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Evaluation of reed resources in Latvia and analysis of its use for energy production

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Abstract

The increasing demand for energy, limited resources of fossil fuel, as well as pollution of the environment and changes in the global climate have raised more interest about the renewable resources. The use of renewable resources has become a very important part of European Union policy. The aim of the paper was to analyse reed resources in Latvia, its dynamics, volume and quality to produce clean energy. The use of reeds as a renewable energy resource contributes in minimizing fossil fuel consumption. The paper presents the results of a research of reed resources in lakes of Latgale (a region in Latvia). The investigation of reed resources showed that in the region they are scattered and rational usage of them is connected with environmental aspects. The greatest amounts of reed resources are concentrated in the biggest lake in Latvia - Lubana Lake and near to it. Studies show ed that the reed areas in Lubana Lake and Kvapanu ponds have doubled since 1997 and as a result these water reservoirs are becoming overgrown. Using direct measurement methods and metering from distance, it was stated that the total reed resources of greatest Lake - Lubanas are about 6830 tons year^{-1} in area of 734 hectares and are situated in 701 reed blocks. The aggregated reed resources of Latgale region are 18 000 tons year^{-1} of dry biomass. The investigation proved that reed resources of the region are sufficient to replace up to 21 thousand tons of different fossil fuels. The physical properties of the reed were measured. Carbon quantity, ash content and structure, moisture content proved that reeds are a profitable fuel for heat energy production. Balanced harvesting of reed gives a positive influence on environment.

Key words

Wetlands, Common reed, *Phragmites australis*, Renewable energy, Biomass, Environment quality, Clean energy

Introduction

Fossil fuel reserves are decreasing and this along with environment quality concern generates increasing interest in renewable energy resources. Use of renewable energy resources lessens national dependence on energy resource providers and facilitates domestic economy. Renewable energy resources in Latvia constitute one third of the primary energy resource balance and two most frequently used renewable resources are wood and hydro resources. Wind energy and biogas are used in a significantly smaller amount. While sun energy is used in very little quantities in the form of pilot projects. The Program of Latvian Renewable Energy Resource Usage sets a target to increase the proportion of renewable energy resources in the primary energy balance to 35% by 2010 and to 37% by 2016.

Latvia is a "green" country and has a large biomass production potential. Recently, pollution prevention technologies have been progressing, thus encouraging national economy development. There are wide choice of biomass used as energy sources: direct use of wood for heating, using waste from forestry and timber industry - saw dust processed into pellets, wood remnants into woodchips. Additionally for producing bioenergy cultivated quick-growing trees are being cultivated (Lazdins, 2008). The potential amounts of timber cutting waste and peat resource have been calculated (Cars, 2008). Biomass use is not limited only to peat and wood, energy can also be extracted from other types of biomass – straws, grass and other plants. One of the potentially usable types of biomass is reeds grown in water bodies of Latvia. Currently, they are used in small amounts only for rural buildings. To its energy content the common reed is almost equal to wood chips (Komulainen *et al.*,

2008). Lakes constitute about 1000 km^2 or 1.5% of national territory of Latvia. The number of lakes larger than 1 ha is 2256, 16 lakes are greater than 10 km^2 and add up to 45% of the total area of lakes in Latvia; Latvia's lakes are characterized by eutrophication, which often has a negative impact on lake biotopes as rotting water plant remnants are emitting methane (CH_4) in the atmosphere. Cutting and harvesting the reeds can decelerate eutrophication processes. The life cycle of reed canary grass plantation is several years long. During the first two years, the biomass is not harvested. In the first harvesting 7600 kg dry matter ha^{-1} was measured (Lindh *et al.*, 2005). Studies of the reeds' extraction impact on wildlife show that harvesting of reeds has a significant impact on reed beds, reeds are shorter and thinner in harvesting territories. (Valkama *et al.*, 2007). However, harvesting of reeds is feasible without negative impact on ecosystems due to determining optimal reed cutting intervals. Investigations proved that short-term reed cutting (1-2 years) has no impact on biotopes. Reed growing conditions differ in states and even water bodies, therefore research is necessary to qualify the reed properties of each water body. The time of harvest is very important – when reed are cut in winter from ice, no damage to biotope is done. This study analyzes the reed bed dynamics in water bodies of Latgale. The possibilities of using reed as a fuel and its energy potential are evaluated. Biomass amount that can be harvested from one lake area unit, the total reed resources in each lake and region were determined as well as the fossil fuel amount, which can be substituted by reed grown in lakes of Latgale. Reed use could facilitate regional development, lessen unemployment and dependence on fossil energy resource providers.

