A Proposal Of A Logistics Model For The Use Of Biomass For Energy For Local Communities Within The Concept Of Sustainable Rural Development

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A PROPOSAL OF A LOGISTICS MODEL FOR THE USE OF BIOMASS FOR ENERGY FOR LOCAL COMMUNITIES WITHIN THE CONCEPT OF SUSTAINABLE RURAL DEVELOPMENT

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Abstract

The paper presents a concept for a digital platform model for the biomass logistics network for local communities. This concept refers to the strategy for the development of renewable power engineering in Poland to the year 2020, adopted by the Polish government. The status and prospects for biomass production are presented, from which it results that plant production for energy purposes may in the nearest future constitute an important alternative to food production. In turn, main problems connected with the organization of biomass market at the local and regional levels are also discussed. In the proposed model the digital platform would be available on the Internet for all links of the logistics chain, starting from producers and ending with buyers (processors) of biomass. Primary benefits of the implementation of such a system include the development of local energy biomass markets and maintenance of their effective operation; comprehensive utilization of local energy biomass resources for the production of green energy; initiation of an appropriate development of biomass power engineering as an element of sustainable rural development.

Key words: sustainable agriculture, renewable energy sources, biomass logistics network

1. Introduction

The multifunctional model of agriculture, preferred in Poland and in the European Union, assumes for farms the development of activity which is not directly connected with food production. Within the concept of the so-called sustainable development one of the alternatives, which is going to gain in importance in the next years, will undoubtedly be the production of energy from biomass (the development of plantations of energy crops and plants for the production of biofuel or additives to conventional fuels).

Changes in the image of agriculture are consistent with assumptions concerning energy production – in the next years significant changes will take place in the fuel and energy balance of Poland. The share of energy generated from the so-called renewable sources in this balance will increase systematically (in 2006 the percentage of renewable energy in the energy balance was 5.5%, whereas in 2004 it was still 3%) (Kamieński, 2007).

The strategy for the development of the sector of renewable energy production in Poland, approved by the Council of Ministers in 2000, assumed that in 2010 a total of 7.5% and in 2020 14% produced energy will come from renewable sources (Ciechomski, 2005). The goals of the European Union concerning the energy sector up to 2020 are even more ambitious – within the 3 × 20% priority up to the year 2020 the following goals have been planned:

- 20% share of renewable energy in the primary energy balance,
- 20% reduction of energy consumption,
- 20% reduction of greenhouse gas emissions.

The use of biomass in Poland, in spite of the considerably increased interest in this type of production on the part of farmers, is still low. Due to the natural conditions the share of biomass in the total production of renewable energy in Poland is and will remain dominant (currently over 90%); however, it should be attempted to increase the utilization of biomass resources (at present according to estimates in relation to the possible resources of available biomass they are used only in 12%) (IEO, 2004).

For this reason it seems justified to conduct analyses on the production and utilization of biomass. Preliminary investigations indicate that increased interest in energy crop cultivation and biomass production results in the development of technologies of biomass production, logistics, storage and processing for various energy products. It may be expected that in the nearest years demand for biomass will considerably increase on the part of petrochemical, energy plants and heat and power plants, which will result in the necessity to develop efficient systems (networks), which will participate in the collection (transport and harvesting), preliminary processing and storage of biomass.

Systems of this type should concentrate around an integrator(-s) and - depending on the scale of demand for the technological charge (different forms of biomass as the raw material) - they may vary in their scale and range of impact – from regional (e.g. power plants) – to commune (e.g. local boiler plants - schools, commune office buildings, clinics, etc.). These networks presented in the interactive form and available on the Internet need to supply information to all parties interested in the production, processing and utilization of biomass. It is assumed that when developing the system criteria concerning the type and quantity of biomass and products connected with its pre-processing should be taken into consideration. This would facilitate the development of cooperation between individual entities and a more complementary adaptation of their facilities and expectations. The producer would gain information on who may harvest, transport, pre-process or store their biomass, the end buyer would know where to get their technological charge from (who collects bigger batches of the raw material), while companies involved in the logistics services between the producer and the end buyer would know who to cooperate with.

