local consumption and a functional regional bio-energetic cycle it is not necessary to invest into the packaging line and thus to increase the final price (packing into smaller volumes). The pelletizing unit can keep the adequate reserve of raw material and produce pellets whenever it is demanded. The price of bio-pellets can fall then on around 1 200 – 1 400 CZK per one ton.

In the area of the Hranicko Region the potential for similar manufacturing capacities for bio-pellets production exists. This fact is conditional on common collaboration of agricultural basic production and technical possibilities of final pellets sale and consumption. This could be the suitable option or completion of waste biomass sources for regions with the higher rate of agricultural production.



Bio-pellets can be produced according to the actual need and demand or can be stored. Farmers' cooperation, Argotech Poličná.

As already mentioned above, **the transportation costs** play the significant role within the whole economy of the biomass use. The failure of local pellets' supplier can evoke the increases of transportation costs. In the next chart there is a simulation of the relationship between the *price growth* of bio-pellets caused by the transportation costs increase per one ton and the *travel distance*. If the travel distance grows then the transportation cost per unit of fuel grows as well.



Price raising of one ton of bio-pellets caused by the increasing of travel distance.

Transportation and bio-pellets storage are important parts of the process of transformation. Bio-pellets must be **stored** under the proper conditions and must be protected against the unfavourable weather, esp. humidity. The system and the capacity of stores depend on the availability and distance of producers. The nearer the producer is and is able to deliver the fuel regularly, the storage area can be reduced only on the necessary size (in case of unexpected circumstances).

The way of storage can also differ according to the size of supply bin for kettle feeding and to the way of fuel feed. In the case of automatic feeding systems attached to the bulk supply bins (often numbers of cubed meters) there we usually take account of all-year supply in the store. There is a need to have the buffer stock in the case of smaller supply bins. The fuel is stored in a proper way (in bulk, bagged ...) before filling the supply bin.

2.3 Utilization

Bio-pellets are nearly entirely used for buildings' heating. The sort of source (kettle) should meet the thermal characteristics of the particular building. Today's automatic kettles for bio-pellets are controllable within the broad power range which optimises its utilization.

If we want to use bio-pellets, we should purchase the kettle with automatic ash removal. This kind of kettle is around 15 – 20 thousand CZK more expensive than the classical automatic kettle without the mentioned facilities.

Advantages of kettles for bio-pellets:

- high rate of unmanned services
- service comfort
- ecologic source – fuel of renewable, available source
- grant support on source purchase
- offer of national kettle producers



Changing quality of bio-pellets and improper kettle for its combustion can cause unpleasant effects. On the picture - Ash clinkering in the area of the burner and cinder pocket.

Absent of the regulation establishing a sort of minimal quality of bio-pellets is a specific problem. Changing quality of fuel can cause significant problems during its combustion. How the fuel while the combustion acts, which kinds of ash it generates and so on are questions to be taken into account.

Today it already is possible to buy suitable kettles for bio-pellets combustion on the local market. Those are offered by the notable kettle producers, e.g. Verner, Viadrus, Ponast and others.

In the past the bio-pellets were delivered to larger installations for co-combustion with coal (e.g. thermal power stations) eventually with wood waste in kettles of higher output.



Left: pellets burner. Right: detail of matrix press for bio-pellets production.

3. Wood Waste – Lump Wood, Wood Chips and Others

In the whole Czech Republic, the lump wood is the most common form of biomass for energy use. It is the historically oldest form of energetic biomass and what more, it is the way of processing that requires the least energy (and financial) inputs.

There is a limited possibility about its use when we consider the requirements of unmanned process (thus automatic service), easy manipulation, and storage and so on. That is the reason why other forms of wood biomass are supported. Then we talk especially about wood chips, eventually wood waste.

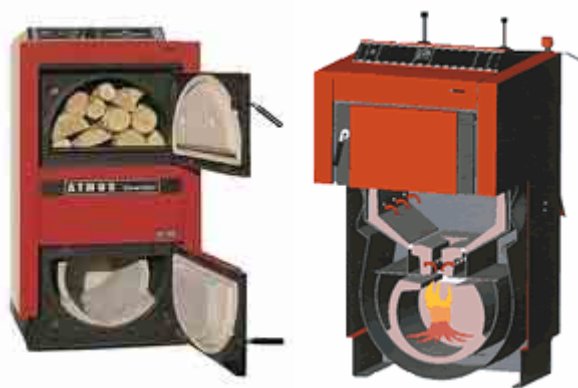
In the field of family houses, **lump wood** combusting is the number one so far, especially in the country and smaller villages. A **wood chip** is promoted at the installations of higher outputs – larger buildings of public or private sectors. Then there are some ways of **wood waste** combustion: family houses with higher requirements of labour input, eventually in the modified kettles (for whole or halving wood pallets); higher powers in the case of kettles designed for that kind of industry or manufacturing waste. Those are technologies usually equipped with hydraulic means for wood waste cutting (for demanded size and regarding the system of fuel feeding).

3.1 Lump wood

Lump wood is and still is going to be the dominant form of processed biomass for energy use in lower power installations. Definite **advantages** are:

- relative availability
- low costs of its purchase
- low costs of its modification (cutting, chipping)
- trouble free storage
- possibility of self-help within its preparing, ...

High level of servicing at lump wood usage was limited by the use of **gasification technologies** at the kettles. Carbon in the biomass molecules reacts at the high temperature (around 500 °C) to form so called wood gas (mixture of CO, H₂, CH₄, CO₂ and others). The wood gas is combusted on the kettle burner. Wood in the form of cleft timber is put into the supply bins in larger volumes. That's the reason the kettle does not need to be fed so often (fuel feeding period can be even 8 hours, depends on the actual kettle power).



Gasification kettles ATMOS for the use in family houses, lower powers. Source: ATMOS

Different units are used at the trade and manipulation in wood. In the following table there is a list of the most common ones.