Fig. 1: Common lake reeds *Phragmites australis*

Materials and Methods

The object of study is the lakes' common reed, *Phragmites australis*. Reed is a perennial, tall (usually 120-250 cm) grass family plant (Fig. 1).

The rootstock is decumbent. The straw is bare, sharp, firm, slightly glazy and thick (d= 0.7-1.2 cm). Leafs are lanceolate (20-40 cm length, 2-4 cm wide), aeruginous, nibbed, the lower side is mat, volva is long. The trigger of leaf is furry. Panicles are long (20-40 cm), dense and reddish brown.

Reeds are widespread in Latvia. Usually they are routed in large, mono dominant beds in water reservoir and sea shores, moist woods, marshes and wet meadows. With its decumbent rootstock (vegetative sprout can reach 10-15 m) they rapidly occupies new areas. This species (mostly mono dominant) belongs to plant sets in forested fens and overgrown shallow waters, e.g. Cl. Phragmitetea, All. Phragmition.

The objective of research was to study the reed growth dynamics in natural circumstances of Latgale lakes and pond in years 1997 to 2008, to evaluate the amount of reed biomass in the greatest lakes of region and to assess its capacity to produce energy.

Biomass studies were carried out in the natural and artificial water bodies of Latgale region in the 2009/2010 winter. With the help of orthophoto snapshots reed beds of all the Latgale region lakes were evaluated and the potentially significant were further studied by taking measurements and determining the reed resource in each lake. According to the research results, potential reed usage contribution in production energy was assessed. Using orthophotographical snapshots from years 1997, 2005 and 2008, reed bed expansion dynamics in Kvapanu ponds and Lake Lubana were investigated.

To determine region's lakes with the highest reed potential – with area of over 100 ha, literature analysis were used. Reed resources were evaluated using direct and remote measurement methods. The direct measurement method was used to measure the reed resource amount, which could be harvested in lakes and ponds per 1 m^2 of reed bed. The calculations took into account only the part of reeds, which were above ice in winter. Measurements and weighing was done in 10 sample areas of 25 m^2 on each lake. The areas were chosen in places, which conform to the average reed bed thickness, determined in a reed bed survey.(Cubars *et al.*, 2009).

To define reed properties, 10 averaged samples from each lake were used. The samples were gathered and dried under a shed in natural conditions for 2 weeks without additional heating. The reed moisture content was measured with the standard method by weighing before and after drying in a drying cabinet with 160 ±

5°C for 5 min, after which the samples were cooled for 2 min and placed in the exsiccator for 10 minutes.

Reed ash content was evaluated in a laboratory with rapid inceneration standard method, a crushed sample weighing 1 g was placed in a furnace with the temperature of 850 ± 15°C and exposed for 40 min. (Avgushevich, 1987). Carbon content in the reed samples, wood and peat was measured with carbon/sulphur analyzer ELTRA CS- 2000, which operates on the principles of chromatographic analysis. Carbon content analysis was done for the averaged reed samples from Lake Lubana as well as various wood and peat samples for comparison.

The reed bed total resources and reed dynamics research was done using remote survey method in the ARC GIS software. Experimental data were processed mathematically according to the normal distribution (Douglas *et al*., 2003). All the Latgale region water bodies were assessed by various criterions- mirror-like area, plant growth and reed mass per m^2. The target volumes were lake mirror-like area of over 100 ha, plant growth over 3% and reed bed mass above 0.4 kg m^{-2} lakes and ponds which had not reached these volumes, were qualified as industrially insignificant and were excluded from further research.