When utilizing renewable energy sources from biomass the primary factor determining the success of the whole enterprise is to provide adequate amounts and quality of required biomass. For this reason the need to develop a system gathering producers and processors of biomass and to create logistics models of this type is fully justified.

2. The current status and prospects for biomass production

When analyzing the current status and further development of biomass production and utilization it is necessary to take into consideration changes which took place in the 20th century as well as those forecasted in the future. The most important factors shaping the world energy balance in 2050 include (Shell 2007):

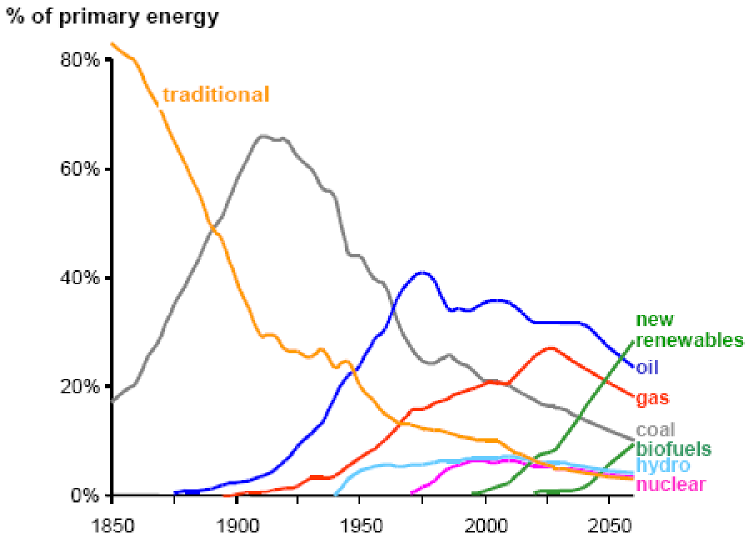
- demographic changes; in 1907 world population was less than 1.7 billion, at present it is approx. 6.5 billion, while in 2050 it is expected to be 9 billion,
- increasing wealth of societies; average affluence worldwide is estimated to increase 4 - 5 times as a result of fast industrialization of developing countries,
- power demand is expected to double, at the simultaneous doubled increase in the utilization of its every unit (energy consumption per unit of production will drop by 50%),
- the necessity to use renewable energy sources; in connection with the depletion of fossil fuels the utilization of wind, solar, hydro and biofuel energy, etc. is expected to increase from 6 to 10 times in relation to the present level.

The evolution of the power system worldwide in the period 1850 - 2050 is presented in Graph 1.

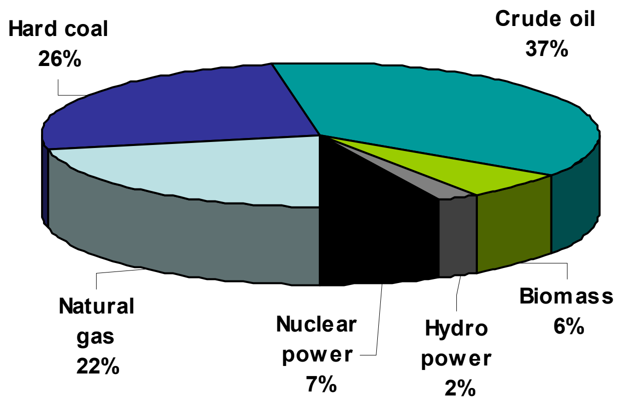
The above forecasts indicate that the biggest problems of present times are connected with increased threats for the natural environment and a deficit of power resources. Extraction of power raw materials from less and less accessible beds will also result in an increase in their prices on the world markets. The shares of individual power raw materials in the total world energy consumption balance are presented in Graph 2.