Abbreviation of the unit*	Description
[plm] or [pm] (solid cubic meter)	1 m ³ of solid wood mass
[prm] or [rm] (stacked cubic meter)	1 m ³ of stacked wood, contains 60-75 % of wood
[prms] (stacked cubic meter – loose)	1 m ³ of loosely spread wood chips in bulk

**Abbreviations are presented in Czech*

Here the orientation conversion coefficients among the units are mentioned:

	Solid wood [plm]	Composite wood [prm]	Wood chips [prms]
[plm], [pm]	1,0	1,43	2,43
[prm], [rm]	0,7	1,0	1,7
[prms]	0,41	0,59	1,0

Purchase and price of lump wood (firewood)

The price of lump wood (firewood) depends on many factors. The basic are:

- place and date of material withdrawal
- way of transportation
- kind of wood
- form of wood (spitted, one-metre pieces, raw round timber, waste wood)
- way of packing (heap on wood, pallets, baskets ...)

The lump wood can be bought on several places depending on the level of its processing, availability and so on. The examples of particular places are listed in the following table. You can find out the place where to buy the lump wood incl. the estimated average prices (the price can differ seasonally or regionally).

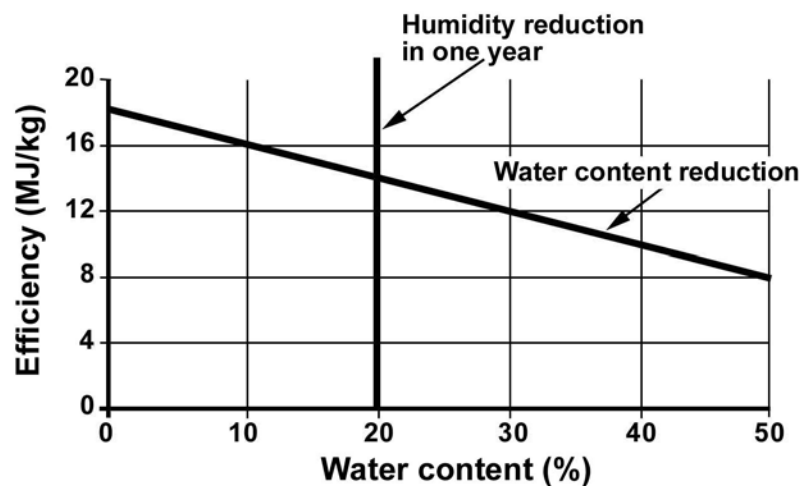
Place of purchase (subject)	Description, level of transformation	Estimation of average price
Forest enterprises – forests' owners	Wood selling in the forest (graft wood). Interested persons have to exploit the wood incl. its transport and transformation.	Several EUR per stacked cubic meter (prm)
Forest enterprises – forests' owners	Exploited wood at thinning. Usually necessary to exploit, event. already heaps on wood.	From several EUR up to 6 EUR per stacked cubic meter (prm)
Forest enterprises	Exploited wood brought together, form of	9 – 11 EUR per stacked

	round timber.	cubic meter (m ³)
Manufacturing enterprises - primary	Waste after timber processing, border wooden board, ends of trees, pole timber.	9 – 18 EUR per stacked cubic meter (m ³)
Firewood trader	Different levels of processing, different kinds of wood (softwood, hardwood), final products, cut and spited pieces on transport pallets or in bags.	16 – 40 EUR per stacked cubic meter (m ³)
Manufacturing enterprises – further processing	Different forms of wood waste, trimmings, residue, aborted products.	9 – 18 EUR per stacked cubic meter (m ³)



Typical heaps on wood outside family houses.

It is required to reduce humidity of the wood mass through its common storage. The acceptable humidity level moves around 20-25 %. The next chart shows the relation of wood efficiency to its humidity



Relation of wood efficiency to its humidity.

Table of efficiency and volume weight in relation to water content at chosen bio-fuels.

Kind of fuel	Water content [%]	Efficiency [GJ.t ⁻¹]	Volume weight of fuel in bulk [kg/m ³]
Lump wood (softwood)	0	18,6	355
	10	16,4	375
	20	14,3	400
	30	12,2	425
	40	10,1	450
	50	8,1	530
Wood chips (pine)	10	16,4	170
	20	14,3	190
	30	12,2	210
	40	10,1	225
Wood briquettes	6 - 12	15,5 - 18,5	650 - 850
Wood pellets	6 -12	16,5 -18	650 - 750

Lump wood still has the **very well perspective**. This is because of its availability, price, undemanding processing and still more modern technologies for its burning.

3.2 Wood chips, short rotation forestry

Wood chips are the crushed wood material, fraction size of several centimetres. It is combusted in the kettles specially designed for that purposed. Its heating power depends on the characteristic of raw material and especially on its humidity. Heating power commonly set is in between 10,5 – 14,4 MJ/kg.

Wood chips is prepared by the process of chipping (or crushing), depends on the needed size of the final product. Chipping machines are used for the process of chipping – their power and level of mobility are very variable. For municipalities the chipping machines for several hundreds of thousands CZK are enough (between 300 – 600 thousand CZK). The price depends on the nominal power, way of driving, maximal diameter of the chipped material and others.



Chipping machine carried and driven by small-tractor. Municipality of Obec Stráž nad Ludinou. Wood chips from the above mentioned chipping machine – Municipality of Stráž nad Ludinou.

Branches from the maintenance of villages, forests, parks, orchards, hillsides, streams and rivers, eventually the wood waste from inhabitants are **the raw material for the process of chipping**. Also some waste after logging is able to be processed.

A big advantage of chipping is the fact, that the material not suitable (or at least very troublesome) for lump wood production is exploited. This kind of wood material usually stays idle on its place or is burned. The process of chipping helps to increase the biomass use by the waste material exploitation. This material usually was not used in the past. No extra tools or devices are used for this kind of biomass production – what is a great advantage as well.

