
Agro-biomass-to-energy Systems in Transition Economies: Cases of Ukraine and Lithuania

Yuliya Voytenko, Laurencas Raslavicius

Abstract

Economies in transition (EiTs) (e. g. Ukraine (UA), Belarus, Lithuania (LU), Moldova, etc.) face broad needs for energy security enhancement, energy diversification, revitalisation of agriculture and improvements in the state of the environment. Development of national bioenergy potentials can contribute to delivering solutions to these problems. However, EiTs face technical, political, financial, and capacity-based constraints in their transition to bioenergy. This work focuses on bioenergy from agricultural waste in UA and LU as an early emergent area. It applies country based case study analysis and cross-case comparison of straw-to-energy realities in UA and LU. Analysis identifies and describes crucial factors hindering and facilitating the development of agro-bioenergy sectors in the two countries. The outcomes of the paper are principally transferable to other EiTs.

Keywords: bioenergy management, economies in transition, non-technical barriers to bioenergy, straw

1. Introduction

Economies in transition (EiTs) (e.g. Ukraine (UA), Belarus (BY), Lithuania (LU), Moldova (MD) etc.) are characterized by significant dependence on energy imports, require revitalisation of their agricultural sectors and improvements in the state of the environment (Gavrilita & Druta 2009; IEA 2006; Voytenko et al. 2009). The development of the countries' biomass-to-energy potentials could help resolve these problems via leveraging economic, social and environmental bioenergy¹ co-benefits² (Berndes et al. 2008; Peck & Voytenko 2008; Voytenko et al. 2009). Bioenergy co-

benefits can contribute to the alleviation of such challenges as energy insecurity, unemployment, rural depopulation and poverty, poor state of the environment etc. However, EiTs face technical, political, financial and capacity-based constraints in their transition to bioenergy (Srebotnjak & Hardi 2011; Raslavicius et al. 2011; Voytenko et al. 2009; Voytenko & Peck 2011b). While overcoming these requires a targeted action at different levels and by a variety of stakeholders (Voytenko & Peck 2011b), the area remains largely unresearched. In particular, the knowledge to support the formulation of national strategies and policies in EiTs to overcome their barriers to bioenergy is highly needed.

This paper focuses on case studies from agro-bioenergy sectors in two EiT countries: UA and LU. These two countries are chosen for analysis and form a research interest for comparison as both UA and LU:

- 1) are highly dependent in their total primary energy supply (TPES) on energy imports from other jurisdictions (mainly natural gas (NG) from Russia) (IEA 2006; Raslavicius et al. 2011);
- 2) have significant potentials for biomass-to-energy and straw-to-energy in particular (V. Dubrovin et al. 2004; Geletukha et al. 2010; Grynyuk 2009; Radchenko et al. 2009);
- 3) are characterised with both an emerging policy environment supportive of renewable energy (RE)/ bioenergy, and
- 4) emerging 'on-the-ground' straw-based heating systems (Dolinski & Geletukha 2010; Katinas et al. 2007; Miskinis et al. 2009; Raslavicius et al. 2011; Voytenko et al. 2009; Zheliezna & Geletukha 2009).

The objectives of this paper are to:

1. present the contexts for existing practices of straw-to-energy in UA and LU;
2. identify and describe key facilitating and constraining factors for the transition to agro-bioenergy in both countries;
3. compare and contrast the two contexts.

The paper is expected to contribute to the knowledge of bioenergy practitioners and policy makers pursuing a transition towards bioenergy in UA, LU and other EiTs. While each of the two countries has its own transition path towards agro-bioenergy, when viewed together UA and LU constitute a 'learning environment' for other EiTs (e.g., MD, BY, Poland (PL), Hungary (HU), Czech Republic (CZ), Romania, Bulgaria etc.). Such countries have both need and potential for energy from biomass, and heating systems utilising agricultural residues are emerging (Ganko 2009; Gavrilita & Druta 2009; Fuchsz & Kohlheb 2009; Kolská & Sobolíková 2009; Srebotnjak & Hardi 2011; Voytenko 2011; Voytenko et al. 2009).