In the European Union (25 countries in 2004) the share of renewable energy sources (RES) in the so-called primary fuel structure was approx. 6%, with biomass predominating, as it accounts for 2/3 of renewable energy sources (Graph 3).

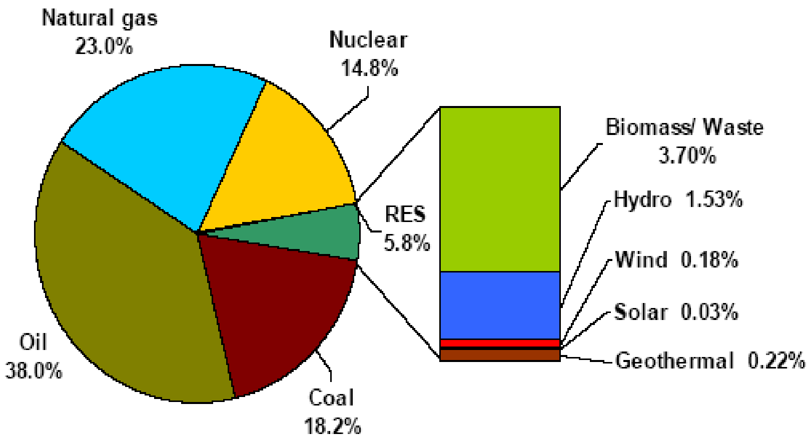
In Poland, similarly as it is worldwide, the shares of individual power raw materials in the overall structure have been changing following the economic development and increasing population of the country. The share of coal has decreased gradually (within the last 50 years by 50%), while those of crude oil and natural gas have increased (Graph 4). For several years now the importance of renewable energy sources has been observed to increase (in 2006 it was 5.5%).



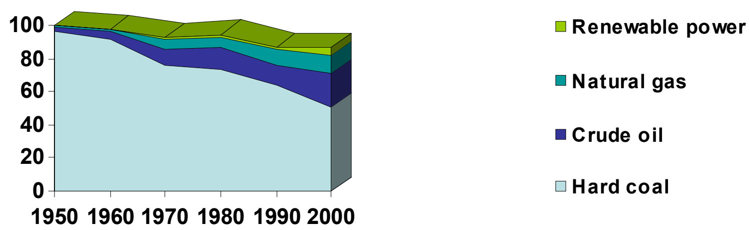
Graph 1. Dynamics of changes in energy utilization (source: Shell, 2007)



Graph 2. Worldwide consumption of power raw materials (source: Bocheński, 2007)



Graph 3. The role of bioenergy in the total energy balance of EU – 25 according to data from 2003 (source: Arseniak, 2007)



Graph 4. Consumption of basic power raw materials in Poland (source: Bocheński, 2007)

It results from the graphs given above that at present non-renewable fossil energy carriers have the highest share in the total energy consumption (e.g. 85%), but within the next several decades their role will decrease in favour of nuclear power and renewable energy sources. It is assumed that around the year 2060 the latter will constitute over 50% consumed energy resources (Bocheński, 2007).

Renewable energy sources in Poland have gained in importance especially in the last 3 - 4 years, when their share practically doubled and is currently almost 6%. Emphasis on the production of energy from renewable sources results from the previously mentioned *Strategy for the development of renewable power engineering* adopted by the Polish Parliament and from the EU directive no. 2003/30/EC *on the promotion of the use of biofuels or other renewable fuels for transport* (an increase in the share of biocomponents – biodiesel and bioethanol – in the market of fuels used in transport from 2% in 2005 to 5.75% in 2010 and further to 10% in 2020). Moreover, it results from these documents that the primary source of renewable energy in Poland in the medium-range forecasts will be biomass. Its utilization in the production of liquid biofuels as well as solid fuels requires a considerable increase in biomass resources. Apart from the traditional sources of biomass such as wood and wood waste, the role of energy crop plants and agricultural products as well as organic wastes of agricultural origin is expected to increase significantly.

