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Nordic Council of Ministers

# Perspectives for R&D in Bioenergy in the Baltic States

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## Preface

Closer cooperation within the Baltic Sea region has been a key issue in the work of the Nordic Council of Ministers in 2009, and I am pleased to present this report on the possibilities of Nordic-Baltic bioenergy cooperation and proposals for closer cooperation between Nordic and Baltic researchers.

With the Cop-15 in Copenhagen just around the corner, the role of renewables is more accentuated than ever, and our failure to safely and effectively introduce them in our energy systems will have an immense impact not just on us, but on the generations to come.

We cannot lift this task on our own, and I believe that our ability to cooperate and share knowledge across borders will be tested in the years to come.

The Baltic Sea region has an advantage here since we already have structures and the will to cooperate, and I think with our diversified approach and qualities we have much to offer.

This report is the result of this year's Icelandic chairmanship and our three offices in Estonia, Latvia, and Lithuania. It is the hope that it will both inspire and contribute to the increased cooperation in our region. This being said the conclusions are those of the authors only, and do not necessarily reflect the views of our organisation nor the Icelandic chairmanship.

I wish everybody good reading.



Halldór Ásgrímsson  
Secretary General of the Nordic Council of Ministers



# 1. Introduction

It can safely be claimed that almost all renewable energy sources (RES) have been known to mankind for millennia. Now with the increasingly obvious drawbacks of energy systems based on the relatively recent use of fossil fuels, age-old energy-carriers are making their re-entry, albeit in a modified form. Thus, traditional windmills have developed into modern electricity-generating wind power stations, while heat and light from the sun are stored in photovoltaic (PV) cells and the water-wheel has become hydro-power.<sup>1</sup> Similarly, wood and other plants are converted into sophisticated derivatives allowing for energy efficient utilisation.

The most conspicuous reason for the revival of these traditional energy sources is of course the fear that emissions resulting from the burning of fossil fuels will cause irrevocable damage to the climate. But there are also other important reasons, such as the suspicion that the availability of fossil fuels will peak in the foreseeable future<sup>2</sup> leading to ensuing price hikes, or a wish to reduce the political importance of the relatively small number of major producer countries of fossil fuels. Indeed, an increased awareness of the need to striving towards enhanced energy security through a broadening of energy sources is a significant factor pushing towards diversification of sources.

Behind this, one major indirect reason for the deployment of RES-technology can be identified, namely the challenge to enhance knowledge-creation through the development of new technology. There is plenty of evidence that large systematic efforts in developing technology often result in spill-overs, which benefit a much broader area than initially intended. Computers were not long ago thought of as being demanded in only small quantities and hardly anybody could predict the virtual explosion of the Internet, including the profound impact it has on many previously unrelated services, such as medicine or finance. In analogue with this, developments previously not foreseen could in the future be expected to originate from a massive development of renewable energy. Of course, renewable energy might draw from battery technology developments in mobile communication and from the universal use of computers (in balancing the grid), and from material science (in reducing transmission losses).

The entire energy sector is often discussed from a supply-side perspective, i.e. focus is almost exclusively put on the availability and price of

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<sup>1</sup> Usually only small-scale hydro is considered a RES.

<sup>2</sup> For a discussion on this topic, see Smil (2005).

various forms of energy. Climate change is today probably the single most important factor broadening this perspective to encompass the atmospheric impact of various modes of production.<sup>3</sup> However, the energy sector can also be approached in terms of knowledge creation, or research and development (R&D), by which in this context is meant not only the actual supply, but the broader implications for the capacity of a society to mobilise and develop technologies, sources, and skills with the aim to create a knowledge-intensive industry.

Throughout this report there is one particular underlying assumption: renewable energy technology will become increasingly important in the near future. Of course, such assumptions can never be proven right in advance, but many indicators point in this direction. The subsequent assumption is that as this industry is many times still in its infancy, the Baltic States could still have a possibility to develop internationally important technologies and industries in this field. There are examples of development of several sources of RES in the Baltic States, but this report focuses on one, namely bionenergy. The main reason for this is that bioenergy, especially biomass,<sup>4</sup> is the dominant RES in all of the Baltic States. It should also be added that the Baltic States have large resources for bioenergy, at least in relative terms.

Among the Baltic States, only the Estonian mode of electricity generation through the combustion of oil shale causes significant emissions of green-house gasses (GHG) to the atmosphere. Lithuanian, and especially Latvian electricity generation cause only modest emissions. Therefore reducing emissions will not be the utmost reason to develop renewable energy in these countries. However, all three Baltic States have set as a goal to enhance energy security, which almost by definition will have to include a variety of domestic energy sources.

The Nordic countries have been engaged in cooperation with the Baltic States in the energy field since the 1990s. These projects have largely been technical and financial support for converting boilers in the district heating system in order to enhance the use of biomass. Although bi- and multilateral R&D projects in the energy sector have been financed, the explicit goal of most investment has been in the climate policy framework, i.e. the objectives have been to reduce emissions, not to enhance R&D cooperation in the first place.<sup>5</sup>

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<sup>3</sup> Strictly speaking, energy cannot be produced. Different energy carriers can only be converted into others, e.g. fossil fuels into electricity or biomass into heat. However, in order not to complicate the reasoning the concept of energy production will be used.

<sup>4</sup> The following definition of biomass is from Directive 2009/28/EC: "the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances) forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste"

<sup>5</sup> EFUD 2003

## 2. Method, objectives, and limitations

In this report, bioenergy refers to the technologically sophisticated utilisation of wood and plants for energy purposes. Simply burning wood is of course also a form of bioenergy, but the point made here is that some sort of new or significantly modified technology is required in the process. Thus, the burning of wood for heat in state-of-the-art boiler houses would qualify as bioenergy use, while burning the same amount of wood in a traditional oven would not. Furthermore, the conversion of wood and plants for energy purposes is also regarded as bioenergy.

The focus in this report is on research and development (R&D) in the sphere of bioenergy. This excludes some practical measures, such as fiscal incentives for the introduction of bioenergy or legislation promoting the use of bioenergy. Neither is the aim to map bioenergy resources in the Baltic States- a vast number of reports and scientific articles already cover this area. Nor is the aim to calculate energy prices in various scenarios, nor to discuss general RES policies as this has also been done before.<sup>6</sup>

The concept of R&D as used in this study includes technological development, the sophisticated production of wood and plants, including new plant types or the mixing of existing plants for improved performance, or new methods of collecting or harvesting. In the bioenergy sector also a number of institutional improvements have to be seen as R&D, such as more efficient delivery systems from the fields to the point of end-use.

The situation in each country is described in terms of natural resources, technological development, and institutional development – a categorization that covers the aspects mentioned above. However, the boundaries between these aspects are not precise and they are often intertwined.

This report is largely based on a number of interviews with people professionally engaged in energy research and to a lesser extent, individuals active in the bioenergy business. The aim of the interviews has been to identify developments “below the surface”, i.e. R&D projects

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<sup>6</sup> A summary of the aspects mentioned above can be found in Silveira, Andersson & Lebedys (2006)

at the planning or otherwise initial stage. Also speculative assessments of the future by people with an insight into present developments have been a key element in the interviews. Due to the speculative character of many discussions, which form the basis for this study, no individual interviewee is referred to in connection with any particular statement or reasoning. A full list of all interviewees can be found in the reference list.

Generally speaking, as this study will show, there is relatively little R&D in bioenergy in the Baltic States. However, the main objective with this study is not only to map present trends, but to identify realistic future prospects for increased cooperation with the Nordic countries, where various forms of bioenergy technologies and methods are well developed and where significant R&D in bioenergy is performed. Currently, an estimated 30% of global biomass-based heat and power generation takes place in the Nordic countries. Another indicator of the importance of the Nordic bioenergy sector is that approximately 10% of global scientific knowledge production in bioenergy originates from the Nordic countries (in terms of peer reviewed articles).<sup>7</sup> Against this background, close cooperation the Nordic countries would offer the Baltic States a rather obvious stepping-stone for the development of their R&D in bioenergy.

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<sup>7</sup> Borup et al (2008)

## 3. International developments in bioenergy

### 3.1. Bioenergy and biofuels

Bioenergy is a broad concept including basically all energy stemming from biological substances. In this context a distinction will be made between:

- 1) Biologically derived fuels
- 2) Heat and/or electricity generated from the combustion of biomass

The introduction of 1<sup>st</sup> generation biofuels initially took place rather swiftly, but concerns about the long-term viability of fuels based on agricultural products or products grown on arable land have significantly altered the perspective. It is widely feared that the large-scale production of 1<sup>st</sup> generation biofuels will cause price hikes in the production of food, which would seriously affect people living in poverty.

The category 1<sup>st</sup> generation biofuels includes:<sup>8</sup>

- 1) Bioethanol (based on plants containing sugar)
- 2) Biodiesel (based on plants containing oil)
- 3) Biomethane (landfill gas, biogas, anaerobic fermentation of organic waste)

In 2007 some 1.5% of world transport fuels consisted of biofuels (of 1<sup>st</sup> generation), the production of which has occupied just below 2% of world arable land. The European Union (EU) is the third biggest producer in the world of 1<sup>st</sup> generation biofuels, trailing the USA and Brazil.<sup>9</sup> Replacing agricultural products with organic municipal waste and industrial waste may open up new perspectives for 1<sup>st</sup> generation biofuels, especially bioethanol, which otherwise would face the prospect of being phased out.<sup>10</sup>

So far, 2<sup>nd</sup> generation biofuels are not commercially produced. The concept of 2<sup>nd</sup> generation biofuels refers to non-food biomass which either through biochemical or thermo-chemical processes is converted into fuel, ethanol or diesel. Thus, 2<sup>nd</sup> generation biofuels could replace the need to use arable land for fuel production and thus counteract the upward pressure on food prices caused by 1<sup>st</sup> generation biofuels.