2. Materials and methods

2.1. General approach, scope and target audience

This work presents results on straw use for energy in UA and LU, and compares the two contexts. A detailed analysis of country settings, biomass and straw-to-energy potentials, available support schemes for bioenergy, economics of straw-to-energy installations and functioning straw-to-energy practices and technologies in UA and LU is applied to underpin the identification of constraining and facilitating factors for the transition towards agro-bioenergy in both countries.

The focus of this paper is on agro-biomass and straw in particular. In UA straw³ has the highest potential among all agricultural residues (358 PJ yr⁻¹) and constitutes one fourth of total UA's technical biomass potential, which could be further increased at higher levels of agricultural productivity (Geletukha et al. 2011). In LU crop residues including straw have prospects to substitute firewood, the share of which in LU RE balance is forecasted to decrease from 86.7% (2009) to 55% (2020) (Bankines konsultacijos 2008; LEI 2009; LEI 2010). In addition, agro-biomass residues provide new feedstocks for 2nd generation biofuels⁴. The demand for straw as a fuel is expected to rise as it is one of the easiest and cheapest biomass options to be developed in UA and LU, whose economy is significantly contributed by agriculture (V. Dubrovin et al. 2004; Grynyuk 2009; Katinas et al. 2007; Miskinis et al. 2009; Raslavicius et al. 2011; Streimikiene et al. 2005).

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The results of this work are targeted at policy makers in UA, LU and other EiTs including municipal leaders, local and sub-regional authorities and related to them agricultural, industrial and energy groups. Not least important target audience involves non-governmental actors (NGAs) such as bioenergy business groups (e.g. equipment manufacturers, bio-energy and environmental consultants, potential investors in bioenergy activities etc.), non-governmental organisations (NGOs) interested in RE and energy security, farmers and rural development actors seeking to diversify their incomes by energy production from agro-biomass, academia and researchers etc.

2.2. Methods

Data collection involved desktop and field research. Desktop research covered literature review on biomass and straw use for energy and their potentials in UA and LU including scientific publications, reports, case studies, related policies and laws, documents from bioenergy events etc. Field studies involved 14 in-depth interviews with key actors in the agro-biomass production chain in UA and site visits to two grain producing farms with straw-fired installations, straw storages, baling equipment, premises with heating needs etc. (cf. Voytenko & Peck 2011b). In LU the data was also collected through the generalisation of long-term common labour practices between the JSC “Axis Technologies” (the largest company in the Baltic States that installs and modernises biomass-fired boilers), LU District Heating Association and the Ministry of Energy. The information provided by them underlines the analysis and discussion.

Data analysis involved in-case analysis of straw-to-energy sectors in UA and LU and identification of factors facilitating and constraining transition to agro-bioenergy in both contexts as well as a cross-case comparison between the two countries. Previous studies have demonstrated that the success of biomass straw combustion technologies was not only determined by technical and economic factors but also by the social system in which the technology is embedded (Meijer et al. 2010). Thus constraining and facilitating factors are structured in four major domains:

- 1) *political and legislative;*
- 2) *technical and technological;*
- 3) *financial and economic;*
- 4) *capacity and knowledge-based.*

The selection of these categories is driven by previous research by the authors (Raslavicius et al. 2011; Voytenko et al. 2009; Voytenko 2011) and existing literature in the field (Geletukha & Dolinsky 2009; Geletukha & Zheliezna 2010a; Srebotnjak & Hardi 2011). Data analysis was also supplied with 'on-the-ground' initiatives of functioning straw-to-energy systems (9 in UA and 58 in LU).

3. Energy from straw in Ukraine

3.1. Country context

UA occupies a strategic geopolitical location between Russia and the EU and is the world's largest NG transit country by volume (IEA 2006). 51% of UA's TPES is imported (Raslavicius et al. 2011), which places UA among the most energy dependent countries in Central and Eastern Europe. Prices for imported NG have increased almost five fold in the last 10 years (Dolinski & Geletukha 2010; Geletukha & Zheliezna 2010b) while NG share in UA's TPES remains disproportionately high (37%) in comparison to global and EU figures.