It is assumed in forecasts that up to the year 2014 agriculture is to supply 60% total biomass used in the production of heat and electricity. According to the estimates by Faber and Kuś (2007) the realization of goals presented above would require the supply of 7.4 million ton biomass in 2010 and 10.6 million ton to the year 2015. At the assumption that forestry may supply approx. 2 million ton waste wood annually and 2 million ton straw will be obtained from agriculture, for the realization of the first goal it would be necessary to acquire approx. 3.4 million ton biomass from plantations of energy crops in the first case (2010) and 6.6 million ton in 2015. It results from field experiments with such plants as willow, Miscanthus, shrubby althea, reed grass or Jerusalem artichoke that the average yield of those plants, depending on soil conditions, ranges from 8.6 to 18.7 t d.m. per year/ha. Taking into consideration the fact that in field experiments the obtained yield is generally by 20% higher than that recorded in commercial production, the actual yield of dry matter of the above mentioned energy crops may be approx. 10 t/ha. Coverage of such a calculated demand for biomass to be used for solid fuels (i.e. primarily for power and heat supply) would require the establishment of permanent plantations of energy crops with an area of 340 thousand ha to the year 2010 and 660 thousand ha to 2015. The above mentioned authors predicted that this production will be located first of all on soils of the cereal-fodder strong complex, cereal-fodder weak complex, good rye complex as well as weak and very weak permanent grassland complexes. Weak and very weak rye soils due to a deficit of water will hardly be suitable for this direction of production. The utilization of currently fallow lands (most of these lands are found in provinces with a highly comminuted agrarian structure or in provinces with high shares of weak soils).

As far as the area of lands to be cultivated for solid fuel production is concerned, we need also to add the area of lands to be used for the production of raw materials for liquid biofuels. In the opinion of soil cultivation specialists, when considering the limiting factors the assumed potential rape cultivation area in Poland should be 1 – 1.1 million ha. If esters are added solely to diesel oil used in transport, then the demand for rape will be 0.87 million ton in 2010 and 1.52 million ton in 2020. In order to produce such quantities of rape it will have to be grown on the area of 410 and 475 thousand ha, respectively. Apart from biodiesel oil made from rape, an important role will also be played by the production of plant raw materials to be used for bioethanol. Different raw materials may be used in the production of ethanol: cereal and maize grain, potatoes, sugar beets, but also waste products rich in sugar or starch, such as e.g. molasses. Since the production of alcohol from sugar beets and potatoes is much more expensive than from cereals it has to be assumed that 80 - 90% bioethanol will be produced from grain – especially maize. It results from estimates that in 2010 approx. 1.4 million ton and in 2020 as many as 2.5 million ton grain will be processed to produce bioethanol. Assuming that up to that time the mean yield of grain recorded in Poland will be 4 t/ha, the area of grain cultivation for bioethanol will range from 350 thousand ha (2010), through 500 thousand ha (2015) to over 600 thousand ha (2020).

Summing up, in 2020 (and after that time the production of biomass should be further developed) the area of crops grown for fuel substitution should be almost 1.8 million ha (over 1.5 million ha in 2015). It results from this fact that plant production for energy may in the nearest future constitute a significant alternative (and competition) for food production. This may be even more so as, apart from soils of poorer quality, it will also be necessary to use good sites for the cultivation of energy crops.

3. Problems in the biomass market

In further considerations over the problems with biomass the following issues - possibly hindering the development of the biomass market - need to be taken into account (Grzybek, 2007, Zawistowski, 2007):

- a lack of forecasts concerning the share of biomass from forests (wood), which may be potentially used for energy up to the year 2020. Simulations performed by Płotkowski (2007) following three scenarios indicate that the volume of wood biomass, which may be used for energy, ranges from 11 to almost 16 million m^3. However, calculated values are theoretical in character and after the so-called processability is taken into consideration, they are reduced to 3 - 5 million m^3.