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<sup>8</sup> OECD/IEA (2008)

<sup>9</sup> Ibid.

<sup>10</sup> Economist.com, 18 September 2009 "Waste not, want not: ethanol from rubbish is the latest biofuel"

There are many potential sources for the production of 2<sup>nd</sup> generation biofuels, including forest residues such as branches, stubs and tree-tops, waste from processing of wood or municipal solid waste. Other potential sources include grasses or short rotation forest crops on land not in agricultural or even forestry use.<sup>11</sup> In short, initial assessments indicate that the raw material for 2<sup>nd</sup> generation biofuels would stem from sources not currently in use, and the use of which would have no known negative consequences.

The reasons for these fuels not to have been introduced yet on a broad scale are manifold, but at least the following can be identified; technical barriers, uncertainty of costs, and no unequivocally leading production technology. A large-scale launch of 2<sup>nd</sup> generation biofuels would require government support especially to keep initial costs down, but also more concretely research, development, demonstration and deployment.<sup>12</sup>

Nordic R&D in 2<sup>nd</sup> generation biofuels is intense, in particular in Denmark, but also in Finland and Sweden. In Denmark, R&D in this field is closely connected with the food industry, while in Finland and Sweden the forest industry is the driving force.<sup>13</sup>

### 3.2. The EU Legal Framework for Renewable Energy Sources

EU legislation on bioenergy is intertwined with other legislation on RES and it is, as a rule, not addressed separately. The most important directives with a bearing on bioenergy are listed below.

In *Directive 2003/30/EC* the European Community set a target of reaching a share of 5.75% of renewable energy in road transport by 2010.

*Directive 2004/8/EC*, on the promotion of cogeneration based on a useful heat demand in the internal energy market, calls for the increased use of combined heat and power (CHP) in all Member States. The Directive does not state explicitly what energy source would be recommended, because the process itself enhances efficiency by generating both heat and electricity in a single unit. Nevertheless, using biomass or biofuels would naturally result in even larger emission reductions of CO<sub>2</sub> than using e.g. natural gas.

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<sup>11</sup> Doornbosch et al. (2008)

<sup>12</sup> Ibid.

<sup>13</sup> Borup et al. (2008) and Vinnova Analys 2009-09

*Directive 2009/28/EC* stipulates a target of 10% of energy from renewable sources in transport by 2020 in *all Member States* (in parallel with a target of 20% renewable energy sources, RES, for all Community energy use) Furthermore, the Directive also lays down national targets for the overall use of RES in the Member States. In this context, the following targets are of interest:

Table 1. RES targets for some Member States

Country	Share of RES in all energy 2005	Target, all energy 2020
Estonia	18%	25%
Latvia	32.6%	40%
Lithuania	15%	23%
Denmark	17%	30%
Sweden	39.8%	49%
Finland	28.5%	38%

Source: Directive 2009/28 EC

Table 1 above shows that the targets for individual Member States for 2020 appear to be extrapolations from the present situation, i.e. the share of RES is assumed to grow steadily. Nevertheless, the methods chosen to achieve the targets are to be decided on the national level.

The *Directive 2009/28/EC* further stipulates that “*the main purpose of mandatory national targets is to provide certainty for investors and to encourage continuous development of technologies which generate energy from all types of renewable sources*”. It could be claimed that there is a competition situation between various RES technologies, but in many cases RES are complementary, for example when wind power is backed up by bioenergy. Moreover, no individual RES technology is likely to generate enough energy to cover total demand of a modern society and therefore future RES-based energy systems are likely to consist of several technologies.

The *EU Biomass Action Plan* from 2005 calls for all Member States to establish national action plans for enhancing biomass, the primary function of which is to identify and remove bottlenecks hampering the introduction of bioenergy.

At least theoretically, a Member State could either produce all biofuels required by itself, or import all, but the explicit purpose of the Action Plan is to pave the way for both development and trade.

### 3.3. Energy and emissions – basic data

In order to provide a sufficiently comprehensive picture of energy production and consumption in the Baltic States and the Nordic countries, a number of indicators have been collected in table 2. It should be emphasised that the Baltic States very small in energy terms compared with the Nordic countries. For example, total energy production of the Baltic States combined is less than half of Finland's. Final consumption is similarly much lower than in any individual Nordic country (with Iceland as an exception). On the other hand, there is no clear difference in the share of renewable energy in final energy consumption on the group level. Differences can be observed on a country-level only. Table 2 also illustrates import-dependency, which is particularly high in Latvia, Lithuania, and Finland. Denmark and especially Norway are net exporters, mainly of fossil fuels. Energy is commonly regarded as an issue of national security and thus the overall import-dependency can often serve as a proxy for how energy supply is addressed on the political level.

Table 2. Basic energy statistics 2006 in Mtoe<sup>14</sup> (with RES)

Energy	Estonia	Latvia	Lithuania	Denmark	Sweden	Finland	Norway
Total production	3.86 (0.62)	1.85 (1.84)	3.26 (2.23)	29.52 (2.96)	32.34 (14.81)	18.11 (8.65)	223.66 (11.6)
Net Imports	1.88 (-0.10)	3.17 (-0.39) <sup>15</sup>	5.46 (-0.01)	-8.08 (0.30)	19.8 (-)	20.95 (-0.08)	-197.6 (0.03)
Gross Inland Consumption	5.42 (0.53)	4.63 (1.43)	8.43 (0.79)	20.91 (3.26)	50.34 (14.81)	37.82 (8.58)	25.03 (11.63)
Final Energy Consumption	2.77 (0.40)	4.20 (1.02)	4.72 (0.58)	15.63 (1.00)	33.22 (5.07)	26.68 (4.43)	18.39 (1.06)
Energy intensity (toe/MEuro*100)	551	327	435	109	160	241	120

Source:

[http://ec.europa.eu/energy/publications/doc/statistics/part\\_2\\_energy\\_pocket\\_book\\_2009.pdf](http://ec.europa.eu/energy/publications/doc/statistics/part_2_energy_pocket_book_2009.pdf)

Table 2 shows that among the Baltic States, Latvia's domestic energy production can be classified as almost exclusively based on RES. This is mainly a consequence of Latvia's hydro-power plants combined with the wide-spread use of biomass in district heating. However, Latvia is heavily dependent on imports, the origin of which usually is not RES. Thus, Latvia's gross inland consumption of energy is significantly less RES-based than its production, although it is still the

<sup>14</sup> Mtoe stands for million tonnes oil equivalent, a unit used for the comparison of different types of energy sources.

<sup>15</sup> Because Latvia's domestic electricity generation is based on hydropower, the negative sign in front of the figure most likely indicates exports in order to balance the grid in the neighboring countries during periods of excessive water supply.

highest among the countries compared, being slightly more RES-intensive than Sweden.

Contrary to Latvia, Estonia is far more self-sufficient in energy production, but at the same time much less RES-intensive. The reason for this is that Estonian electricity generation almost completely originates from oil shale, a highly GHG-intensive fossil fuel. Estonia also produces shale oil, i.e. oil extracted from oil shale, which is used mainly in boiler houses for heating. The Estonian oil shale industry is of crucial importance for Estonian self-sufficiency in energy and it is also regionally a major employer - a fact which can be assumed to have an impact on the political willingness to switch to other sources.<sup>16</sup>

The Lithuanian situation is made complicated because of the imminent decommissioning of the Ignalina nuclear power plant, due in end 2009. The reliance on nuclear power is also an explanation for the significant difference between gross inland consumption and final energy consumption (because nuclear power also generates enormous amounts of heat, from which usually only a fraction can be used). Similar discrepancies can also be seen for Sweden and, partially, for Finland. In the case of Estonia the discrepancy is mainly a consequence of energy losses in connection with the combustion of oil shale.

From table 2 it can be observed that the Norwegian situation differs radically from the situation in other countries because of Norway's extensive energy resources, both oil and natural gas and hydro power. However, Norway is included in the table for the sake of completeness. The same applies for Iceland, with its enormous resources of geothermal heat.

Another aspect worth highlighting is the fact that the energy intensity (i.e. the amount of energy required to produce a unit GDP) is significantly higher in the Baltic States than in the Nordic countries (with the exception of Iceland, but as said, a comparison here is meaningless because of the geothermal resources of Iceland). This indicates a major difference in the economic infrastructure between the two groups. This is certainly no news, but an aspect that has to be taken into account when discussing the energy systems and especially the scope for any RES. It should however be pointed out that all of the Baltic States have significantly reduced their energy intensity since the early 1990s; the figure for Estonia was 1,216 (toe/MEuro\* 100) in 1993, against 551 in 2006, while the corresponding figures for Latvia were 827 and 327 and for Lithuania 851 and 435, respectively. This reduction implies that major energy efficiency measures have been implemented in the energy-economic infrastructure in the last decade and a half, but

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<sup>16</sup> Holmberg (2008)

also that significant scope for improvements remain. The corresponding figure for Finland, the Nordic country with the highest energy intensity, was 241.

The probably most common argument in favour of the introduction of RES is the need to reduce emissions of CO<sub>2</sub> in particular, but also other green-house gases. Table 3 below shows the CO<sub>2</sub> intensity and per capita emissions in the Baltic States and the Nordic countries.