The maintenance of open spaces, parks, forests and similar places is provided. The price of the biomass gained this way is not high. The efficient system of biomass process is developed at low investments.

The **process of chipping** can be also considered as a suitable supplement of the bio-energetic system of lump firewood utilization. The waste material processing gives the economic and environmental advantage.

Orientation price of wood chips

Humidity	Orientation price per 1 ton	Utilization
Wet – approx. 40 % of humidity	1 000 – 1 300 CZK	for kettles with „sequential combustion“
Dry – approx. 20 % of humidity	1 700 – 2 300 CZK	pyrolysis combustion in kettles

Wood chips is being combusted in the kettles specially designed for its combustion (it is also possible to burn it – with certain limitations – in the older kettles for fossil fuels equipped with so called under sequential combustion. The output should be sized in accordance with the need of heat in the particular building. Also the storage and buffer stock will be needed for the kettle operation. The fuel bin and the system of feeding the wood chips to heating chamber need to be placed properly. The kettles' outputs get from around 50 kW up to several MW. Its price moves from many thousands CZK upwards.



Example of the kettle using wood chips. Source: <http://www.kwb.at/>. Right: fuel box.

Special machines that produce “wood chips” of the size of lump wood exist nowadays. This material can be used either as a lump wood or as a fuel for kettles of higher outputs (in a similar way as a wood chippings and waste).



Example of the processed biomass – bigger pieces. It is a product of the wood crusher pictured on the right.

Further we will mention the production of wood chips from waste biomass of industry and the cultivation of short rotation forestry as a source of biomass. Short rotation forestry is usually processed by chipping.

3.2.1 Production of wood chips from waste wood

Different manufacturing companies and firms are the specific areas of biomass sources. Those produce a large amount of wood waste that is either sold to individuals (for heating) or is used directly within their own activities and operations (for heating, industrial heat, drying ...).

Different sizes, proportions and characters of wood waste (saw-dust, wood-shavings, wood chips, smaller or bigger pieces ...) are usually a problem. Wood crushers of all sorts of construction characteristics and capacities are used for the size and kind unification. Those ensure the homogenizing of material for its further storage and transportation towards the feeding system of the kettle.



Example of the wood crusher for waste processing in the wood production firm and its use in the kettle for wood chips.



Example of waste wood – at the choice of wood for furniture production for households.

According to the field survey, the most of the potential of waste biomass already is used within the particular subjects. Especially the economic stress on the costs lowering and materials appreciation is necessary for the firms' benefit. Then less waste is sold to other people or delivered to larger sources of heating (small municipalities' heating plant).

The group of energy wood waste can be extended to e.g. no reversible wood packing, different wooden auxiliary materials and so on. Its energy use usually depends on its amount, quality, kind and transformation possibilities for the use in particular kettles (usually only by cutting, grinding ...).

3.2.2 Short rotation forestry

Short rotation forestry (SRF), its possibilities and its use must be also briefly mentioned in connection with biomass use for energy purpose. In this chapter, conclusions of the expert study prepared within the sub-project BRIE are summarized.

The group of tree species called **short rotation forestry** has the ability to reach high production of biomass in a short time period when compared to other tree species. The most common species of this group in our latitude are members of the *Populus* and *Salix* genus – thus poplars and willows.

For the successful and gainfully poplars' cultivation the suitable site for the outplanting must be chosen. The site with permanent humidity during the whole growing season is the most suitable for poplars. The outplanting in the site where the saturation line is available during all seasons or the site of the high and steady rainfall totals are suitable places for the SRF cultivation. The ideal depth of the saturation line moves between 0,6 – 1,2 m below the land surface.

It is naturally also possible to plant poplars out of the mentioned sites. Then it is necessary to optimize the silvicultural operations and take account of lower production.

Under the conditions of the Czech Republic the following species are proofed: black poplars and its hybrids, balsam poplars and white poplars. Nowadays there also is an experience with *Populus tremula* and its hybrids. Among willows we know about: white willow (*Salix alba*), osier willow (*Salix viminalis*), event. daphnia's willow (*Salix daphnoides*).

The biomass production value in the Czech Republic has been estimated on the basis of testing areas monitoring so far. It is already obvious that under the favourable climatic conditions (up to around 400 m above sea-level) it would be possible to reach the **economic meaningful production** of 10 – 12 tons of dry mass/ha/year in the triennial rotation of several proofed cultivation.

If the tendency of plantation founding on little sites will persist, the production of the given period is going to be markedly lower. Harvesting within such a short rotation will not be acceptable in the economic point of view. The worse the conditions are, the longer the silvicultural cycle is – up to 6 years. Efficiency of such biomass production is not determined yet. Costs of harvesting and transportation of the wood chips are thus higher than the silvicultural costs. Those are going to grow up further and can significantly influence the economy of biomass cultivation in the less favourable areas.



Poplar plantation at its harvesting. Source: taken over 3)

From the available information about the experimental harvesting of small experimental fields appears that the production of dry mass reached at the best clones of poplars and willows in the first triennial rotation was only 3,5 t/ha/year and in the second triennial rotation 8 – 10 t/ha/year. These are more likely an orientation data. The real production in real terms is usually lower than the calculated value. In any case the realized values are relatively low and confirm the fact, that for the efficient biomass cultivation **the main principles for plantations with very short rotation** are necessary to be followed:

- full-area preparation of land
- only high quality escalope for outplanting
- full-area cultivation of land
- only cultivated and proofed clones use as a planting stock
- sufficiently supply of the site with water and nutrients

Nowadays in the Czech Republic the most productive clones of poplars are J – 104 and J – 105, through media promoted as “Japanese poplars”, abroad marked as Max 4 and Max 5. It was discovered on the experimental fields under our natural conditions that these clones can give a production of 10 – 12 t of dry mass/ha/year in the second rotation.

Because of the **preservation of diversity** in plantations the cloned mixture must be used. Cultivation of one clone in large dimensions can cause large economic losses if any harmful organism specialized on a particular clone or genus spreads out.