Results and Discussion

Kvapanu pond is one of the greatest pond facilities in Latvia. It consists of 6 ponds with the total area of 610 ha and the average depth of 1 m. Studies of reed growth dynamics showed that reed areas in Kvapanu ponds were rapidly increasing. According to 1997 orthophoto 74 ha of reed were found, constituting 12.1% of pond mirror-like area; in 2005 there were 120 ha of reed, and in 2008 -160 ha, occupying 26.4% of the total pond area (Fig. 2).

In year 1997, 269 separate reed beds with area of 0.01-6.38 ha were observed, while in 2008, as the reed beds were spreading and conjoining, only 106 individual beds could be determined and the greatest continuous reed bed was already 21.2 ha (Fig. 3).

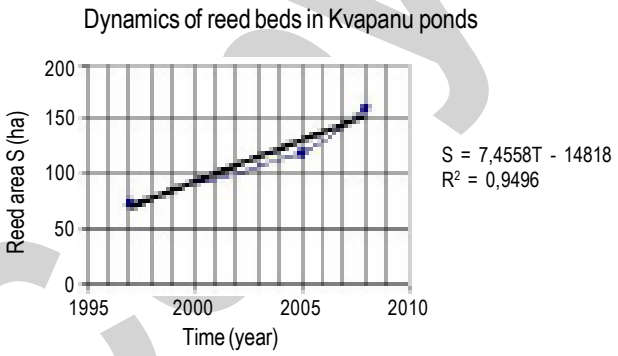

Fig. 2: Reed bed dynamics in Kvapanu ponds in years 1997 to 2008

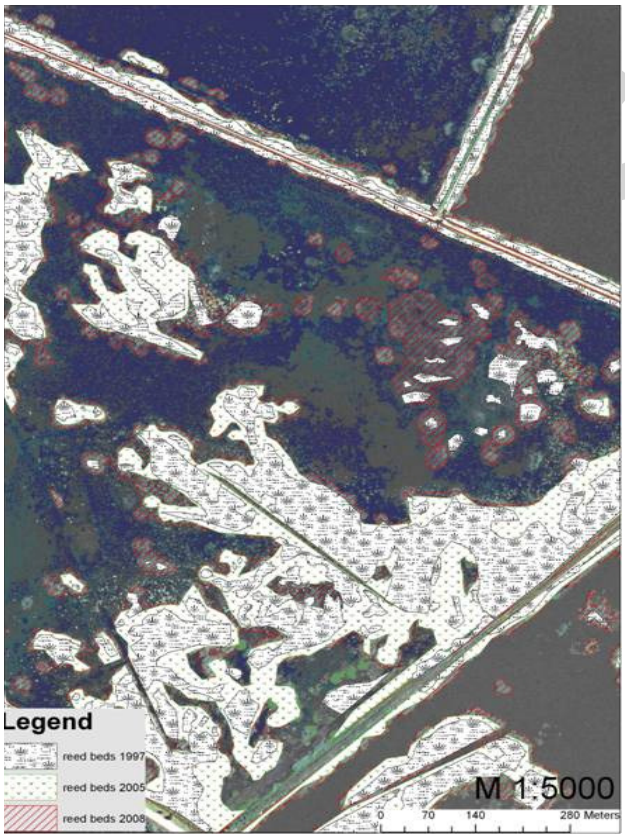

Fig. 3. Reed beds in Kvapanu ponds

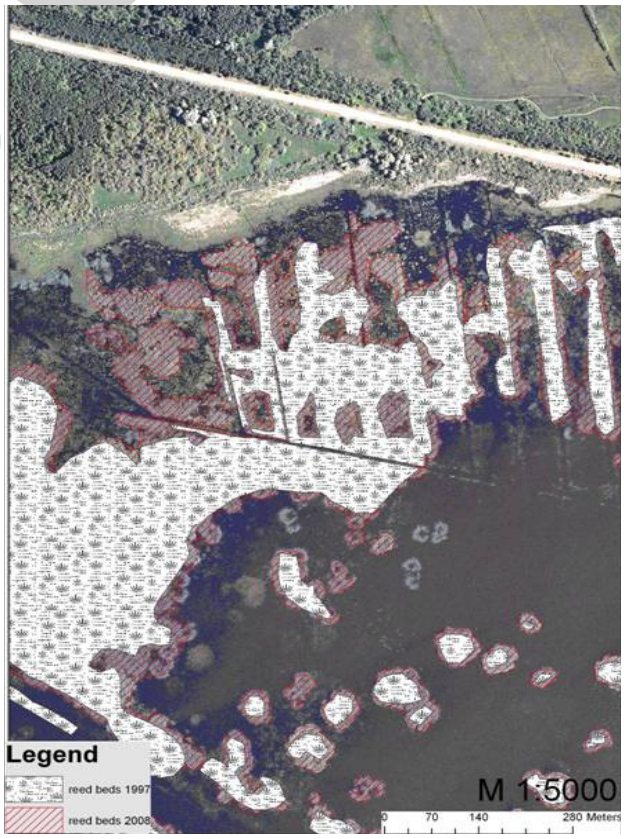

Fig. 4: Reed beds in lake Lubana

Similarly, in the artificial water bodies, reed beds were expanding in Lake Lubana (Fig. 4). Lake Lubana had mirror-like area of 8210 ha, average depth 1.6 m, the shores gently sloped, the bed of water body was loamy with patches of slimes. In the year 1997 orthophotos 440 ha of reed beds were found occupying 5.36% of the total mirror area. In 2005 there were 678 ha of reed and the mean yearly growth rate was 29.25 ha or 0.36 % of total area of the lake.

Orthophotos from year 2008 showed reed beds in 734 ha area, composing 8.94% of the total lake area (Fig. 5).

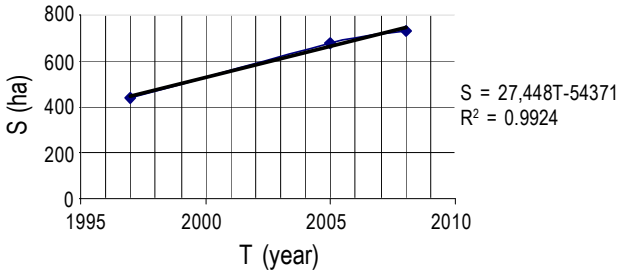

Fig. 5: Reed bed dynamics in Lake Lubana