Table 3. Emission of CO<sub>2</sub> (2007)

	Estonia	Latvia	Lithuania	Denmark	Sweden	Finland	Norway	Iceland	EU-2
CO <sub>2</sub> intensity (tCO <sub>2</sub> /toe)	3.09	1.96	1.79	3.04	1.21	1.89	1.73	0.82	2.5
CO <sub>2</sub> emissions per capita (kg/capita)	12,4	3,97	4,5	11,7	6,7	13,5	9,3	11,7	9,2

Source:

[http://ec.europa.eu/energy/publications/doc/statistics/part\\_2\\_energy\\_pocket\\_book\\_2009.pdf](http://ec.europa.eu/energy/publications/doc/statistics/part_2_energy_pocket_book_2009.pdf)

From table 3 it can be concluded that the picture regarding CO<sub>2</sub> emissions per capita is far from unequivocal. Finland, Estonia, Denmark, and Iceland top the list and their emissions clearly exceed those of Norway, which is on par with EU-27. Sweden, Latvia and Lithuania have per capita emissions far below the average. What these three countries have in common is an electricity generation system not based on fossil fuels (hydro in Latvia, nuclear in Lithuania and both nuclear and hydro in Sweden). When comparing the CO<sub>2</sub> intensity, i.e. the emissions of CO<sub>2</sub> in relation to the output of entire energy system, Estonia tops, closely followed by Denmark. Summing up, table 3 indicates that there is no clear-cut division between the Baltic States and their Nordic neighbours in terms of CO<sub>2</sub> emissions. From this follows that cooperation patterns between the Baltic States and the Nordic countries based on climate policy targets alone (i.e. emission reductions) are likely to be sub-optimal if the assumption is that the primary scope for reduction is to be found in the Baltic States.

### 3.4. Production of biofuels in the Baltic States

All three of the Baltic States have their own domestic production of biofuels, mainly aimed at export markets. The development of this industry was rapid until the 2008 economic crisis, after which a lull has occurred.

Total production capacity of biodiesel in the Baltic States was slightly in excess of 400 thousand tonnes in 2008. The corresponding figure for the Nordic EU members was a total just below 700.<sup>17</sup> Thus, the production capacity in the Baltic States is rather close to the Nordic capacity and accounting with the fact that a large share of Baltic production is exported to the Nordic countries, the Baltic States have become a relevant actor in this field in the Nordic region. The production of biodiesel in the Baltic States relies on one major production unit in each country.

Total production of bioethanol has experienced a dramatic growth in the EU since 2004. Total production increased from 528 million litres in 2004 to 2,855 million litres in 2008. Amongst the Baltic States Lithuania produced 21 million litres in 2008 and Latvia 16 million litres. In Lithuania new production facilities are expected to further increase production, market conditions allowing. The corresponding production figures for Sweden and Finland in 2008 were 78 and 50 million litres, respectively.<sup>18</sup> However, as was mentioned above, currently there are serious doubts about the long-term viability of bioethanol.

The production of biogas, whether from biomass or waste, tends to be capital-intensive, which might explain the relatively slow development of the sector in the Baltic States. Biogas production can currently be said to be only in its initial stages, but a number of biogas projects have recently been launched. Most biogas production units in the Baltic States are little more than demonstration facilities. Some small production facilities have been closed down in connection with bankruptcies of farms supplying them with waste for gas generation. Having said this, it appears that especially in Latvia biogas generation is witnessing a boom with a number of new, increasingly large biogas projects in the pipeline. It is nevertheless far too early to say anything about their success. Among the Baltic States, Estonia produced an estimated 2.4 million m<sup>3</sup> of biogas in 2008. Latvia and Lithuania produced both approximately 6 million m<sup>3</sup> annually.<sup>19</sup> Especially the generation of biogas from biomass has been identified as one of the key sectors in Nordic bioenergy-related R&D.<sup>20</sup>

There is relatively little domestic R&D embedded in the Baltic biofuel projects (with a major exception in Estonia, described below). If present biofuel projects are implemented, especially those involving the production of biogas, this sector has the potential to play a key role in

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<sup>17</sup> European Biodiesel Board, [www.ebb-eu.org/stats.php](http://www.ebb-eu.org/stats.php). It can be added that total production of biodiesel in the EU was 7,755 tonnes in 2008.

<sup>18</sup> European Bioethanol Fuel Association, [www.ebio.org/statistics.php?id=6](http://www.ebio.org/statistics.php?id=6)

<sup>19</sup> [www.bioenergybaltic.ee](http://www.bioenergybaltic.ee)

<sup>20</sup> Borup et al. (2008)

Baltic R&D. Furthermore, the experiences in the Baltic States from the commercial production of 1<sup>st</sup> generation biofuels for an export market should not be underestimated. It is possible that a foundation for further cooperation has been established, such as business relations and the increased awareness of the potential of commercialisation of bioenergy, which could be valuable if the step to 2<sup>nd</sup> generation biofuels is taken.

## 4. Estonia

### 4.1. General overview

The use of bioenergy in Estonia is more or less restricted to production of heat. In 2006, wood accounted for 16% of heat production. Fossil fuels, in particular natural gas and oil shale, composed almost 70% of heat production. In electricity generation, the share of oil shale exceeds 90%.<sup>21</sup>

The Estonian *Long-Term National Development Plan for Fuel and Energy Economy Until 2015* from 2004 calls for the increased use of biofuels and identifies CHPs based on biomass as having significant potential. The main difficulties in expanding the use of CHPs are basically the relatively small heat loads needed in Estonia (due to the small settlement size), recent installation of boilers for heating only, and the comprehensive exports of biomass products which put domestic users at a disadvantage. The small heat loads are actually a technological challenge, because the international development of small-scale CHPs has been lagging behind while using large CHPs would be both costly and a waste of resources. Moreover, replacing recently installed boilers with new CHPs would also generate excessive costs.

The Development Plan calls for a 20% share of CHP (regardless of fuel) in electricity generation by 2020, the present figure being 11%. The target share of CHP-generated electricity from biomass for 2013 is 3%.<sup>22</sup> So far three major CHPs running on biomass have been taken into use (or will soon be taken into use); at Ahtme, at Vão near Tallinn and at Luunja near Tartu.<sup>23</sup>

The more recent *Development Plan for the Promotion of Use of Biomass and Bioenergy for the Period 2007 - 2013* from 2007 explicitly calls for research and development in the biomass and bioenergy sector. For this purpose, there is a need to assess the potential of biomass, to study various energy crops, to study available technologies (e.g. biogas, CHP, fuel production, materials, life-cycle analyses), bio-fuel potential in transport, and institutional aspects (such as legal issues, taxation, support schemes).

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<sup>21</sup> Estonian Energy in Figures 2007

<sup>22</sup> [www.bioenergybaltic.ee](http://www.bioenergybaltic.ee)

<sup>23</sup> Estonian Energy in Figures 2007

Moreover, the plan states that there is a need to analyse the state of bioenergy in Estonian R&D performed by research institutions, to develop specific study tracks in the field of bioenergy, to modernise the research infrastructure, and to encourage students to study bioenergy abroad. In addition to this, there is a need to constantly upgrade statistics.

In brief, the broad picture emerging from the development plan is that coordinated R&D in bioenergy is more or less non-existent in Estonia. A number of the issues identified have already been addressed, such as mapping of soil for bioenergy purposes. However, it remains to be seen to what extent the present economic difficulties will affect the continued implementation of the plan.

The number of Estonian participation in projects related to bioenergy in the EU's 6<sup>th</sup> Research Framework Programme (FP-6) was five, from which four were specific support action (SSA). Generally, the projects with Estonian participation were focused on data collection and processing and information dissemination. Two other projects with a partial bearing on bioenergy R&D focused on the use of sewage water in energy crop plantations.<sup>24</sup>

## 4.2. Resources

Estonia has basically three sources for bioenergy:

- 1) residues from forestry
- 2) growing biomaterial,
- 3) waste (human, agricultural, and stemming from forestry).

### 4.2.1. Residues from forestry

Wood is the most important source of bioenergy in Estonia, amounting to 8.6% of gross inland consumption of fuels. Its share in electricity generation is negligible, but wood accounts for 16% of heat production.<sup>25</sup> The future of wood in the Estonian energy system is at present unclear, because of two opposing trends.

In the 1920s and 1930s some 30% of Estonia was covered by forest. Today the figure is significantly higher, exceeding 50%, because during the Soviet period reforestation took place. However, the quality of the wood is often low and efficient harvesting is complicated and therefore expensive. Moreover, the age structure of the wood is such that a potential production peak will be reached within the next decade,

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<sup>24</sup> [www.archimedes.ee](http://www.archimedes.ee)

<sup>25</sup> Estonian Energy in Figures 2007

with an ensuing decline in overall amounts the following decade.<sup>26</sup> This restrains the potential for long-term use of wood in the energy system. A contrary trend can also be observed; with improving forest management, it is likely that in the coming years, wood will remain in focus among Estonian bioenergy sources. One reason for this is that fuel wood might be of increasing interest for the oil shale-based power generation industry, which could reduce its need for oil shale by mixing it with biomass, and then wood in particular. Research at Tallinn Technological University has shown that a mixing 10–20% biomass in oil shale in the gasification process leads to significant reductions of sulphur emissions (but not CO<sub>2</sub> reductions extensive enough). Moreover, the amount of oil shale needed is simultaneously reduced, the reserves of which are gradually drying up in the coming decades.

It can be assumed that if Eesti Energia, the owner of the two big oil shale-based power plants, starts purchasing large amounts of fuel wood this will be reflected as an upward pressure on prices, which in turn might cause smaller buyers, such as operators of municipal boiler houses, to turn to other sources, in particular natural gas.