Thus a need for energy security enhancement and the reduction of UA's dependence on fuel imports is a priority concern. In parallel, the revitalisation of UA's agriculture and environmental improvement are also listed as primary issues of national interest (IEA 2006). Biomass being an indigenous source of energy supply can contribute positively towards combating these challenges.

3.2. Support schemes and mechanisms for bioenergy

The UA government and Parliament passed a number of documents supporting bioenergy development. The main ones include:

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- 1) *State Development Programme of Biofuel Production and Consumption* – a framework policy aiming at biofuel share increase in UA's TPES to 5-7% (CMU 2009);
- 2) *Law #1391-VI On Amendments to Some Laws of Ukraine on Support of Biofuel Production and Consumption*, which sets measures to increase the alternative fuel^s share to 20% of total fuel consumption in UA by 2020 (VRU 2009);
- 3) *Law On Green Electricity Tariff (GET)*, which sets a feed-in-tariff for renewable electricity for 20 years.

3.3. Biomass and straw-for-energy potential

Currently the bioenergy sector in UA is not established although a number of initiatives have emerged (Voytenko 2011; Voytenko & Peck 2011b). Biomass supplies 0.7% in UA's TPES, much of which is informal (Dolinski & Geletukha 2010). Estimates show that UA can mobilise ca. 1 EJ/yr of biomass for energy (18% of TPES), with the majority (72%) from agricultural residues and energy crops (Geletukha et al. 2010; Geletukha et al. 2011). Currently ca. 4.7 Mha of arable land in UA are not used (Geletukha & Dolinsky 2009) and can potentially be covered by energy crops. This is forecasted to grow to 20 Mha in 2030 (Raslavicius et al. 2011).

While no commercial use of dedicated energy crops has been reported yet (Voytenko & Peck 2011b) it appears common to use agricultural residues (mainly straw) for heat production on a small scale (i.e. in boilers below 1 MW) (Voytenko & Peck 2011b). Besides, straw has the highest potential among all agricultural residues – 358 PJ/yr (25.7% of total UA's technical biomass potential), which could increase by ca. 2.5 times, if agricultural productivity in UA were to reach EU levels (Geletukha & Dolinsky 2009). According to Dubrovin *et al.*(2004) and Radchenko *et al.* (2009), between 6-10 Mt of currently produced straw could be used for energy in UA, if local competitive straw uses in each region are taken into account. Their estimates leave two thirds of national straw production for such uses.

3.4. Straw use for energy: existing technologies and markets

Current energy production from biomass in UA is estimated to be some 38 PJ/1 (0.9 Mtoe) and is restricted to heat production – predominantly from firewood (Dolinsky 2008). Where utilised for energy, crop residues are burnt in converted or specially designed boilers (Geletukha et al. 2008; Zheliezna & Morozova 2007). Only a small number of companies in UA produce straw-fired boilers, heat generators, and grain-dryers on crop residues. At present the main straw use for energy is performed in UTEM⁶ boilers. OJSC UTEM operates under the license of the Danish company Passat Energi A/S and is not only the biggest straw-fired boiler manufacturer but also the only one producing water-based straw-fired heating systems of up to 1 MW (Fig. 1) (Svintsitskiy 2009; UTEM 2009a). As of 2010 ca. 25 such units had been installed (Svintsitskiy 2009), supplying heat for municipal buildings in villages or/and for local agricultural enterprises (Voytenko 2011). The total installed capacity of UTEM boilers is ca. 10 MW. Annual straw use in them is nearly 0.2 PJ (Avdeev 2008; Oliynyk 2010; UTEM 2009b; UTEM 2010). Current total annual fuel consumption in all boilers in rural areas of UA is 84 PJ. It has been calculated that this demand can be met by straw available in the country (Zhovmir et al. 2007).