Detailed information about the ways of cultivation and other circumstances can be found in the expert study elaborated within the sub-project BRE (see references no 3).

Further **processing of biomass production** of sort rotation forestry is identical to the processing – chipping of other wood waste incl. its storage.

4. Guide for Utilization

The use of biomass as a fuel is really efficient and at a careful appreciation and choice of a proper source and fuel it also is friendly to the environment. On the other hand, at the level of consumption it is not possible for all the people to use biomass at the present time. The reasons for this statement are the **limited production possibilities of landscape**, forests and agricultural areas but also the alternate use of biomass for other use (foodstuffs, industry and technical raw materials and primary commodities, building products and so on).

Range of problems and factors that significantly influence the economy of the bio-energy systems services or reliability of heat and electricity delivery are necessary to be taken into account.

How to get along the intention of biomass use as an economic efficient and environmental friendly energy source?

Question	Answer, solution searching	Conclusion (output)
Am I able to use biomass as a source of energy?	Do I have the suitable technical conditions and close and lasting source of fuel for the biomass use?	Decision whether to continue at the preparation of the project!
Which kind and form of biomass would be the best for me?	I will find out which kinds of biomass am I able to provide in my neighbourhood in a long term.	Specification of 1-2 kinds of biomass coming on force.
Where do I want to use biomass energetically?	I will consider the building, if the use of biomass is suitable here.	The building is suitable for the use of considered kind of biomass incl. its availability, needed power ... or there are any limitations (which ones?).
What is my final product?	I need only heat! I am able to produce also electricity and use the occurred off-heat – I will push the economic benefit of the intention up!	Decision – electricity + heat or only heat (most of cases).
What amount of biomass I will need?	I will identify roughly the need of heat and fuel. Am I able to purchase such amount of	Yes – I will continue. There are some doubts –

	biomass for acceptable price in a long term?	alternate suppliers must be verified (event. the alternate kind of biomass)
Is there the possibility of a visit of a similar installation of the biomass source?	I deal with the information and try to find someone with similar intention that is already realized (practical experience).	I will visit a similar installation, examine particular questions, and check the benefits and problems. I will decide if the project continuation.
Where can I buy it?	Where particularly and under what conditions can I buy biomass in the region? Will the supplier enter the long-lasting contract with me?	Yes – I have the possibility of the purchase. The contract will be entered. If it is to the contrary I search for the alternate supplier (to check other possible providers also in case of the positive answer are recommended).
How much it is?	What are the foreseen investments and operating costs?	What are the final costs (investments, operating costs and other necessary expenditures)? Total amount and demand on financial flows.
Is it profitable for me?	I will check the economy of the intention. What will happen with the whole economy if the prices of fuels change?	The intention is or is not interesting for me. If not, I have to consider other circumstances - other effects (environment preservation) or I will relinquish the intention.
Will I find any programmes of support for my intention (dotation?)	I search in the programmes of support if there is any programme for a disposal I think of.	The programme of support exists or not. The support refers to my identity (in which amount).
Is the project going to be really realized?	To consider all possible information from all points of view.	I will decide (alone or collectively) about the project's realization or its stopping.
Realization of the project.	Complete project preparation, administrative procedures, financial assuring, event. funding (dotation), continuous verification of feasibility and economic utility, testing operation.	Complete installation of a source for biomass energy use. Project has fulfilled or not (and why) my expectations.

The level of total energy consumption in the region, municipality or building is an important factor. That is the reason why the realization of energy savings and economy drives on buildings and technologies and energy efficiency rising of all system elements are important steps towards the higher and more efficient use of renewable energy sources. Among others the **capacity of regional sources** of biomass and its self-sufficiency has been strengthened due to the energy consumption reducing. We satisfy higher number of subjects (buildings ...) using the same amount of fuel.

Within the sustainable regional bio-energy system the **balance between the biomass consumption and the land capacity of given countryside in the long term** must exist (incl. relevant exports or imports of given kinds of biomass).

Along the preparation of similar intentions the consultation with skilled experts is recommended. The experts have experience not only with the single preparation and realization but also with funding and administration.

5. Economic Point of View

The economic point of view of renewable energy sources use incl. biomass is **the most important factor** considered at its implementation.