There is already a shortage of forest residues, caused by several factors; in particular the fact that in Estonia a rather vibrant industry producing wood chips and pellets has developed in the last decade. However, most of the production of these wood-based fuels is exported, especially to Sweden, where market conditions, including the price, tend to be more stable than in Estonia.<sup>27</sup> The flip side of this is that many Estonian users, mainly boiler houses producing municipal heat, find it difficult to come over wood-based fuel.

#### 4.2.2. Growing biomaterial

Estonia has an estimated 400,000 hectares of land theoretically available for the production of biomass. This land is however split into several small parcels around the country, commonly of the size 1-5 ha. Proximity to the user is of crucial importance, because of the lower energy content of biomass. Thus, transporting biomass from a great number of small parcels to the place of end-use might turn out to require more energy than can be obtained from the biomass itself – or in other terms, be more expensive than using the amount of energy needed for the transports directly for the end purpose.

There has also been increasing criticism against using arable land for growing bioenergy purposes. It is claimed that the global demand for

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<sup>26</sup> Paist et al (2005) assess that total wood fuel supply will decrease from today's 5 million m<sup>3</sup> to 2.3 m<sup>3</sup> in 2030.

<sup>27</sup> Since the late 1990s, more than half of Sweden's imports of fuel wood originate in Estonia. (Ericsson & Nilsson (2004)). Heavy taxes levied on carbon dioxide and sulphur in Sweden make imports of biofuels attractive. It can be discussed whether an unforeseen consequence of this policy has been that the development of bioenergy in the Baltic States is hampered.

food will increase, which in turn requires more land for food production. Thus it is likely that growing energy crops will not be sustainable in the long run.

Since the collapse of the Soviet Union and the subsequent diminishing market for Estonian agricultural production, the amount of available land, i.e. previously agricultural land not in use any longer, has actually increased. Another reason for this increase is the fact that a number of people who had their ancestral farmland returned in connection with the privatisation in the 1990s are not engaged in agriculture.

A number of crops have been tested in Estonia for energy purposes. Among these, salix (willow) appears not to be economical in Estonian conditions. An experiment with willow in Tartu by the Estonian University of Life Sciences showed that expensive technology would be required and this would be economically viable only with significantly increased demand. In particular harvesting costs pull down the profitability of willow.

Other crops experimented with include reed canary grass, which might not be socially acceptable, because in many locations it would be a new plant. Moreover, it needs additional fertilizers to grow. Hemp has also been tried, but it has not proven viable from an energy perspective. Approximate analysis has been made on grass, but initial results indicate that productivity would be low.<sup>28</sup> Every summer grasslands throughout Estonia are harvested, in part for landscaping objectives (financed by the EU). Such hay is often left in the fields and not used. This has raised the question whether hay could be used in boiler houses. However, hay is a complicated fuel, which needs preparations before it is burnt. One solution would be to mix it with wood chips to achieve higher density and consequently higher energy contents. Because of the low energy contents, long-distant transport of hay is not a viable solution, but gasification could become an option. Today, research in this field is only in its initial stages.

However, one crop has turned out to be promising; namely reed. Reed is domestic for Estonia and it has historically been used for different purposes, such as construction material for roofs. Reed can also be used as insulation material while the residuals can be burnt.

A joint Estonian–Finnish Interreg project, “Reed strategy in Finland and Estonia” has produced encouraging initial results. The project was administered by Southwest Finland Regional Environment Centre, while most of the technical testing took place at the Department of Thermal Engineering of Tallinn University of Technology. It is re-

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<sup>28</sup> See the section on Lithuania, where initial results appear more encouraging

cognized that far more R&D (in both technology, biology, and agriculture) is still required for reed to become a major source for bioenergy, but at the same time using reed for various bioenergy purposes – such as gasification - has become increasingly plausible.<sup>29</sup>

The estimates on the area available for reed energy purposes in Estonia vary, but assessments in the range 3,500 – 7,000 hectares on an annual level are most common. The uncertainty stems from a number of factors, including no definite agreement on harvesting methods, the need for nature protection and the economic viability of reed in some areas due to e.g. density. Moreover, reed cannot be harvested in the same location every year and thus the annually harvested area needs to be significantly smaller than the total area in use for energy purposes. On the other hand, reed has high productivity, usually 7 tonnes/ha, but occasionally as much as 70-80 tonnes/ha.

Reed harvested in winter is dry and can be burnt as such. Reed harvested in summer might be better to gasify or to use for the extraction of liquid fuels, but harvesting in summer increases the risk of damaging the roots. Harvesting reed in the summer has one additional advantage; during the growth season, reed ties up nutrients, especially nitrogen, the excess of which the Baltic Sea currently suffers from.

So far, there is only little experience of biogas generation from reed. Small-scale experiments have been carried out by Tallinn University of Technology. Thus much more research would be required to establish the properties of reed in the gasification process. However, it is estimated that biogas generated from reed within a CHP would be one of the most efficient methods.<sup>30</sup>

Burning reed in small furnaces usually requires that reed is compressed to pellet or briquettes for increased density, but some additives have to be used, such as 5% turnip rape in order for the material to become solid enough. In bigger furnaces (i.e. with a capacity in excess of 300kW) and district heating boiler houses reed bales can be burnt, usually mixed with wood chips.<sup>31</sup> The amount of available reed in Western Estonia could theoretically generate 26 GWh electricity and 29 GWh heat in a CHP, but in practice the figure would be much smaller, not the least for reasons of nature protection.<sup>32</sup> Although these figures are very small in absolute terms, the relevant issue in this context is that reed might prove to be not only a local fuel, but if the R&D ef-

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<sup>29</sup> Specifically for Estonia, the results and ensuing policy conclusions are to be found in “Roostike strateegia Väinamere piirkonnas 2008-2012”, while the entire project is described in Komulainen et al. (2008)

<sup>30</sup> Kask quoted in Komulainen et al (2008)

<sup>31</sup> Ibid.

<sup>32</sup> Total electricity generation was 9,731 GWh (in 2006) and heat generation 10,335 GWh (2006). Source: Estonian Energy in Figures 2007.

forts turn out successfully, a possible cornerstone for a future bioenergy industry. International interest in reed has recently witnessed a surge, which in turn could have a major boosting effect on Estonian R&D in reed, where Estonia actually has become one of the pioneers. At present a large-scale project on the use of reed is being modeled, in which three villages would be using reed as a material and a fuel, pressing briquettes and making pellets. *“If we could find active villages in Estonia, we could create ‘reed societies’ where many people would make a living of it.”*<sup>33</sup>

Lihula municipality in Western Estonia is currently constructing two boilers for biomass; one boiler for reed, straw and natural grasses and another for wood chips. The aim is to reduce emissions of CO<sub>2</sub> in the municipal heating to merely 2% of the present (heating has so far been based on shale oil). The construction of the boilers, financed partially by Norway and the EEA<sup>34</sup>, is at the same time a pilot project for municipal use of biomass, in particular reed residuals stemming from the reed pellet industry in the area.

#### 4.2.3. Waste

A potentially important chapter in Estonian R&D in the bioenergy sector started in January 2009 with the cooperation agreement between the Centre of Renewable Energy at the Estonian University of Life Sciences and Institut National de la Recherche Agronomique of France. This cooperation is expected to strengthen the laboratory experiments for controlling the anaerobic digestion in connection with biogas generation from various types of waste.<sup>35</sup> So far, the process of anaerobic digestion is not known in such detail that would be required for any large-scale utilization. But with improved understanding, it is possible that for example gasification of biologic substances in waste water could become an integral part of municipal waste water treatment. At present the unknowns include how various substances behave in the digestion process and how maximal production can be reached. Increased knowledge would open new perspectives also for the conversion of residuals from agriculture or municipal waste into biogas.

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<sup>33</sup> Ülo Kask, personal communication, 1 September 2009.

<sup>34</sup> [www.eeagrants.org/id/620](http://www.eeagrants.org/id/620)

<sup>35</sup> Both the rector of EMU and the director of the Centre of Renewable Energy interviewed for this study expressed high expectations on this cooperation. See also [www.emu.ee/289425](http://www.emu.ee/289425)

### *4.3 Perspectives for technology development*

The Estonian bioenergy sector, by and large dominated by using biomass as a fuel in boiler houses and some CHPs, is in technological terms almost completely relying on imports. The share of Estonian technological product development is almost insignificant. It can be claimed that in a technological sense, Estonian companies are sub-contractors, providing pipes, maintenance, and electrical works for the installations. This applies not only to the bioenergy sector, but to renewable energy at large. So far, there have been only few signs of Estonian companies emerging as producers of equipment or entire installations. Whether this should be seen as a major shortcoming can be discussed, but the fact that Estonia has invested in developing bioenergy without having any significant technological product development indicates a structural weakness.

Innovations connected to existing technologies are a possibility for Estonian companies, especially as suppliers of energy. Many applications of bioenergy require locally adjusted technologies to develop their full potential. Thus it can be argued that until now, Estonian companies in the bioenergy sector have been learning the business and the technology, but the time might have come to take the first steps towards a domestic industry. This process might be encouraged by the opening of the electricity markets in Estonia, Latvia and Lithuania, when possible surplus electricity from biomass-fuelled CHPs can be traded on a much bigger single market. Some observers claim that especially the niche called agroenergy (using agricultural waste for biogas generation in particular) is about to take off in the Baltic States. While business has remained hesitant in investing in technological development in other fields of bioenergy, agroenergy appears increasingly to be an exception. Therefore the previously described research on controlling anaerobic processes conducted at Estonian University of Life Sciences may turn out to be an important component of cooperation between research and business.