The reed bed expansion stimulates changes in lake ecosystems, rotting plant remnants lessened the oxygen content in water, influencing organisms living in the lake and intensifying methane (CH_4) emissions in the atmosphere. Well-balanced and scientifically grounded reed harvesting could reduce the eutrophication processes in the lakes and ponds of the region. Winter cut reeds had moisture content 8-12% and when reeds are used as a fuel, there was no need for special drying, the moisture content complieswith pellet production requirements (Cubars *et al*., 2009).

Carbon content in reeds was 41.9-43.8% and did not significantly vary over different lakes and sample area. Reed was similar to wood and peat by carbon content (Cubars *et al*., 2009). Reed ash content in all the Latgale lakes concerned oscillates in the amplitude of 1-5 %, averaging at 2%. Studies show that reed burning in a conventional furnace without additional equipment and preliminary reed processing does not ensure complete combustion (Fig. 6), microscopic analysis show obvious organic remnants, which vanish only after 2 hrs in furnace.

Fig. 6: Reed ash after burning in a conventional furnace

When wood is burnt in these conditions, there are much less organic remnants. Therefore, to prevent energy losses, the furnace and preliminary processing should be optimized adequately for reed biomass (Cubars *et al*., 2009).

Survey of Latgale lakes and ponds showed that the total number of lakes in conformity with the criterions was more than 35, but the remote measurement research indicats that, ranking by the disposition and resource quantities, there were 22 potentially significant reed harvesting places – lakes and ponds. According to field measurements, significant reed resources were found in 20 water bodies; Lake Cernostes and Lake Pusas were excluded from further research, because field measurements gave too low average reed mass per m^2 values. Research done in 2009/2010 winter period shows that reed in lakes of the region differed and the mean biomass was 0.51-0.93 kg m^{-2} (Fig. 7.)