- local and difficult to assess utilization of waste products from wood processing, solid industrial wastes e.g. from paper and furniture industries, as well as recycled wood. Thus 6 -10 million m^3 need to be added (reported values should be treated as theoretical and highly arbitrary).

- a scattering of other potential biomass sources such as orchard wood, agricultural products and organic wastes. A lack of the market for agricultural biomass at an adequate scale and at present a lack of producers willing to offer larger batches of the raw material at one time practically eliminates this type of biomass from the commercial scale commodity turnover.

- a lack of competitive edge and instability of the cultivation area of agricultural biomass; resources of this type of biomass are dependent on the size of the production area (yields of biomass) and the ratio of prices for staple crops for human consumption and for animal feeds (sugar beets, rape, wheat). In a situation when production costs of biofuels are generally higher than prices for fossil fuels, increasing the share of biofuels may be achieved thanks to an active fiscal policy promoting biomass use.

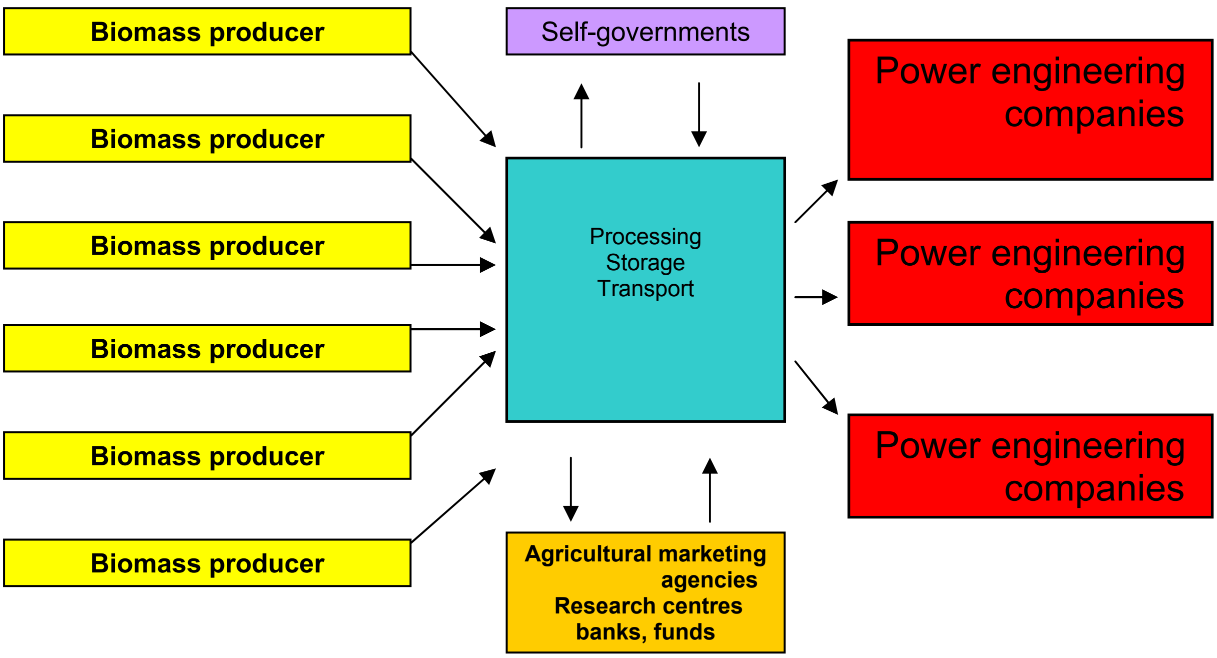
- considerable technological and organizational risk connected with the wider-scale introduction of biomass to power and heat supply engineering as well as the production of liquid fuels. The basic problems include complicated supply and logistics, changing legal regulations, weak support on the part of administrative bodies, technological problems (the location of installations, graining and other physical properties of biomass, corrosion, erosion and deteriorating efficiency of boilers, unstable fuel composition).