Another future perspective for Estonian bioenergy would be to develop into a “testing ground” for international suppliers of equipment. To a certain extent already taken place in the 1990s when biomass-fuelled boilers were installed with support from the Nordic countries. Becoming a “testing ground” could be highly beneficial for Estonia and the development of Estonian know-how.<sup>36</sup> In any bioenergy project calculations are first made in theory then in the field, and this process usually goes back and forth several times, in particular because local

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<sup>36</sup> For instance the Swedish-Finnish pulp and paper producer StoraEnso is rumoured to study the potential of producing biogas in Estonia.

conditions have to be properly identified. Failure to count with location-specific factors can easily make the use of bioenergy prohibitively expensive. The preparation processes would provide ample of opportunities for Estonian experts. Furthermore, Estonia has been open to new innovations in other fields (especially ICT), which indicate preparedness to utilise new technology. Especially the possibility to participate in the development of 2<sup>nd</sup> generation biofuels appears to generate interest.<sup>37</sup>

#### *4.4. Institutional development*

The development of bioenergy in Estonia is hampered by a number of institutional factors, among which the most important are:

- Research institutes have not won the trust of business. The institutes still carry some heritage from the Soviet system and research tends to be split into several areas with relatively little coordination and cooperation.
- The research institutes have difficulties in raising funds for their activities
- The Estonian domestic market is too small for generating a big industry
- So far, cooperation of the Estonian farmers is not self-evident due to the incentive structures. Farmers need long-term binding contracts for investing in bioenergy production
- The dominant role of oil shale in the Estonian energy system might cause crowding out of alternatives

The Estonian national energy technology programme has been set up to alleviate problems related to the implementation of research results, a process which also includes defining the most important issues, to coordinate research performed in Estonia and to identify sources of financing, including foreign financing. Bioenergy is one of the principal target areas. There is at present political support for the development of bioenergy, and support mechanisms have been under development. However, nobody expects bioenergy to solve the entire energy puzzle.

The Centre of Renewable Energy at the Estonian University of Life Sciences has been coordinating cooperation between universities and companies in the field of bioenergy for the last two years. Insufficient cooperation between research and business in many areas is a widely recognised problem in Estonia, which hampers the process of turning research results into marketable products. The universities are perceived by the business sector to produce too little output with marketable potential. Especially the limited capacity to turn laboratory results

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<sup>37</sup> Similar thoughts were expressed by many interviewees for this study in Estonia

into practice is perceived a crucial bottleneck. The experiences of the Centre of Renewable Energy show that cooperation can be developed, as is the case especially in biology-related fields, including bioenergy, where contacts with business have been promising so far. Success requires closer cooperation between agronomists and engineers, which may take its time to develop. However, already now there are signs of the emergence of the specific field for cooperation, commonly referred to as “growing energy”.

For the bioenergy sector to develop, one crucial question is the supply of biomass. It has to be locally produced, because long transportation will make it too expensive. This fact emphasises the need for smooth cooperation with local farmers. To minimize the risks for both farmers (volatile prices) and consumers (failure of delivery) of bioenergy, some type of stable agreements need to be developed, perhaps financed through EU schemes.

Oil shale will almost certainly remain the crucial component in the Estonian energy system in the foreseeable future. The reserves are big enough to allow continued use for several decades. At the same time oil shale is perceived a guarantee for national self-reliance in the energy field. Moreover, it cannot be excluded that oil shale will become globally important in the future as a result of instabilities in the global oil market. Such a development would make Estonian know-how in the field internationally demanded. On the other hand, oil shale combustion causes large emissions of green-house gases and unless this issue can be addressed and a sustainable solution found, Estonia might equally well be stuck with a marginal, relatively inefficient technology.<sup>38</sup> The attempts to mix oil shale with biomass in order to reduce emissions have to be seen against this background, namely to strengthen the potential of oil shale. For this reason it is justified to raise the question whether mixing biological substances with oil shale should be treated as bioenergy in the first place, or rather as a competing type of energy.

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<sup>38</sup> One technology often perceived as a solution to the problem of CO<sub>2</sub> emissions is carbon capture and sequestration (CCS), by which is meant that CO<sub>2</sub> is removed before being emitted into the atmosphere and stored in underground hollows. Initial surveys have however not found the Estonian ground suitable for such long-term storage. Source: Holmberg (2008).

## 5. Latvia

### 5.1. General overview

Biomass is widely used in Latvia, mainly in district heating. In Latvia biomass is used in 1,500 out of 3,000 boiler houses, although not exclusively. Especially wood is used as fuel in heating, which has raised concerns over long-term supply; large quantities of wood are being exported, which has led to upward pressure on the price level. Wood residues as scrap from sawmills are used for the production of briquettes and pellet, but vast amounts of residues from forestry are mainly unexploited due to the high costs involved.<sup>39</sup>

The share of wood in the Latvian energy system is striking; 31% of total primary energy supply and a whopping 84% of *domestic* primary energy supply. On the other hand, Latvia is highly dependent on energy imports - 68% of gross inland consumption in 2006 - while, as was mentioned above, large quantities of wood fuel are exported.<sup>40</sup> Thus Latvia produces significant amounts of wood fuels, but domestic consumption in heating is heavily reliant on imported natural gas. Some 30 % of fuels used in boiler houses are wood while only an insignificant share of fuels used in CHPs are wood or other biomass. In total, 15% of energy supply in heating is from renewable sources.<sup>41</sup>

Regarding electricity generation, total supply in 2007 was almost 7,800 GWh, from which 2,800 GWh originated from Latvian large hydro plants and 1,500 GWh from large CHP plants. An additional 600 GWh came from small CHPs, from which 42 GWh originated from renewable sources. As the CHPs almost exclusively run on natural gas, basically all renewable electricity in Latvia originates from large hydro plants.<sup>42</sup> Imports of electricity are crucial for Latvia, most of it originating from Lithuania (nuclear) and Estonia (oil shale).<sup>43</sup> The share of electricity from renewable sources, including hydro (from gross consumption) was 37.7% in 2006, rendering it a third place in the EU, where the average share of renewables was 14.6%. The use of

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<sup>39</sup> Renewable Energy Policy Review Latvia 2004, [www.erec.org](http://www.erec.org)

<sup>40</sup> The main markets for Latvian exports of wood chips and wood waste are Sweden, the United Kingdom, Denmark, the Netherlands, Estonia, and Lithuania

<sup>41</sup> Latvian energy in figures (2008) and EU energy in figures 2009

<sup>42</sup> Large hydro is not universally accepted as renewable energy.

<sup>43</sup> It should be pointed out that Latvia is periodically an exporter of electricity. This happens when water levels in the Daugava river are high.

biomass for electricity generation in Latvia, 0.6%, remained far below the EU-27 average of 2.7%.<sup>44</sup>

Latvian energy policy is outlined in *Guidelines for Development of Energy Sector 2007-2016* (approved by the Cabinet on 27 June 2006). The guidelines call for increased self-sufficiency and diversification of supplies, while reducing dependency on external sources. As a part of these measures, the efficient use of renewable sources in CHPs is considered important. A total of EUR 140 million from the Cohesion Fund in 2007-2013 will be allocated for energy efficiency measures, district heating, and CHPs using biomass. In the same token, the document states that high priority is given to the construction of a condensed power plant mainly based on coal, while Latvia also supports the construction of a new nuclear power plant to replace Ignalina in Lithuania, from which Latvia has imported a large share of its electricity.<sup>45</sup>

Specifically for bioenergy, the *National Program for Production and Use of Bio-fuel in Latvia* from 2003 discusses the possibilities to generate biogas from municipal and industrial waste.

Summing up, the Latvian approach to bioenergy and other renewable energy sources appears somewhat hesitant. On the one hand, renewable energy is supported, but on the other hand other solutions suggested leave only little room for the development of renewables in electricity generation. In heating focus is strongly on bioenergy, though.

## 5.2. Resources

In addition to relatively large resources of wood in Latvia, there is also straw available for energy, mainly heat production. At present one boiler house is using straw.

The quantity of biogas annually produced in Latvia is approximately only 1% of the theoretically potential amount. Biogas could be generated from agricultural waste, municipal wastewater, especially from the food processing industry, and from landfill gas. However, the decentralisation of agricultural production seems to have reduced the potential basis for such raw materials.<sup>46</sup> The main reason is the break-up of large collective farms into smaller individual farms, which consequently have no centralised waste management.

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<sup>44</sup> EU energy in figures 2009

<sup>45</sup> <http://www.em.gov.lv/em/2nd/?cat=16670>

<sup>46</sup> Renewable Energy Policy review Latvia 2004, [www.erec.org](http://www.erec.org)

Municipal waste could have the potential to become a major source for biogas. Approximately 40% of all municipal waste in the country has been deposited near Riga, which should be seen as a clear advantage for using it for producing biogas, because no long-haul transport of waste is needed. The main obstacle for utilizing this source of 900,000 tonnes annually is that sorting has not functioned; 885,000 tonnes are not properly sorted.<sup>47</sup> However, trials with a recently constructed CHP only 30 km away from Riga have highlighted yet another difficulty; although electricity generation from the biogas generated from waste suits well with the grid, the use of heat simultaneously generated remains unresolved. The distance to Riga is too big for an efficient use, and in addition to this Riga already has a functioning heating system in place.

Differently from Estonia, Latvia does not have large resources of reed, mainly due to the characteristics of the coastline (the Estonian coast is rugged, with many bays and small islands while Latvia's coastline is open and unbroken). Latvia has neither big lakes similar to those in Estonia, which are fertile ground for reed.

### 5.3. Perspectives for technological development

One of the leading institutions in Latvia in research and development of RES-related technology is the Institute of Physical Energetics of the Latvian Academy of Sciences. The Institute has been the coordinator of the national energy research programme 2006-2009 (together with Riga Technological University and University of Latvia), a EUR 3 million energy research package, which also contains research on bioenergy. The Institute has also broad experience from participation in EU Framework Programmes 5, 6, and 7.