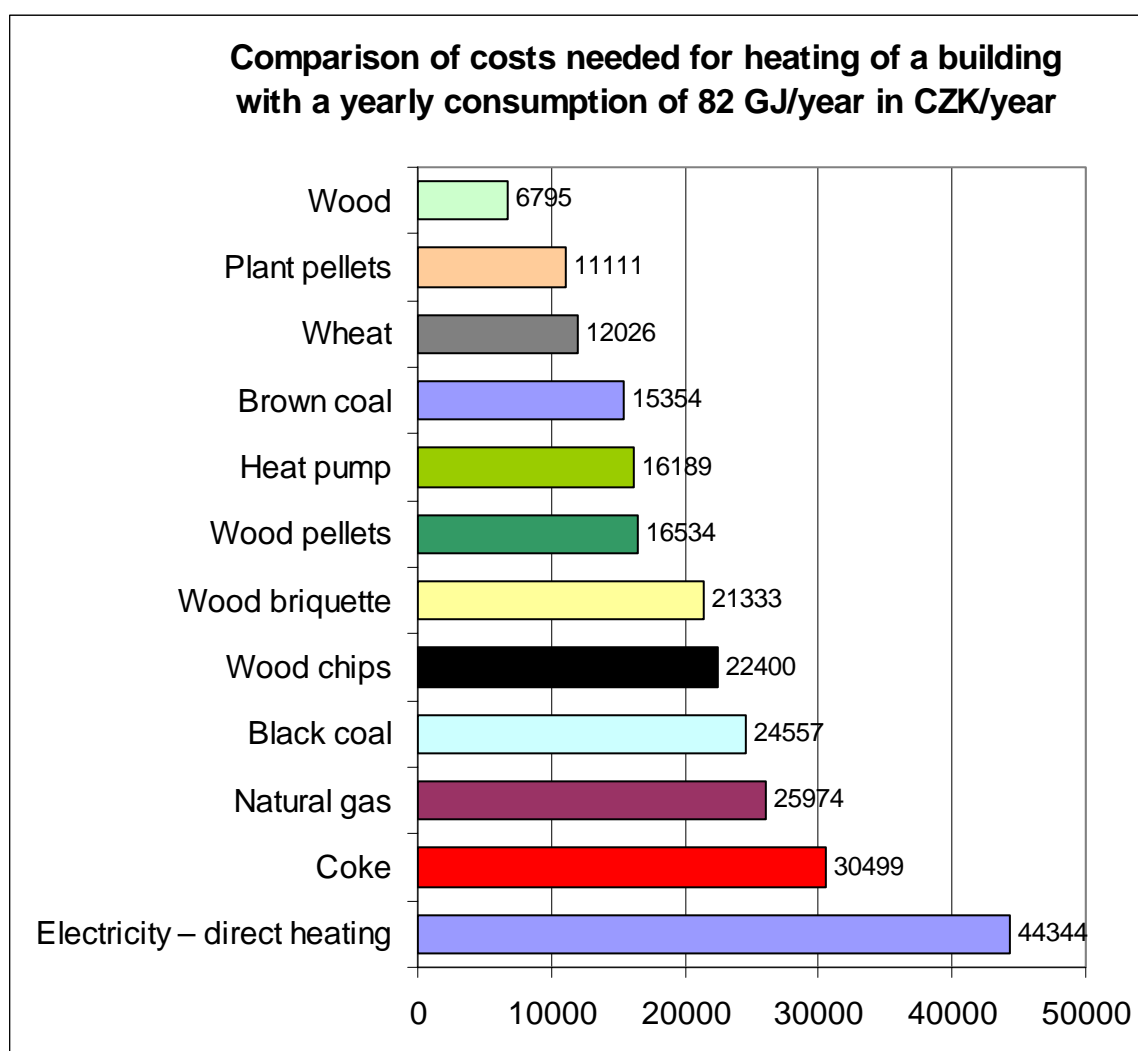
Each of the area of the bio-energetic cycle (production, transformation, and consumption) has its clear economic parameters – inputs and outputs. Output of one area is one of the inputs of the following phase at once. Prices of outputs of particular areas are depending on them. Economic influences and factors can be divided as follows:

Area	Output	Economic effects (examples)
Production	wood mass, fytomass for combustion or other energy use	<ul style="list-style-type: none"> - the cost of labour - the cost of input materials - cultivation demandingness (production) - level of mechanization and labour efficiency - tax policy - weather – production fluctuation - dotation support - storage, transfer to the place of transformation - others
Processing	particular kinds of biomass for combustion, event. for biogas production (wood chips, pellets, silage, briquettes, lump wood ...)	<ul style="list-style-type: none"> - the cost of labour - level of necessary investments (incl. depreciation) - technology and energy demandingness of the technology - technology efficiency (fault liability) - capacity utilization of the technology - seasonal accessibility of raw materials - price of inputs and materials - financial support - level of competition

		<ul style="list-style-type: none"> - import – export of products - cost of transportation (on the place of consumption) - others
Consumption	heat, electricity	<ul style="list-style-type: none"> - price of other fuels and energies (market regulation) - price of required investments - financial support - others

In terms of consumer that can stimulate its consumption due to the production and building up capacities for transformation of biomass for energy use, the main factors are:

- investment demandingness of the source
- fuel accessibility
- and esp. its PRICE!!



Comparison of costs needed for heating of a building with a yearly consumption of 82 GJ/year.

Source: www.tzb-info.cz

Because the costs for heating of a particular building are the main motivational factor of given kind of energy use, the orientation comparison of costs needed for heating of a building with a yearly consumption of 82 GJ of energy for heating was made. The comparison of costs is showed in the previous chart. Also losses and transformation operations of particular types of fuels and sources are taken into account while the calculations.

The chart shows clearly the **economic advantage of biomass use** as a fuel in the form of lower costs needed for heating. Some short notes to the single kinds of fuels:

- Wood – the cheapest fuel, conditioned by heavy labour inputs, large storage capacities, wood drying
- Pellets of fytomass – very good option, low level of servicing, automatic kettle, good controllability, limited sources so far, high investments demandingness of a kettle
- Wheat - good option, low level of servicing, automatic kettle, good controllability, depends on a current crop and prices for food-processing purposes
- Wooden pellets - good option, low level of servicing, automatic kettle, excellent controllability, higher investments demandingness of a kettle
- Wooden briquettes – higher level of servicing, higher price – used mainly for additional heating in fireplaces and stoves”
- Wood chips – need of larger storage capacities, demandingness technology in the view of investments, economic profitability at larger installations (from 50kW upwards)

Economic contributions are of course not only on the side of consumption. Increase in regional and local sources use improves the landscape tending, pushes up the employment rate, and reduces the volume of imported fuels and so on. In addition the financial resources expended on energy supply ensuring stay in the region and serve for further regional development.

6. Environmental Benefits

Environmental benefits from the energy biomass use are very important. **The particular benefits** can be divided into several basic areas:

- Reduction of fossil fuels consumption (as exhaustible materials)
- Reduction of greenhouse gas production (CO₂) from the combustion of non-renewable sources of energy
- Regional systems (production, transformation, and consumption) reduce the transportation demand (again the reduction of CO₂)
- Total reduction of emission load pressure (depends on the fuels compared – see the comparison mentioned below)
- Landscape tending and its maintenance
- Others

Other environmental benefits are generated by the specific production of a particular kind of biomass (see chapter 6.3 Specific contributions of short rotation forestry) or by other local specificities.