As far as biomass for solid fuels is concerned (i.e. mainly used for combustion), at present biomass is utilized locally (at the site of processing) on a limited scale. Biomass power engineering is developing in high-capacity heat and power generating plants, and not in case of scattered generation, which hinders the formation of local biomass markets and does not promote investments in energy crops (the necessary transport of biomass at long distances). Cogeneration in high-capacity plants, developing dynamically, is based primarily on the utilization of forest biomass. This results in the absorption of biomass from local markets and an increase in biomass prices, at the simultaneous drop in the value of certificate of origin property rights, which in turn bring about reduced profitability of investments in new biomass power plants of small and medium capacity. The overall instability is also the effect of poor and delayed implementation of mechanisms generating the market for energy crops (Stryjenki, 2007).

Conditions discussed above justify the need to perform analyses on the balance of energy biomass presented on a local scale potential demand and the likely supply. The initiation of studies on the logistics model for the biomass market should be a tool ensuring reliable biomass supply to combustion plants and guaranteeing collection of biomass from producers; at the same time it should facilitate long-term investment decisions, both on the part of power plants (modernization, purchase of new technologies), and on the part of biomass producers.

4. A model of a digital platform for the biomass logistics network

It is assumed that the digital platform is to be the primary tool in the communication between the biomass producer and buyer on the local market. The territorial range of the so-called primary biomass market is expected to be the area of a given commune. Primary commune biomass markets would form county markets and these in turn would be combined into provincial markets. The platform includes also active participation of local self-governments and different types of entities and supporting institutions (research centres, agencies, associations, banks, funds). The diagram of the existing relationships is presented in Graph 5.



Graph 5. A diagram of relationships in the local biomass logistics system
Source: Stryjenki, 2007

Taking into consideration the power supply potential of communes within the scope of the logistics system (apart from forest biomass and wastes from wood processing industry (approx. 3.2 to 5 million ton wood, which is the equivalent – in terms of the calorific value – of 1.6 – 2.5 million ton coal) these include first of all:

- surplus production of crops for human consumption and fodder crops (cereals, potatoes, maize, hay, straw, etc.); this surplus will be gradually diminishing with an increased interest in the typical energy crops,

- purposeful production of plants for energy; cereals, potatoes, sugar and fodder beets, maize, rape (jointly over 4 million ton staple product + approx. 2 million ton straw)

- energy crops for the local heat and electric power supply (common osier, Virginia fanpetals, poplar, Jerusalem artichoke, Miscanthus). According to Jasiulewicz (2007), the area used for cultivation may cover (with some limitations) approx. 50% poor quality soils, which will yield 30 million t d.m. (3 million ha x 10 t d.m.). Some species of energy crops may also be grown on fallow and degraded lands (1 million ha), which at the average yield of 10 t d.m. would give approx. 10 million t d.m. Thus, the equivalent of approx. 20 - 30 million t coal could be produced.

Summing up, in the year 2020 and beyond as much as 50 million ton biomass charge will be harvested, transported, stored and supplied annually.

Thus, in order to avoid transporting large batches of biomass over long distances it is justified to create local biomass markets, balancing the supply and demand, as well as develop electronic logistics systems minimizing costs connected with harvesting, transport and storage of biomass. An additional advantage of the development of the digital platform may be the creation of local power supply centres, i.e. the utilization of the existing heating infrastructure in small towns (heat and power generating plants using biomass – the so-called cogeneration) or the application of biomass (either raw or naturally dried) in local power engineering systems (up to 30 km). In the optimal scenario, thanks to such a system, communes self-sufficient in energy could be formed and exist, which - promoting this solution and investing in such facilities - could use fully their land potential (poor quality soils, fallow land, degraded meadows, etc.) for the production of biomass. These communes would profit from such enterprises thanks to (Jasiulewicz, 2007):

- more effective utilization of labour force resources in the commune,
- increased income from agriculture,
- turnover and capital remaining in the commune,
- improved ecological conditions in the commune – the state of the atmosphere, land, waters (tourist value),
- utilization and development of infrastructure.