The Institute of Physical Energetics has three major areas of activity:

- 1) Environmental policy studies as background for EU policy implementation in energy and climate change by the Ministries of the Economy and the Environment
- 2) Environment energy modeling; assessments for energy policy
- 3) Integration of RES and energy efficiency and background studies for governmental institutions

The Energy Resources Laboratory at the Institute is experimenting with different RES. In biomass, focus of research is on new technologies, especially for use in CHPs, of which there at present are four in Latvia. The main issue to be studied is the heat load, because the calorific value of biomass is lower than that of fossil fuels and the biomass available is not always of good quality while it tends to be more expen-

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<sup>47</sup> Technical review of the utilisation of waste material for biogas production in Eastern Europe. BIG>East 2008, available at [www.big-east.eu](http://www.big-east.eu)

sive than natural gas.<sup>48</sup> The CHPs consequently need to be adjusted to the fuel while maximizing output.

The estimates of the potential for CHP with biomass vary. The potential outside Riga is estimated to be in the range 87 to 110 MW electricity, but the simultaneous heat generation becomes a problem because there are only a handful of cities in Latvia which are big enough to consume the heat stemming from large-scale CHPs. In the biggest city Riga, there is already a well-functioning system based on natural gas and thus switching to biomass would cause major expenses, which especially in today's economic crisis can hardly be justified. This situation illustrates a more general dilemma; although the potential of biomass is big, it has not been clarified who the actual users should be. Thus one has to separate production potential of bioenergy from how it actually fits in with the present energy system. In addition to this, there is also a logistic problem, especially with transports, because biomass tends to be voluminous, while the sources, contrary to waste, often exist far away from consumption. Thus transports might easily end up eliminating gains made by using biomass instead of e.g. natural gas.

At present R&D efforts on developing CHP seems to have been intensified internationally. In particular R&D on micro-, small-, and medium-scale CHP with biomass has grown in importance, but comprehensive R&D is still needed to reach the demonstration stage.<sup>49</sup> There exists no particular Latvian technology development of CHPs based on biomass and the main efforts are put into preparing technology transfer from abroad. However, such technology is rarely a precise fit with the needs of the Latvian energy system, which would require much smaller units. Similar problems are faced by Estonia and Lithuania. Against this background, R&D in developing CHP of a significantly smaller size than currently available could be perceived a niche for the Baltic States.

In purely speculative terms, Latvia could have the potential become a leader in combustion technology for biomass. At present there are some companies in Latvia producing new types of biomass boilers for heat, but not CHPs.<sup>50</sup> Latvia could gain from becoming a "testing-ground" for various new technologies, especially in biomass CHP. It can be said that Latvia, similarly to Estonia, was already a sort of "testing ground" in the 1990s, when several boilers were constructed through foreign funding, especially from Sweden.<sup>51</sup>

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<sup>48</sup> There are several reasons for this. One is, as in the case of Estonia, that wood fuel is exported to Sweden, which has led to an upward pressure on prices. The price level is also affected by availability, which in turn is a function of methods used in forestry.

<sup>49</sup> Van Loo & Koppejan (2008)

<sup>50</sup> Leading Latvian boiler producers include companies such as Orions, Grandeg, and Komforts.

<sup>51</sup> Pervod kotel'nykh na mestnoe toplivo: drevesinu i druguyu biomassu. Vides projekti

However, becoming a “testing ground” for CHP is hampered by the fact that there exists no specific institution, which could conduct the relevant testing, in particular because financing is wanting. If it would be possible to find partners for the installation of pilot plants, also the municipalities would probably be more eager to participate. Especially in the case of small-scale CHPs, public-private partnerships would probably be the most viable option, because this would involve business from the very onset. Also development of purely biomass CHP would probably require intensified public-private partnership, but such schemes seem remote under today’s economic conditions.

Another area in which Latvia has a potential to develop an advantage is modelling of scenarios of RES integration into the energy system, where Latvia could be a “testing ground”, too. EU policy modelling has a tendency to focus only on potential, not on actual use, which especially in the case of bioenergy is an obvious drawback. Experience at least in Latvia has unequivocally demonstrated various types of limitations to using the full potential (the complications described above).

#### 5.4. Institutional development

A couple of years ago the Institute of Physical Energetics carried out a study assessing its economic, environmental and social impacts of wide-scale utilization of bioenergy in Latvia. In particular, the inclusion of social aspects was new and it contained employment effects and regional development. The study concluded that biomass has the direct employment effect of 500 new jobs in all of Latvia plus 100-500 indirect jobs. Some of this is however not new employment. Such jobs include the installation of technology and maintenance. These figures indicate that developing bioenergy for the sole sake of creating jobs in the countryside might be a highly inefficient strategy.

Energy planning is a prerequisite for any successful launch of large bioenergy projects. The key issue is when and where should bioenergy be used. Ad hoc projects and non-coordinated pieces of projects rarely produce the outcome looked for. The bottom-line is that municipalities or municipal energy providers are the actual decision makers. Therefore they need to be persuaded by carefully prepared demonstrations.

A number biomass spatial projects have been carried out with the support of Interreg funding. Through such projects, the availability of biomass and soil quality are measured. In order to strengthen the scientific basis for municipal use of biomass, the number of such projects should be significantly increased. The logical step at present would be to initiate scientifically inclined projects on spatial planning

to initiate scientifically inclined projects on spatial planning in cooperation with the municipalities.

Similar to the situation in the other Baltic States, exports of wood and wood-based fuels generate more stable incomes than selling to Latvian municipalities, in particular because of contractual matters. Foreign purchasers, contrary to Latvian municipalities, often offer long-term contracts with stable prices.<sup>52</sup> Although exports generate income, the consequence of this development is that Latvia ends up exporting products with little or no value added, such as pellet or wood briquettes. Moreover, exports have led to higher prices and insecurity about the supply of wood fuels for municipal boiler houses. Under these circumstances natural gas often becomes the most economical option.

Cooperation between the Baltic countries in the field of R&D in bioenergy is highly limited. There are a number of conferences and other occasions to meet, but there are basically no joint efforts: “*we participate in each others’ seminars only*”. The main reason for this is naturally the lack of intra-Baltic funding and thus cooperation patterns tend to focus on other countries or the EU. The Institute of Physical Energetics, for example, has comprehensive cooperation with Roskilde University Energy research programme in Denmark and the Danish Energy Authority.

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<sup>52</sup> Ericsson & Nilsson (2004).

## 6. Lithuania

### 6.1. General overview

Lithuania has been almost completely dependent on the nuclear power plant at Ignalina for electricity generation; in 2006 the share of nuclear power was 70%. After the decision to decommission the power plant by 2010 in connection with the EU accession in 2004, Lithuania has been forced to find replacement within a relatively short period of time. It is possible that the energy transition taking place in Lithuania is one of the most drastic experienced by any EU member, although Lithuania has been negotiating with the other Baltic States on the possibility to construct a new joint nuclear power plant to replace Ignalina. This would imply that the present situation is perceived as temporary, which in turn will most likely have an impact on the development of other energy sources.

This notwithstanding, renewable energy and energy efficiency have been high on the Lithuanian energy agenda, although it looks increasingly likely that the lion's share of the (temporary?) energy replacement will originate from natural gas and other fossil fuels.<sup>53</sup> While natural gas constituted 24% of electricity generation in 1990, the figure had dropped to a mere 2% by 1993. During the 2000s the share of natural gas has been almost constantly increasing, reaching 20% by 2006.<sup>54</sup>

Similarly to Estonia and Latvia, Lithuania has a comprehensive district heating network, which since the early 1990 has been partially converted to suit combustion of biomass. Today there are 366 boiler houses for biomass with a combined effect of 600MW. However, there is a capacity ceiling of 700MW in force. This measure was initially introduced to safeguard deliveries to the wood processing industry. According to the Lithuanian biomass energy association, LITBIOMA, this regulation is obsolete today. The biggest fuel for heating is still natural gas and continued conversion to biofuels would require increased funding. A tax levied on natural gas would probably stimulate business investments in the bioenergy sector.

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<sup>53</sup> Lithuanian electricity generation will rely heavily on the outmoded Lithuanian Power Plant together with a few newer CHPs. In 2008, the EBRD financed a major environmental and technical upgrading of the plant, allowing for the comprehensive use of natural gas in most of the units. Source: <http://www.ebrd.com/new/pressrel/2008/080922.htm>

<sup>54</sup> It should be mentioned that total electricity generation in Lithuania went down by more than 50% between 1990 and 2000.

Having said this, it should be added that changes in connection with the closure of Ignalina might change the picture, because the entire demand and supply structure will be affected.

Despite the fact that the district heating system is considered to be well-developed in Lithuania, some infrastructural problems from the Soviet period still linger on affecting the development of district heating or CHPs, especially in small towns.<sup>55</sup> During the Soviet years, the collective farms often had their own boiler houses outside the towns, from which heat was led into the towns. However, the long pipes constructed in those years suffer from poor isolation and disproportional amounts of heat are lost during transmission. In these cases the question is whether to construct a new boiler house in the town or isolate the pipes. Moreover, in the present time of crisis, consumption of heat and other energy is going down. Thus there is no necessary correlation between demand and potential, the latter occasionally being significantly higher than the former. The most urgent issue becomes the efficient supply of heat and energy, assumingly at the expense of further R&D in both biomass combustion technologies and new CHPs.