In the view of an ordinary consumer and of in intention of the government and European Commission as well, the **reduction of greenhouse gas production – carbon dioxide** – is one of the main goals. All those while the regular and reliable energy supply ensuring

and the economic sustainable agricultural production and waste biomass use in the long term. The factor of the total **reduction of emissions and pollutants** produced by the fossil fuels combustion (often in out-of-date sources) is also very important. The calculation leading to the comparison of harmful substances' production from ordinary sources (inc. biomass) was made.

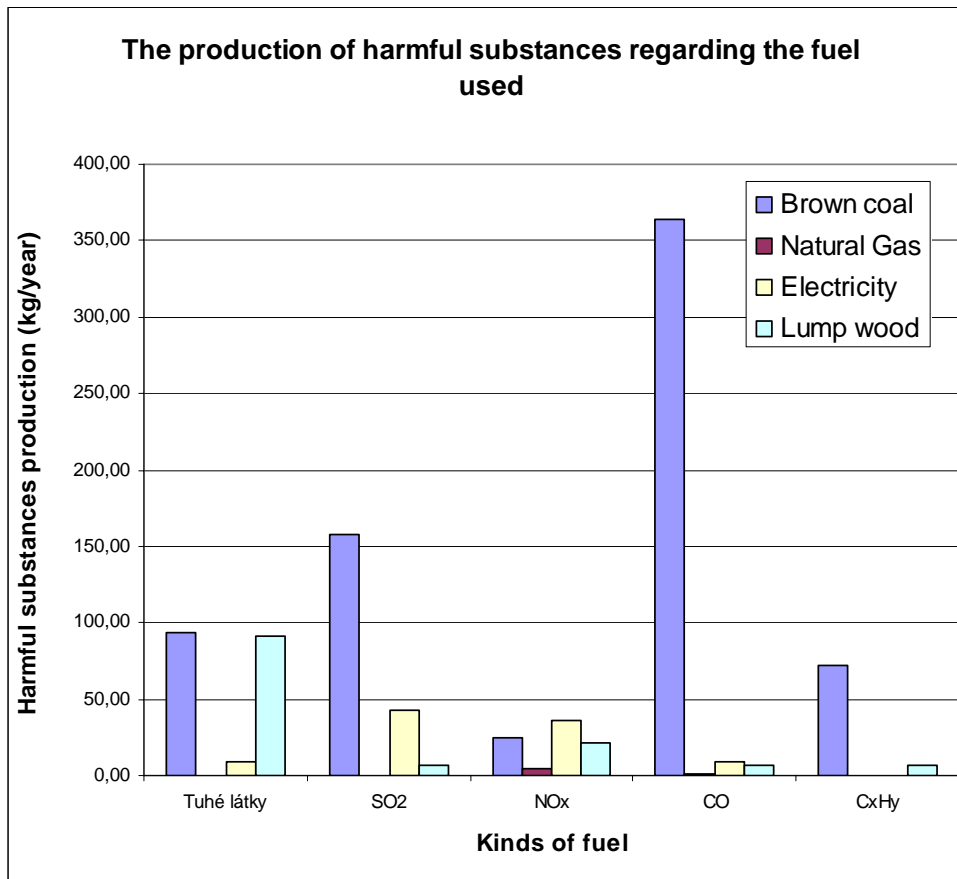
6.1 Fossil fuels substitution – emission reduction

Impacts on a change of emission load pressure were evaluated on the model example already used, on the building with a yearly consumption of 82 GJ of energy for heating. The calculation was made for biomass (lump wood) and three other kinds of fuels or energy (brown coal, gas, electricity – produced in thermal power plant). The amounts of emissions produced are mentioned in the following table:

Emission of a fuel	Emission of brown coal [kg/year]	Emission of gas [kg/year]	Emission of electricity [kg/year]	Emission of lump wood [kg/year]
Pollutant				
Solids	93,17	0,05	8,50	91,33
SO ₂	158,15	0,00	42,47	7,31
NO _x	24,24	4,22	36,01	21,92
CO	363,65	0,84	9,07	7,31
C _x H _y	71,92	0,17	0,00	6,50
CO ₂	13 622	5 231	20 370	7 503

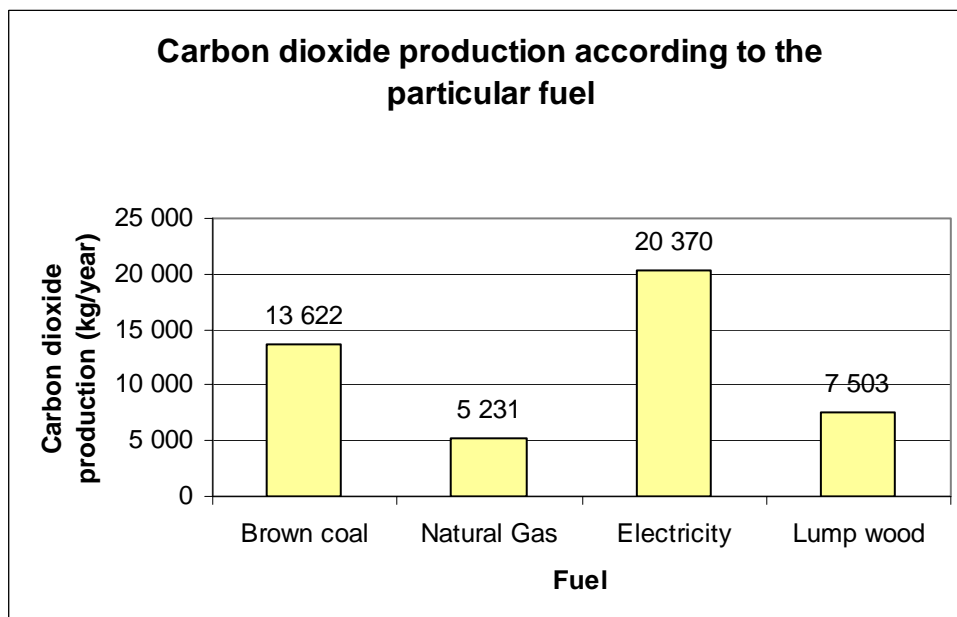
The obtained results are introduced because of the better clearness also in the graphic form. The first chart shows the production of other harmful substances for particular kinds of fuels or energy in the case of the heating of the model building.