UA produces densified biofuels too. 87% (393 kt) of biomass pellets and briquettes produced in UA in Jan-Jun 2011 were exported (FuelAlternative 2011). This is 31.5% more than in Jan-Jun 2010 (FuelAlternative 2011). The main markets include PL, Germany, CZ, HU, LU (FuelAlternative 2009). The main potential external market for densified straw from UA is found in PL (Geletukha 2008). UA has one of the largest potential supply capacities for straw pellets on international markets (Hinge 2009; Sander & Skøtt 2007), which are not, however, leveraged yet. Overall, the bioenergy market in UA has not taken a stable form, and biofuel sales and purchase activities remain random in nature (Geletukha & Zheliezna 2010b).

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Figure 1. 980 kW straw-fired boiler in Drozdy village, Kyiv province, Ukraine



3.5. Economics of straw-to-energy installations

Cost-benefit analysis (CBA) of straw-fired installations in UA was carried out by the Scientific Engineering Centre (SEC) Biomass (see Table 1, next page). Economic performances vary for different installed capacities and with the sphere of fuel substitution. In UA industries and state budget organisations pay a higher price for NG (239.6 €/1000 m³) than population

and communal services (119.5 €/1000 m³), which is known as a 'cross-subsidised tariff'. Thus at the moment the substitution of a gas-fired boiler in industrial and budget sphere application is more profitable. Nevertheless the results for both 250 kW and 860 kW straw-fired boilers demonstrate their profitability in all applications with payback periods ranging from 0.9 to 6.7 years and potential cost savings from NG substitution from 4 000 to 54 000 €/yr (see Table 1, next page).

No similar CBA has been carried out for larger straw-fired installations in UA. However, it is held (Geletukha et al. 2008) that even with the foreign manufacture of biomass equipment heat production from wood and crop residues is competitive with that from coal or NG. Geletukha and Zheliezna (2010c) indicate that technically and commercially viable potential for straw-heating boilers in UA by 2015 is 4000 MW installed capacity (2000 MW of 0.1-1 MW farm boilers and 2000 MW of 1-10 MW neighbour and district heating (DH) plants). They estimate that the required investment is € 256 M (Geletukha & Zheliezna 2010c).

4. Energy from straw in Lithuania

4.1. Country context

LU is a lowland country with transitional (between maritime and continental) climate, which creates favourable conditions for the most of RE and bioenergy sources (Streimikiene et al. 2005). LU agriculture plays important economic, social, environmental and ethno-cultural role. Thus its current and potential contribution to the country's energy supply is natural and beneficial from sustainability perspective (Genutis 2006; Raslavicius & Straksas 2011). Straw use for energy in heat-only boilers (HOBs) can provide an impetus for rural development in LU, create new markets for agricultural waste, and present attractive decentralised energy solutions for rural communities (Raslavicius & Straksas 2011). Currently in LU about 45% of households are connected to DH systems, which is 60% of the country's final heat consumption (Janukonis 2009; Raslavicius & Straksas 2011; Streimikiene et al. 2005).

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Table 1. Cost benefit analysis of straw-fired boilers in Ukraine

Name	Units	Value	
Boiler capacity	kW	250	860
Fuel calorific value	MJ/kg	13	
Equivalent NG use volume	Thousand m ³ /yr	98	336
Straw price	€/tonne ⁷	27.4	
NG price for communal services	€/thousand m ³	119.5	
NG price for industries and state budget organisations	€/thousand m ³	239.6	
Capital works (equipment, project works and installation)	Thousand €	27.4	48.9
Fuel cost (straw)	Thousand €/yr	7.6	25.9
NG for communal services	Thousand €/yr	11.7	40,1
NG for industries and state budget organisations	Thousand €/yr	23.4	80.4
Fuel savings			
From NG substitution in communal sphere	Thousand €/yr	4.1	14.2
From NG substitution in industry/budget organisations	Thousand €/yr	15.8	54.4
Payback period			
From NG substitution in communal sphere	Years	6.7	3.4
From NG substitution in industry/budget organisations	Years	1.7	0.9

Source: Dolinski & Geletukba 2010

4.2. Support schemes and mechanisms for bioenergy

The main documents that determine bioenergy use and development in LU include:

- 1) the *Law On Energy* (Valstybes Zinios 2009a), which regulates LU energy sector and is harmonised with EU legislation;
- 2) supplementary *Legal Act #1474 to the Law On Electric Energy* (Valstybes Zinios 2004), which creates incentives for renewable electricity purchase (i.a. electricity certificates);
- 3) the *Law on Heat Sector* (Valstybes Zinios 2009b), which i.a. regulates combined heat and power (CHP) production from biomass;
- 4) the *Law On Energy from Renewable Sources* (Valstybes Zinios 2011) (effective 31 Dec 2011), which ensures sustainable development of RE;
- 5) the *Law on Pollution Tax* (PRL 1999), which exempts stationary power plants on RES, if their emissions do not exceed marginal values.

4.3. Biomass and straw-for-energy potential

RE supplies 36 PJ (0.87 Mtoe) or about 18% in LU's TPES (Brukas et al. 2011; Government of Lithuania 2010; LEI 2009; LEI 2010). The main RE share (86.7%) is represented by solid biomass, mainly firewood and wood waste (Brukas et al. 2011; LEI 2010). Agricultural waste supplies 0.18 PJ (4.2 ktoe) in LU's TPES.

Available amounts of straw in LU are well-documented, however, their economic potential is difficult to estimate. It is clear that only a portion of the technical potential can be met. In LU annually 1.5–2.0 Mt of straw are produced and used for olericulture, animal feed or bedding (Bankines konsultacijos 2008; Piksrys & Olesen 2008). An increasing share of straw is burnt on the fields. Considering the needs of LU to reduce greenhouse gas (GHG) emissions and improve its energy security, especially in the light of escalating fuel prices, these currently wasted amounts of straw could make a contribution. The forecasted annual straw use for energy in LU in 2020 is 900 000 tonnes (35% of total straw production) (Piksrys & Olesen 2008).

4.4. Straw use for energy: existing technologies and markets

In LU about 58 straw-fired boilers have been installed in 1996–2011. Most of these are batch-fired boilers below 1 MW with the first automatic 1 MW HOB installed in Narteikiai village in 1996. There are two straw-fired boiler manufacturers in LU: UAB Umega (130–600 kW batch-fired boilers) and UAB Kalvis (30–120 kW straw pellet-fired boilers). Currently there are no national straw-fired boiler manufacturers above 1 MW in LU.

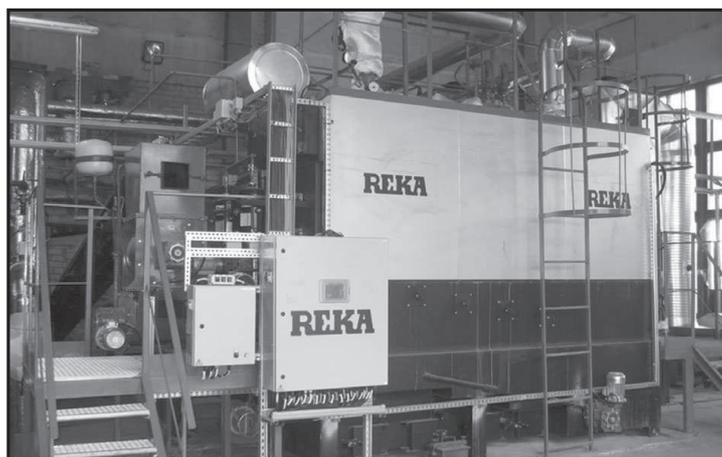
Within 20 years of the post-Soviet era in LU, DH systems survived a set of changing perspectives on their suitability and applicability. Attempts by national experts and support and examples from Scandinavia were among key factors to help save DH in LU (Janukonis 2009). In 2010, 12 out of 52 districts had a biomass share of 40% or more in the annual regional fuel consumption (the rest was mainly supplied by NG), two districts – 30–40%, five – 10–20%, five – below 10%, and 28 – no or non-significant share of biomass content.