Starting in 1993, the Swedish Energy Agency supported Lithuanian municipalities in the conversion of boiler houses from fossil fuels to biofuels in the district heating system. Initially the programme focused on smaller boiler houses. Several boiler houses were reconstructed and new boilers using wood chips were built. Russian heavy oil, mazut, was previously a fuel used in boiler houses and those boilers needed to be cleaned up. Also Venezuelan heavy oil has been used, which contains heavy metals. New filtering systems have been developed to collect the metal from boilers and pipes.

Currently, 78% of the fuel used in district heating is natural gas, while 18% is biomass. In 1997, the share of biomass was a mere 1.2%. LITBIOMA estimates that by 2020 around 70% of district heating could be based on biomass, while 26% of final energy consumption could consist of renewable energy. Furthermore, 6% of electricity would be generated from biomass in CHPs.<sup>56</sup>

Lithuanian R&D in bioenergy is referred to in the *National Energy Strategy* from 2007 and the *Programme for the promotion and production and use of biofuels 2004-2010*. However, the role of R&D in the development of the energy system is not particularly highlighted with the exception of the need to train cadres of specialists in all energy-related fields and to promote energy efficiency. The *National*

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<sup>55</sup> National Energy Strategy

<sup>56</sup> Figures provided by LITBIOMA

*Energy Strategy* calls for the restoration of nuclear power and limits the share of any single supplier country of natural gas for electricity generation to 30%.

## 6.2. Resources

The Lithuanian Forest Institute performs investigation of wood resources, changes of energy infrastructure in small towns and regions. The main challenge in the bioenergy sector is how to cover local energy demand with local resources. The Lithuanian Energy Institute calculates resources on a technical basis, i.e. the scope for utilising for example glycerol (a by-product of ethanol), or old tires (i.e. recovered fuel but treated as a biofuel). Support from EU Regional Funds has been made available for these projects, but technology itself stems from abroad.

Particular attention in Lithuania has been given to the potential of using straw as a biofuel and interesting perspectives exist in grasslands. It has been estimated by the Lithuanian Energy institute that straw could have the potential to become the second most important source of biomass (after wood).

There are large areas which are not well kept from an agricultural viewpoint and often such areas also become a landscape problem. A project at the Lithuanian Institute of Agriculture reckons that maintaining the landscape by converting these areas into bioenergy production areas would be a potential solution. The reason for these areas being left abandoned can be found in the Soviet-time collective farms and their break-up in the 1990s. This caused a situation where some newly established farms were too small to be viable and sometimes with owners not being particularly interested in farming. On the other hand, there was also land handed over to municipalities for a number of reasons, e.g. because it had been used by industry and may still contain toxics. Such land is often left abandoned and it cannot be used for biomass production unless its toxic status is clarified.

On average, Lithuanian fields of all types yield 50% of their potential. Thus more efficient use has to be seen as a major resource in all respects, including bioenergy. 80% of arable land is drained and it is in more or less good shape, but land must be maintained to remain fertile. Underutilised land in relatively good shape opens up perspectives for bioenergy production.

A particularly interesting perspective emerges if straw or other grass could become the raw material for the development of 2<sup>nd</sup> generation biofuels. From a Lithuanian viewpoint, the general developments in developing 2<sup>nd</sup> generation biofuels taking place abroad do not need to be repeated on the domestic arena, it would be “*like reinventing the wheel*”. However, the Lithuanian contribution to this development could be biorefineries using grass as the raw material once basic technology has become widely available. A number of experiments in order to find suitable grass have been conducted by the Lithuanian Institute of Agriculture, for which “*the field is the laboratory*.” The purpose is however broader than preparing for the commercialisation of technology for the 2<sup>nd</sup> generation biofuels, which probably is still years away. The aim is also to develop a natural filter for nitrates and how to make the process as inexpensive as possible. Relying on grass would also mean that no new plant species such as rape would be necessary. Meanwhile mapping of resources and land has to be concluded.

Production of *biodiesel* in Lithuania is based on two crops; sugarbeet and grain, of which the former is a major energy crop yielding up to 70 tonnes/ha. Perhaps because of the climate change, the water table in Lithuanian fields rises only in September, and not in August, as used to be the case only a few years ago. This implies that the autumn climate has become drier, which increases the yield of sugar beets, especially in terms of energy contents.

It can nevertheless be called into question whether further R&D in biodiesel based on agricultural crops will stand a chance in the future because of changing preferences among consumers and policy makers. Biodiesel provides export earnings for the time being, but the long-term perspectives appear increasingly bleak.

The full potential of *wood residuals* appears to have been reached in the heating system, with 80-85% of available wood fuel in use, and the production of wood fuel for heating is likely even to decrease unless efficiency measures for collecting residues are implemented. To increase the amount of wood fuel available for heating would require better integration with forest management and industry.<sup>57</sup> It should be added that exports of wood generate more stable earnings, so Lithuanian producers are sometimes reluctant to sell on the domestic market. This makes Lithuanian wood fuels expensive on the home market for heating compared to natural gas.

New domestic programmes have been launched with focus on forestry and short-rotation crops such as willow. Thus integration of the energy sector with agriculture has become increasingly important.

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<sup>57</sup> Silveira, Andersson & Lebedys (2006)

### 6.3 Perspectives for technological development

The Lithuanian Energy Institute (LEI)<sup>58</sup> is the main performer of research on the efficient use of resources. The LEI measures i.a. the efficiency of boilers using wood as a fuel. The actual research on boilers is limited to testing, conformity assessments, recommendations, and reviews on how to improve the efficiency of the boilers.

Despite the significant increase in the use of biofuels especially in heating, it has to be emphasized that technology is mainly imported and the entire switch towards wood fuel was initiated and made possible by the Swedish Energy Agency. So, far domestic Lithuanian R&D in RES-related technology development has not taken off on a larger scale. Especially technology for boilers burning straw would be needed, but currently there is no R&D in this area. Straw boilers are some 2-3 times more expensive than wood boilers, but with more R&D the cost could decrease.

There is only little demand for R&D from the business sector because technology is usually easier and less expensive to purchase from abroad. Thus Lithuania tends to adjust to outside technological developments. This is of course a perfectly sensible attitude, because Lithuania's role becomes to take in new technology and to apply it. Instead Lithuanian companies have been testing the equipment, for example the boiler houses using straw mentioned above. However, expanding R&D would require much more resources.

The national Energy Strategy foresees that some funding from EU Structural Funds will be directed to R&D in technological development, too, albeit the most part is likely to be directly invested in new boiler houses and CHPs. The use of municipal waste could be an option for boiler houses, but experience shows that there is often resistance among the local population. In the end, the companies operating the boiler houses make their own choices of fuel according to efficiency. In the absence of a carbon tax, biofuels are today even more expensive than natural gas.

There are nevertheless a few projects going on which contain R&D, although on well-known technologies:

- Gasification of waste in Kaunas waste water treatment (a similar project is also underway in Klaipeda).
- In Vilnius a big 60 MW boiler house became operational in 2007 collecting waste in the whole region. The capacity of earlier boiler houses based on waste has not exceeded 10 MW.

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<sup>58</sup> [www.lei.lt](http://www.lei.lt)

- A mix of natural and synthetic biogas has been tried at a CHP biogas plant with a gas turbine in Panevezys. Increased efficiency in electricity generation is expected to be gained through this process. This method could suit several small towns which during the Soviet period constructed comprehensive gas pipeline networks. Today gas to the CHP could be transmitted through these pipes – assuming that gasification does not take place in the CHP itself.

Summing up, Lithuania is not conducting R&D in bioenergy technology, mainly due to high costs, but instead R&D in domestic fuels is expected to become compatible with technological developments abroad.

#### 6.4. Institutional developments

Fluctuating prices for agricultural products, including biomass, hamper investments. Therefore, long-term contracts is a prerequisite for the bioenergy industry to develop. Of course, R&D could be conducted regardless of the current situation in agriculture, but if such R&D would stand a chance to develop into an industry the underlying problems need to be solved. Farmers need guarantees for being able to sell their production, while business cannot be based on today's volatile situation with the prices. Therefore, although there is natural potential for a viable bioenergy sector in Lithuania, other factors hold back development. Similarly, low prices for energy affects the interest in biomass production, especially among small land-owners. Thus it can be claimed that to a large extent, developing bioenergy in Lithuania is basically not a technology-driven question, but a matter of agricultural policy.

Bioenergy is also to a large extent an issue of logistics. In connection with preliminary plans for a large-scale biofuel factory in Kaunas, it turned out that there was no appropriate mapping regarding the obvious facts that 1) land belongs to somebody with his own opinions 2) what kind of contract would that person like and for how long time? The example above illustrates the need to integrate a bottom-up perspective already in the planning phase. Unfortunately, various assessments and recommendations in the bioenergy sector appear to have a tendency to start from top-down assessments of available resources, technologies, etc.

Experience has shown that not all potential for bioenergy is real potential. While a model may be relatively easy to construct, at least in Eastern Europe, socio-economic factors still differ from those in the Western Europe, and especially complications originating from the bureaucracy should not be underestimated. It should also be counted with popular resistance to change. As a consequence, many estimates

on the potential for bioenergy (in whichever form) in Lithuania remain insufficient as a basis for formulating R&D goals.

One particular hurdle to overcome is the lack of mutual understanding between various groups, such as engineers, agronomists, farmers, business people, and municipal decision makers. This is not necessarily a matter of “group cultures”, but occasionally insufficient insight in each others’ domains. Annually fluctuating yields, well-known to farmers and agronomists, have often not been taken into account when assessing the potential for particular crops in energy-related studies. For example, the rainy summer of 2009 changed the agronomic conditions for straw. Without the addition of extra nitrogen the harvest was 4 tonnes/ha, but with additional nitrogen 9 tonnes/ha. This difference, exceeding 100%, is of course extremely complicated to build into any model, but nevertheless it has to be properly understood in energy planning.