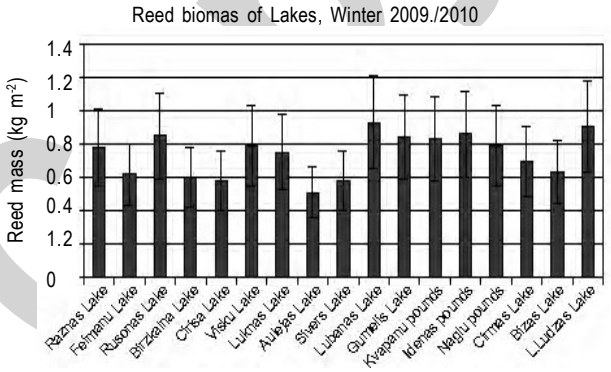

Fig. 7: Reed resources in lakes and pond facilities of the region in the winter of 2009-2010.

The experimental data showed that the most productive reed beds were in Lake Great Ludza and Lake Lubana, respectively, 0.91 ± 0.34 and 0.93 ± 0.32 kg m^{-2}, which may be due to the rich nutrition base as these lakes received purified sewage from Rezekne and Ludza cities. All the other lakes were similar and the reed biomass ranged from 0.51 to 0.86 kg m^{-2}.

Reed resources in lakes are divided by disposition in Latgale region in 4 blocks, which are formed around the greatest and resource-richest lakes :

1. Lubana block
2. Ludza block
3. Rusona block
4. Lake Razna

Lubanas block was the largest in territory and reed resources, it consisted of Lake Lubana, Gumelis, Kvapanu, Naglu and Idenas ponds with the total mirror area 10639 ha, 1130 ha of which are occupied by reed beds and the total block resources was approximately 10130 tons $year^{-1}$ (Table 1).

Ludzas block contained 6 lakes in the vicinity of Ludza town – Lake Great Ludzas, Lake Zvirgzdenes, Lake Pildas, Lake Meiranu, Lake Cirmas and Lake Bizhas, total area 2791 ha with 197 ha of reed, total resources ~ 1530 tons $year^{-1}$.

Table 1: Latgale region reed resources disposition by lakes

Number	Lake or pond	Total area of (ha)	Reed area in 2005 (ha)	AverageOvergrow (%)	Resources Lake, (tons year^{-1})
			Lubanas block		
1.	Lubana Lake	8210	734	8.9	6830
2.	Gumelis Lake	145	50	34.4	420
3.	Kvapanu ponds	610	120	19.7	1000
4.	Idenas ponds	644	134	20.9	1150
5.	Naglu ponds	1030	92	8.9	730
	Total (middle)	**10639**	**1130**	**10.62**	**10130**
			Ludzas block		
1.	Cirma Lake	1261	69	5.5	490
2.	Bižas Lake	140	11	8.1	70
3.	L.Ludzas Lake	846	73	8.6	660
4.	Zvirgzdenes Lake	134	9	6.4	60
5.	Pildas Lake	295	23	7.8	170
6.	Meiranu Lake	115	12	10.0	80
	Total (middle)	**2791**	**197**	**7.1**	**1530**
			Raznas block		
1.	Raznas Lake	**5756**	**236**	**4.1**	**1850**
			Rushonas block		
1.	Rusonas Lake	2373	221	9.3	1880
2.	Feimanu Lake	625	92	14.6	570
3.	Birzkalna Lake	272	25	9.4	150
4.	Cirisa Lake	630	61	9.7	350
5.	Visku Lake	360	31	8.6	250
6.	Luknas Lake	409	87	21.3	650
7.	Aulejas Lake	190	21	11.1	110
8.	Sivers Lake	1860	167	9.0	970
	Total (mean)	**7216**	**730**	**10**	**4930**

Lake Razna was isolated individually with an area of 5756 ha, reed beds of 236 ha and total biomass resources constituted around 1850 tons year^{-1}. The nearby Lake Ismeru and Lake Zosnas were evaluated as industrially insignificant with their reed bed areas. Rusonas block had the highest lake concentration and consisted of 8 lakes, the largest of which was the Lake Rusons – 2373 ha. The total area of the block was 7216 ha with reed beds have spread out in 730 ha, total reed resources per year – 4930 tons.