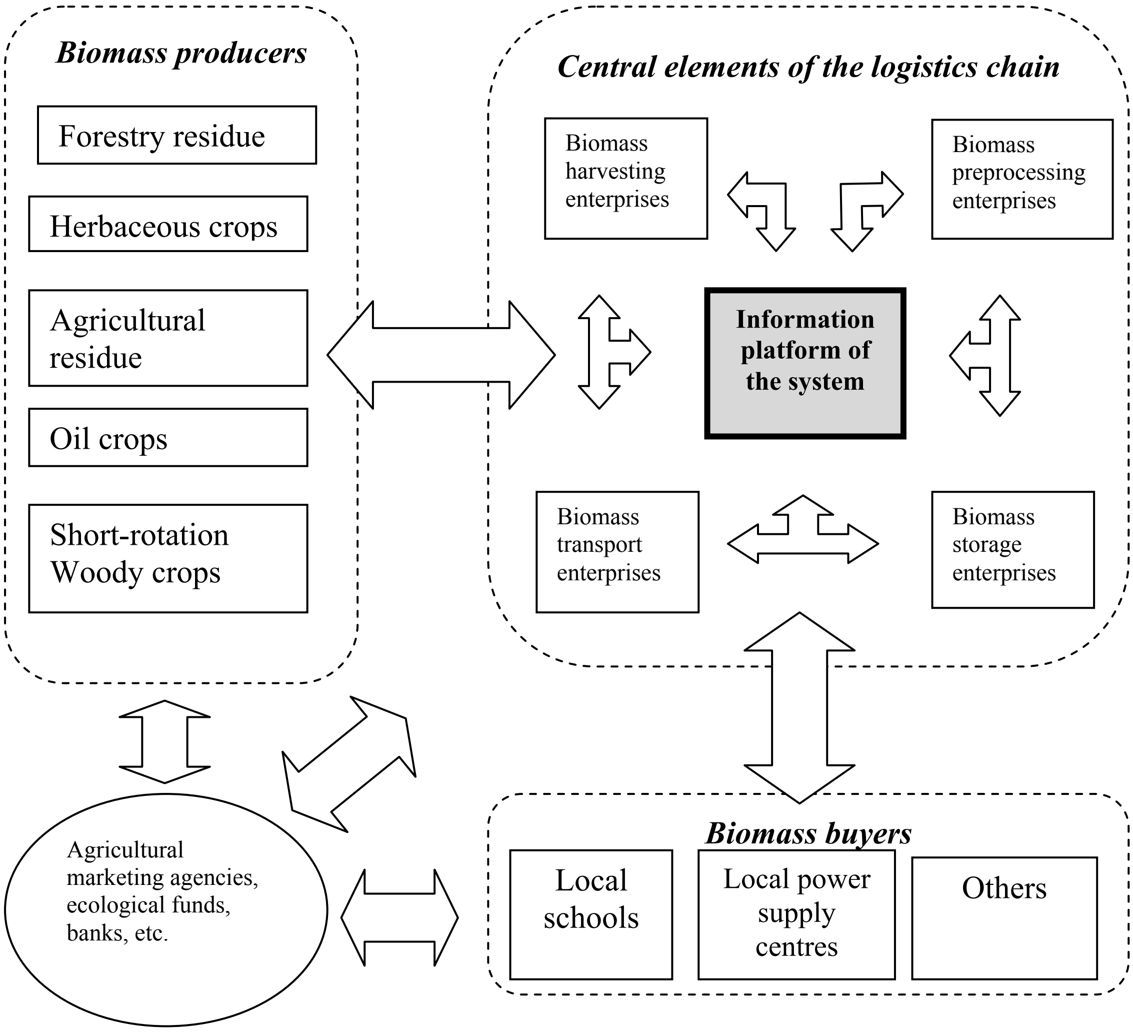
It is assumed that the development of the Internet logistics system should facilitate the realization of the primary goal as well as 2 auxiliary goals. The primary goal is to be an intermediate (through all elements of the logistics chain) on the local biomass market – on the one hand, to guarantee the collection of their product to biomass producers based on long-term contracts or direct purchase, and on the other hand, to guarantee the supplies of good quality fuel to power engineering companies over a longer time scale. Moreover, at the further stage of the project realization (complementary goals) the system is to facilitate cooperation of biomass suppliers and buyers with agricultural marketing agencies, ecological funds, banks, research centres, economic self-government bodies and local and regional self-governments, together with extension services offered to producers, self-governments and power engineering enterprises.