From the viewpoint of the Lithuanian Institute of Agriculture it has become relevant to ask whether a new industry could be developed in rural bioenergy. However, a major obstacle is that Lithuanian farmers are still rather weak in both financial and organisational terms because of former collective arrangements, the legacy of which is not yet completely left behind. Any attempt to develop a bioenergy-industry (commercial or semi-public) would have to organize the farmers.

The utilisation of grass and straw is at least in theory a government programme, but due to the financial crisis, new or modified grants are very difficult to obtain. If a new programme focusing on the development of a rural industry based on bioenergy would be launched, it would be natural to start in small towns or villages.

Regarding biogas, the production of which has picked up in Lithuania, there exist unresolved socio-economic problems. It has been increasingly recognized that such issues are of major importance. First, biogas smells. This fact might appear almost irrelevant in a broader context, but on the local level it is a fact to be aware of. Many people will oppose the production of biogas for this reason. Second, there is a pedagogical issue in explaining how the entire process works. Especially the farmers rarely have the time and interest to become familiar with scientifically inclined studies. In addition to this, a lot of potentially valuable research ends up as articles in scientific journals only and will never be utilised in the implementation phase. Third, getting funding for this type of projects has proven difficult, particularly against the background of the present crisis. Implementing projects therefore requires innovative approaches.

## 7. Concluding discussion – potential for cooperation

### 7.1. General remarks

This study has identified two almost contradictory trends regarding bioenergy in the Baltic States. On the one hand, R&D performed in bioenergy in the Baltic States is rather limited. This might be somewhat surprising, because on the other hand various forms of bioenergy are either already used on a large scale or are widely assumed to become important in the near future. Bioenergy is explicitly recognized in various policy plans as an important component of the energy system in all the Baltic States. Thus the limited R&D efforts raise a number of questions, which probably lack unequivocal answers, but which would be important to discuss in the Baltic States.

In all three Baltic States, bioenergy has a major potential. However, bioenergy is a highly complex mode of energy, because biological, technological and institutional and social aspects have to fit into each other. Thus R&D, which fails to take into consideration crucial elements of these aspects will run the risk of failure. For example, not receiving necessary deliveries of fuel for combustion would promptly stop any attempt to introduce new technology for heating. Thus R&D in bioenergy is multi-faceted and has to include especially social and institutional aspects. This is a fact everywhere where bioenergy is used, but in the case of the Baltic States it has to be added that some institutional issues remain challenging, e.g. the weak organisational structure in agriculture or the difficulties in generating cooperation between the various interest groups. Under such circumstances the perspectives for domestic R&D to take off remain uncertain. Promoting cooperation between e.g. farmers and business people, municipal decision-makers and researchers is probably the first step to the further development of the bioenergy sector in the Baltic States.

However, there are also some advantages in the Baltic States in the broad institutional framework, such as the fact that the countries are sparsely populated, leaving large areas theoretically available for bioenergy production. The legacy of history has left a lot of land fallow, which could be used for bioenergy production. The land available consists of several small parcels, but it should not be excluded that such land can be used efficiently (e.g. can parcels be swapped with landowners to create larger continuous areas?). One of the major obstacles to

the increased utilisation of bioenergy appears to be slowly-changing attitudes among various groups in the societies.

The present trend with boiler houses using biomass in a district heating systems commenced in the 1990s with significant foreign support. Technology was mainly imported, but in some cases local producers have drawn upon these experiences and become producers in their own right. The result has been that the Baltic States have relatively well-developed bioenergy technology in use in district heating. But perhaps more importantly, there is know-how and experience in the Baltic States from the use of bioenergy, which however needs to be constantly upgraded.

## 7.2. Incentives

The Kyoto protocol defines the base year for CO<sub>2</sub> reductions as 1990. Because of the collapse of the energy-intensive Soviet-style industry soon afterwards, the Baltic States face no difficulties in meeting the emission reduction targets. The flip-side of this is that the incentives to develop and utilise CO<sub>2</sub> neutral energy sources might be less pressing. Even in Estonia, with its polluting oil shale-based electricity generation industry, the emissions are still clearly within agreed limits.

The main concern for the Baltic States is security of supply. At present, they are dependent on one supplier of natural gas - the Russian Federation. Natural gas is the most important fuel in the district heating systems and it is an important, albeit not dominant, fuel for electricity generation. Only Estonia has enough domestic resources (oil shale) making its electricity generation independent of the Russian Federation. Latvia, with its significant hydropower capacity, is completely dependent on imports of electricity (some of it from Estonia and until now, Lithuania). Lithuania will be increasingly dependent on imports of natural gas after the decommissioning of Ignalina nuclear power station. In this equation, domestic bioenergy has become an attractive complement. But the utmost reason appears to be security of supply, not the other qualities of bioenergy.

Regarding interest groups, one question raised by some interviewees – without an attempt to find an outright answer – was whether the natural gas industry with Russian Gazprom as the key player has a bigger say in the energy policy of the Baltic States than officially admitted. Although this issue remains speculative (at least in this context), the question as such is justified and should not be omitted from the discussion.

The interest groups behind bioenergy are relatively weak, at least in comparison with other interest groups in the energy sector. As long as the farmers' organizations are not unambiguously behind bioenergy, the political support for investments in developing new technology is likely to remain lukewarm. This situation may change with increasing familiarity with bioenergy among farmers.

Lithuania is planning to construct a new nuclear power plant in cooperation with Latvia and Estonia, which probably would draw financial resources from developing other modes of energy. Therefore it can be asked whether this would cause a "crowding-out" of investment for R&D in the bioenergy sector.

### 7.3. Cooperation patterns

Cooperation between the Baltic States in developing bioenergy R&D is almost insignificant. One reason for this lack of cooperation is the obvious fact that all of the Baltic States lack major resources for R&D in bioenergy. Thus other partners become more interesting. Another explanation is that the potentials for bioenergy differ too much for fruitful cooperation to develop. For example the Estonian R&D on reed cannot automatically be coupled to Lithuanian R&D in straw. For Estonia, cooperation with Finland becomes thus not only a matter of financing, but also of comparable resources.

The Baltic States have created an industry which has become successful in exporting wood chips, pellet and briquettes. Although this often is a local success story for many a small municipality, the added value is highly limited and this contributes to a situation where the Baltic economies remain dependent on inexpensive labour instead of high value added through technological development.

Promoting the understanding of the potential role of bioenergy would be important in the Baltic States. As long as bioenergy is almost solely seen as a question of security of supply (and perhaps justifiably so) and not as a major technology under development, R&D funding will not be directed to it.

In particular the Estonian "Development plan for the promotion of use of biomass and bioenergy for the period 2007 – 2013" has recognised the need to enhance R&D in the bioenergy sector. At present, Estonia, similarly to Latvia and Lithuania lacks a coordinated approach, which increases the risk of leaving individual research projects without connection to a broader energy policy context. Partially this risk can be alleviated through cooperation with the surrounding world (especially through EU programmes such as the FPs), but at the same

time this might leave important research without attention in the Baltic States. Under such circumstances, Baltic researchers would make important contributions to international R&D, but without this generating notable impact on developments in the Baltic States.

#### 7.4. Areas of potential future cooperation

From the reasoning above, it can be concluded that R&D in bioenergy is not particularly high on the agendas of the Baltic States, contrary to the actual use of bioenergy. Individual researchers and companies tend to be aware of the medium- and long-term risks of not actively participating in the development of this potentially important technology. At the same time there is openness towards being “technology takers”, i.e. some sort of testing grounds for new bioenergy-related technology. This would strongly enhance at least the practical know-how of the sector (which under no circumstances can be said to be insufficient at present). A strong candidate for becoming an area for testing is the generation of biogas, in which promising research on processes is currently being conducted in Estonia, while promising preliminary results on various fuels (reed and straw) exist in Lithuania and Estonia.

It has been mentioned in this report that R&D on 2<sup>nd</sup> generation biofuels is almost absent in the Baltic States. However, R&D conducted in the Baltic States on various materials such as straw or reed, might turn out to be important in the development of 2<sup>nd</sup> generation biofuels. Therefore cooperation with the Nordic States in this sector might have significant potential.

There are a few fields in which R&D conducted in the Baltic States might contribute to the broader development of bioenergy. Among the most promising is the straw research in Lithuania and the reed experiments in Estonia. In Latvia R&D has been conducted on the integration of bioenergy in the energy system.

One technology, the implementation of which would be of importance for the energy systems of the Baltic States while at the same time being an almost perfect match with Baltic institutional conditions, is micro- and small-scale CHPs. At present, this sector is gaining increased attention internationally, and if successful, micro- and small-scale CHPs could have profound impacts on the construction of the future energy systems in the Baltic States, where, as has been mentioned, population density is low, self-sufficiency high on the agenda, and most CHPs currently available too big.

The main risk to the Baltic States in the bioenergy sector appears to be left out from global R&D-trends. The reasons for this are mainly domestic, such as lack of funding through insufficient political support. So far, the Baltic States have more or less successfully implemented technology developed elsewhere, but the domestic contributions remain modest. Against the background that the Baltic States need more industry with high productivity and thus value added, bioenergy-related technology would in many respects make a good match with the needs of the Baltic societies. For the Nordic countries, the skills already developed in the Baltic States could be a valuable contribution as would the opportunity to test new technology in locations where there are significant gains to make, in particular where fossil fuels are still burnt for heating. This was an insight of the 1990s, which could be re-used today, but with more focus on technological cooperation than on technology transfer.

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