The chart shows the enormous **emission load pressure** while the fossil fuels use esp. at the CO₂, benzoate pyrenes (C_xH_y) and SO₂ production. Use of gas seems the most ecological in this case. In the other side it is the most economically exacting option. Biomass is on the second place regarding the emissions amount. Significant increase of emissions is obvious only at solid matters (airborne dust). It is possible to reduce the amount of airborne dust in the case of automatic kettle for pellets use. The reduced amount can be only one tenth of the production of classical grid kettle for lump wood.



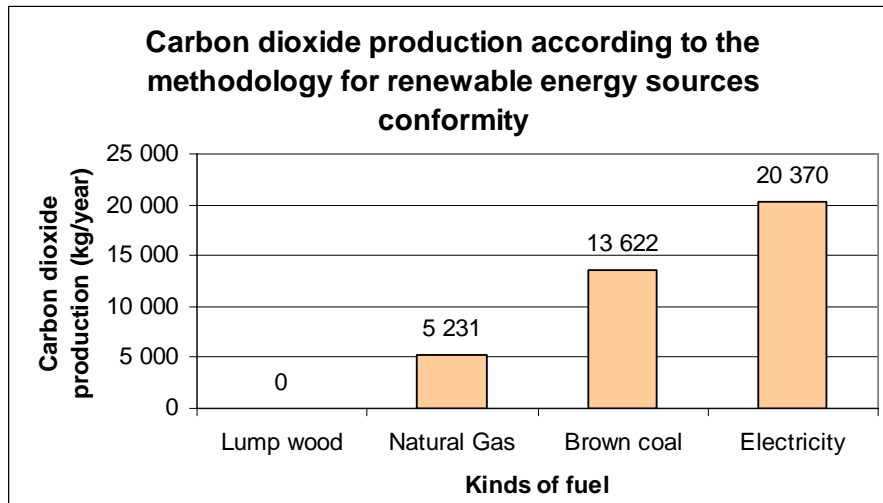
Emissions and pollutants production in the case of the model situation - building with a yearly consumption of 82 GJ depending on the kinds of fuel and harmful substances.

The next chart shows the real production of carbon dioxide of particular fuels. Gas records the lowest production, and then the lump wood is in the second place.



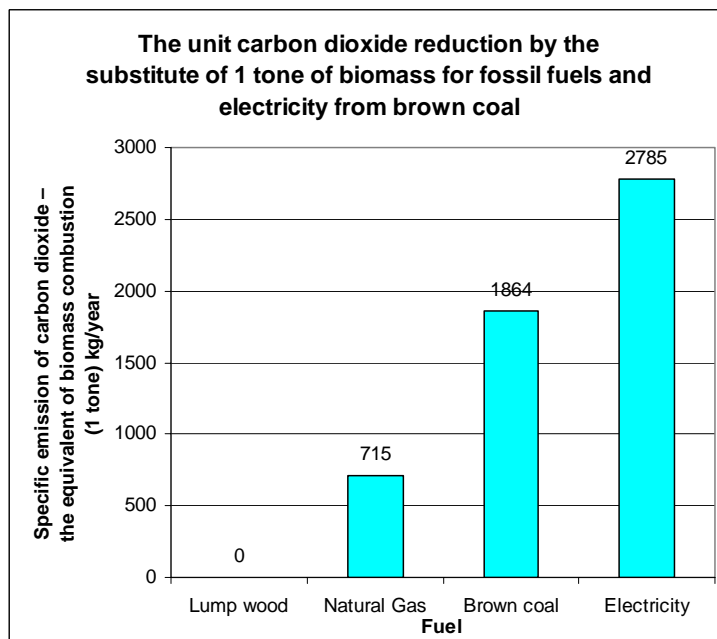
Real production of CO₂ at burning of a given amount of a fuel. Compare to the following chart!

If the project of energy biomass use is considered in term of CO₂ production, then we use the methodology based on the fact, that **biomass combustion is neutral in terms of CO₂**. The consideration is based on the fact, that the amount of carbon dioxide released while the combustion to the air is equal to the amount of carbon dioxide removed from the atmosphere while the biomass growing. Contrary to the fossil fuels there is no increase to the collection of this gas in the atmosphere.



The production of CO₂ at renewable sources of energy is considered as neutral. The amount of carbon dioxide released while the combustion to the air is equal to the amount of carbon dioxide removed from the atmosphere while the biomass growing. Compare to the previous chart.

The **specific volumes of the carbon dioxide production** (equivalent consumption of one ton of biomass in the energy equivalent of the other three compared fuels) were compared lastly. The next chart shows the amount of CO₂ emissions saved in the case of using the equivalent of biomass instead of the given fuel. This chart can be used for a quick check calculation of a total reduction of CO₂ for particular numbers of biomass consumption.



Specific emission of carbon dioxide per one tone of biomass for energy use. Columns responding the CO₂ production in the case of using the energy equivalent in the given kind of energy instead of 1 tone of biomass.