Due to NG price fluctuations from 1996 to 2005, further introduction of fully automatic straw-fired technologies in LU was under consideration. This period marked the development for small boilers (50–375 kW), which were mainly installed on family and pig farms. The second straw-fired automatic HOB of 2.5 MW was installed in 2007 in Akademija town (Fig. 2) and is currently the largest functioning system of this kind in LU.

In 2004, JSC “Radviliskis Machine Factory” started to produce straw pelletising equipment (Fig. 3), which generates straw pellets of similar quality to the wood ones⁸. Mixed biomass/straw pellets production is advantageous due to straw surplus in LU and its low cost. Straw pellets are a new product on the pellet market, and no national quality standards exist. Current annual straw pellet production in LU is 2 000–4 000 t.

Due to the low demand and lack of experience in working with agrobiomass waste suppliers, only a few companies in LU could agree on long-term contracts to supply straw fuel for 1–5 MW HOBs. The price for baled straw in 2011 varied from 40.58 €/t to 52.17 €/t, with a higher price for large rectangular bales due to a more energy consuming process for straw gathering and pressing. Unlike most EU countries, in LU 90% of the collected straw is pressed into round bales (Genutis 2006).

**Figure 2. 2.5 MW straw-fired HOB installation
in Akademija town, Lithuania**



**Figure 3. Straw granulation equipment
by JSC "Radviliskis Machine Factory" (Lithuania)**



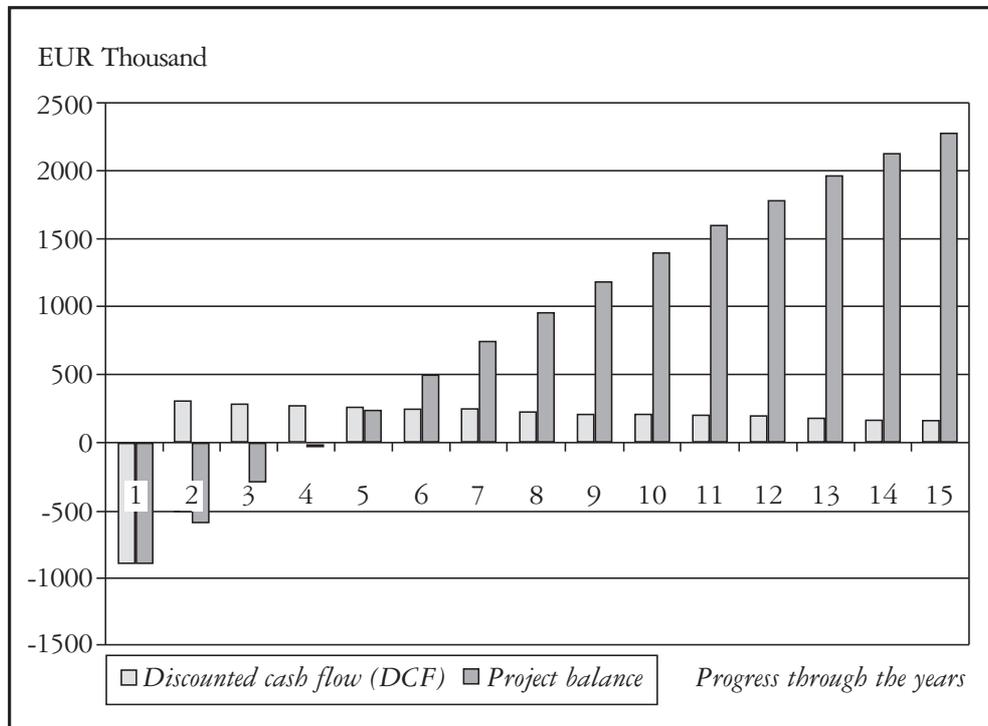
4.5. Economics of straw-to-energy installations

Most of DH companies in LU are co-operatively or municipally owned. DH prices are regulated in a way that limits profits and which does not allow for the HOB utility to save up for investments (Janukonis 2009).

However, it is relatively easy for a DH company to obtain funding on good terms as the security of repayment is high; in some cases the municipality provides a collateral for a co-operative investment. Consumers' ability to pay is also satisfactory. Under certain restrictions the municipality can force to connect to a DH. However, this is not always considered necessary or politically acceptable. Currently direct subsidies on the investments in small-scale biomass-firing plants are absent.