It is assumed that the electronic system, available on the Internet, in its primary part would be directed to the following recipients (individual elements of the logistics chain):

- biomass producers,
- entities dealing in biomass harvesting,
- entities dealing in transport of biomass,
- entities dealing in preliminary processing of biomass,

- entities dealing in biomass warehousing,
- final processors (consumers) of biomass.

After a recipient is identified the system would deliver complete information on the other participants of the chain. Each entity within the system could obtain information on the 5 other ones (see graph 6).



Graph 6. An interactive system of the biomass logistics network
Source: Authors' study.

5. Benefits of the project

Practical realization of the concept of the digital platform for the biomass logistics network should bring about many benefits, both in the macro (nationally, regionally) and micro scale (locally). The most important benefits of this project include such effects as (Pomorski, 2007; Żmuda, 2007; Stryjenki, 2007):

- the realization of international obligations,

- improved energy security of Poland,
- Improved quality of the natural environment – elimination of the so-called low emission – CO_2, SO_2 , NO_x , (utilization of biofuel in ecological combustion systems replacing existing coal-fired boiler plants),
- realization of the agricultural policy of EU and Poland – stabilization of agricultural production by the change of crops and yields for energy purposes,
- meeting social and economic expectations,
- ensuring coherence of energy management with the local economic development program (activation of the agricultural sector by the creation of new plantations of energy crops, management of idle lands, management of excess agricultural lands, prevention of population migration from rural communities, stimulation of demand for agricultural production means),
- a transformation of public awareness of the local community on the ecological fuel combustion,
- reduction of unemployment – creation of new workplaces,
- increased share of small and medium-sized enterprises in the local and regional economy (higher economic and social cohesion of the commune/province).

6. Concluding remarks

The project of a model logistics solution meets the expectations concerning the evolution of the energy supply system of Poland. The attempted more comprehensive utilization of RES in Poland in the future will be realized first of all thanks to the increased role of biomass as an energy fuel. The implementation of the presented proposal for the interactive logistics system will provide:

- the development of local markets for energy biomass and ensure their effective operation;
- full utilization of local resources of energy biomass for the production of green energy;
- initiation of a proper development of biomass power supply system as an element of sustainable development of rural areas.

In terms of specific goals, to be fulfilled by the digital platform of the biomass logistics network, the following processes are going to be facilitated:

– Purchase of energy biomass from producers,
– Processing of biomass for energy fuels and their storage,
– Supplies of biomass fuels to interested power engineering enterprises,
– Balancing of biomass resources and demand for biofuels within a region,
– Initiation of educational activities aiming at the utilization of biomass for energy,
– Search for investors in the sector and encouragement of investment projects in the region,
– Aiding the search for financing of investments required for the establishment of energy crop plantations,
– Cooperation with research centres in the promotion of good farming practice, effective growing and cultivation methods for energy crops, new cultivars of energy crops, technologies of processing biomass into fuels and energy production from biomass.

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