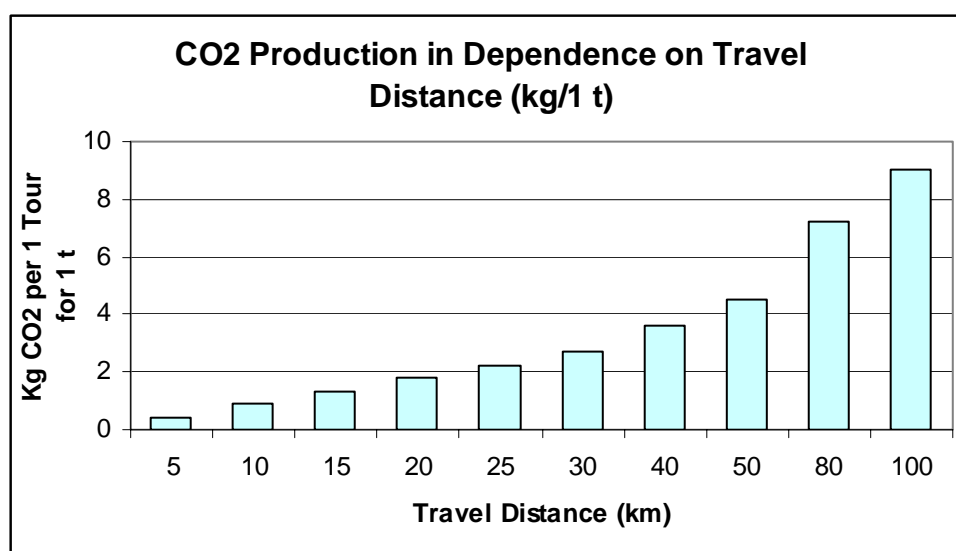
6.2 Influence of the transportation on the CO₂ production

Not only has the process of combustion in our bio-energetic facilities itself participated in the total air load pressure of CO₂, but also the requirements of fuel transportation. At the vehicles operation the CO₂ comes up next to other pollutants. The production of the CO₂ can also be involved into our emission balance. The shorter the travel distances between the places of production, transformation and consumption are, the smaller amount of CO₂ is produced.

The orientation calculation of the **specific production of CO₂ of 1 tone of transported biomass** was prepared. The initial presumptions were:

- vehicle loading limit - 5 tons
- older lorry was used - CO₂ production approx. 450 g per km (gas mileage 23 l/100 km)

The results of the specific production of CO₂ per one ton of transported fuel (e.g. bio-pellets) are graphically illustrated in the following chart. With growing number of driving kilometres the CO₂ production is rising. This is also the reason why it is more efficient to build up regional or local bio-energetic cycles. Demands of the necessary transportation and thus the CO₂ production are reduced.



Specific CO₂ production of 1 tone of transported fuel per particular travel distance.

6.3 Specific contributions of short rotation forestry (SRF)

Beside the economic effects the short rotation forestry brings also the range of other advantages not only for producers but especially for the landscape and environment. Newly founded growths of SRF are a new element in the landscape having several functions.

Among the above mentioned functions can be included:

- **Ameliorative function**
 - The continuous growth of poplars or willows reduces, also in small areas, the unfavourable effects of wind erosion and obstructs the rise of soil erosion. This is

because of the fact, that the species create the root system sufficient for stabilization of the surface layer of the soil already in two years after its outplanting.

- Poplars and willows as leafy species provide the refilling of primary raw materials for the humus production (at the end of every growing season due to the leaves drop).
- Roots help the better aeration of the soil. Soil characteristics get improved according to the length of cultivation.
- The species can fulfil also the decontaminating role in the view of soil decontamination loaded by the previous way of farming or in the view of preservation of underground water sources.

➤ **Biological function**

- It significantly increases the total biodiversity in the agricultural areas.
- Bio-corridors in the territorial systems of the ecologic stability in term of movement and staying of small game, birdlife and members of animals of lower orders.
- Blooming growths of willows offer the spring pasture for bees.

➤ **Complex vegetable effects**

- improving of thermal and moisture regime of the environment
- oxygen production
- CO₂ reduction
- ground layers of the air filtering
- noise and dustiness reduction
- bactericidal and fytoncidous matters production
- increase of the resort value of the landscape

7. National and Regional Programmes of Biomass Use Support

The system of support in the field of energy use of biomass in the Czech Republic is relatively complicated and not providing an easy survey. It touches not only the fields of consumption, but also transformation and production of biomass.

Very brief list regarding the available information is introduced in the Appendix 2 (only in Czech version).

8. References and Other Information

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4. Jakubes, J.; Bellingová, H., Šváb, M.: *Modern use of biomass, Technologic and logistic possibilities*. Czech energetic agency, 2006
5. Konvalina, P., Moudrý, J.: *Plant biomass for energetic*, article in the serial "Zemědělec" 43/2006, pg. 18 – 19
6. Website: *Ministry of Agriculture of the Czech Republic , Ministry of Industry and Trade of the Czech Republic, Ministry of Environment of the Czech Republic, Structural funds*

9. Appendix

9.1. The basic silvicultural technologies of plantations with very short rotation

The schematic list of the silvicultural technology covers the maximal range of operations required before and after the plantation's foundation. It can be decided according to the particular site about the real necessity of some of the steps (see the note). Before the foundation of a plantation it is necessary to decide about the machinery used during the cultivation and harvesting.

Silvicultural phase	Kind of operations	Note
Preparation	land weeding – chemical, mechanical	yes
One year before outplanting	order of escalope and project	yes
	ploughing	yes
1 st year	escalope's purchase	yes
	spring harrowing	yes
	outplanting with planting machine	yes
	interlinear cultivation	yes
	rows weeding	yes
	interlinear cultivation	yes
	protection form wildlife browsing	according to the need
2 nd year	interlinear cultivation	yes
	rows weeding	yes
3 rd year	growth inspection	yes
	growth survey and yield estimation	yes
	harvest	according to the production
4 th year	growth survey and yield estimation	yes
End of 1 st cycle	winter harvest	yes
1 st year / 2 nd cycle	fertilization	according to the need
	interlinear cultivation	yes
2 nd year	growth inspection	yes
3 rd year	growth survey and yield estimation	yes
	winter harvest	according to the production
4 th year	growth survey and yield estimation	yes
End of 2 nd cycle	winter harvest	yes
3 rd cycle	the same is in the 2 nd cycle	
4 th cycle	the same is in the 3 rd cycle	
	presumption – keeping the further yield of the plantation	
5 th cycle	the same is in the 4 th cycle	
	presumption – plantation liquidation after harvesting	