The reed growth level was different in each water body, the smallest proportion taken by reed was in Lake Raznas (4.1%), Lake Cirmas (5.5%) and Lake Zvirgzdenes(6.4%). The most overgrown are in the shallow lakes and ponds respectively. Lake Luknas (21.3%), Lake Lubana (8.9%), Kvapanu (19.7%), Idenas (20.9%) and Gumelis ponds (34.4%), which are infact the most significant reed harvesting areas. The total notable Latgale region reed resources were distributed in an area of 2293 ha and in sum can give 18440 tons of biomass year^{-1} as fuel.

Reed heating capacity was 17.2 MJ kg^{-1}. Thus, the greatest water bodies of Latgale region had the reed potential 94 GWh of heat energy in total.The saved amount of fossil fuels year^{-1}, substituting any of them with reed biomass, is shown in Table 2.

The most notable reed resources in Latgale were scattered over a large territory in Rezekne, Madona, Ludza, Riebini and Aglona regions and were are also found in significant amounts in Daugavpils, Kraslavas and Ciblas regions.

Using reeds grown in water bodies of Latvia has both its negative and positive aspects. The most essential problems and risks of using reeds are relatively high unit weight and ash content,

Table 2: The saved amount of fossil fuels per year, substituting with Latgale region reed biomass

Fossil fuel which can be replaced by reeds	Substitution of fossil fuel (tons)
Natural gas	10 500
Black fuel oil	8 800
Coal	13100– 21350 *
Diesel	7670
Schist oil	8700 – 12200*

*=The amount ranges depending on the fuel type and heating capacity

short harvesting period (2-3 months), the need of special harvesting machinery both lightweight and productive. The risks related to weather are that:

1. The ice might become too thin for handling machinery in winter period.
2. Drifting ice blocks can cut off the reed and waste the entire crop.
3. A thick layer of snow can break the reed and encumber cutting.
4. Fires can destroy the reed beds – the whole year's crop.

Intensive harvesting can lead to loss of productivity, the reed might become thinner and scarcer. The resources are scattered in large territories.

The positive aspects of using reed- there is no need to plant or fertilize reed, they grow by themselves that is why there is no need to invest in agro technology as it is with energocultures, the biomass is homogenous as well and all reeds are similar in their properties, mechanized harvesting is possible. When harvesting reed in winter over ice, the moisture content is relatively low 8-12% and extra energy used for drying is not necessary, the moisture is satisfactory for pellet production. When the reed is cut from water bodies, biogenic elements, which provoke water body eutrophication, are eliminated. If reeds are cut in the winter, the threat of spring fire is precluded. Reed use has a short CO_2 turnover cycle - 1 year. Reed ash is chemically similar to wood ash and so is easily utilizable in agriculture. The use of reed allows saving fossil energy resources, lessens economical and political risks, creates new places of employment and contributes regional development.

The reed areas in Lubana lake and Kvapanu ponds have doubled since 1997. Reed can be used as a heat energy resource. The lakes and pond facilities of Latvia are overgrowing. Reed harvesting can decrease the eutrophication processes.

In Latgale region there are 20 notable lakes and pond facilities that comply with certain criterions. The total reed biomass amount in the largest lakes and ponds of Latgale achieves approximately 18440 tons year^{-1} occupying an area of 2300 ha; total yearly heat energy potential is about 90 GWh. The heating properties of reed are similar to wood. The yearly harvest of Latgale region reed biomass is equivalent to 10 500 tons of natural gas or 8 800 tons of heavy fuel oil, or 13 000-21 000 tons of coal (depends on heating capacity of the coal), 7 670 tons of diesel or 8 700-12 200 tons of schist oil (depends on heating capacity). There is no need to plant or fertilize reeds as, they grow by themselves. No need to invest in agro technology as it is with energocultures. The biomass is homogenous – all reeds are similar in their properties, mechanized harvesting is possible. When harvesting reed in winter over ice, the moisture content is relatively low (8-12%) and extra energy used for drying is not necessary.

Reed harvesting have some impact on ecosystems, therefore optimal models of reed harvesting in Lakes of Latvia should be studied.

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