According to the CBA by JSC "Axis Technologies" for a 2.5 MW straw-fired boiler over 15 years (Fig. 4), with scaling up the boiler capacities the variation of financial parameters becomes less sensitive to the critical variables affecting the economic profitability of straw-fired HOBs. However, the fuel demand is a function of scale, and to ensure a secure crop residue supply straw combustion for energy has prospects mainly in small and medium (0.6–5 MW) heat producing units.

Figure 4. Life cycle assessment of a 2.5 MW straw-fired boiler in Akademija town, Lithuania.



HOB retrofit projects in LU and elsewhere in the Baltic region have shown that investments in 1 MW HOBs would be recovered in 3-5 years depending on the type of the system, its modification (one 1 MW boiler or two 0.5 MW boilers), demand for new premises etc. In larger systems (2-5 MW), however, the simple payback period is 4-6 years.

5. Analysis and discussion

5.1. Facilitating and hindering factors for straw-to-energy in Ukraine

5.1.1. Political and legislative factors

The development of the first support schemes for bioenergy and RE in UA with concrete targets is a significant step forward to create preconditions for the bioenergy sector establishment. However, these appear to be immature and have a number of flaws (Geletukha & Zheliezna 2010a). Almost no attention is given to dedicated energy crops. The *State Program On Biofuel Development* does not specify any sustainability criteria for biofuel production. The *Law On Support of Biofuel Use* does not clearly include unprocessed biomass (e.g. wood and crop residues) and agricultural, forestry and other enterprises that are not biofuel producers per se. The *Law On Green Electricity Tariff* has a number of significant flaws due to incomplete bioenergy definitions, the absence of price differentiation between bioenergy sources, exclusion of co-firing installations from the regulation and a sophisticated procedure for green electricity certificates receipt (Geletukha & Zheliezna 2010a). Besides, this Law can stimulate co-generation of heat and power (CHP) from biomass, which means that it is applicable to larger straw-fired (or other solid biomass-fired) plants (>10 MW), where this technology is available; however, such do not yet exist in UA. In addition, no fossil fuel taxes or differentiated emission taxes exist in UA, which externalises fossil fuel costs. The absence of transparent governmental influence as reported by several interviewees is another factor hindering the success of straw-based energy systems in UA.

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5.1.2. Technical and technological factors

Agro-bioenergy initiatives in UA (Voytenko & Peck 2011b) have shown that straw-to-energy markets and the whole sector were in a latent development phase, and straw was not a commercial energy carrier yet (Geletukha & Zheliezna 2010b). Functioning straw-fired installations are below 1 MW. This is partially because the production of straw-fired equipment above 1 MW is absent in UA. UA lacks national producers of biomass-fired equipment above 2 MW including CHP units and “cheap” domestic biomass-fired boilers of 10-50 kW (Dolinski & Geletukha 2006; Geletukha & Dolinsky 2009; Geletukha & Zheliezna 2010b; Geletukha & Zheliezna 2010c). UTEM is the dominating and somewhat monopolistic straw-fired boiler manufacturer in UA. Other national producers of heat generators (TM «Ukrsetka» 2008; RETRA 2009; Toropets 2009) and grain dryers (OJSC «Bryg» 2010; Kuzmin 2010) play a minimal role on the present bioenergy technology market. They can, however, potentially become suppliers of the required equipment.

The majority of straw-fired installations in rural areas in UA do not supply hot water with heat supply due to the scarcity of central water distribution networks and sewage systems (Voytenko & Peck 2011b). However, all boilers could potentially also supply hot water, which is planned with the two latest UTEM installations (UTEM 2009b; UTEM 2010).

On the other hand, a more smooth transition towards straw-for-energy can be attributed to existing district heating (DH) networks (Voytenko & Peck 2011b) and old tradition of biomass use for energy in rural areas in UA (Lytvyn 2009). Also existing fossil fuel based infrastructure can be converted to biomass. This is a typical example of ‘a technology spillover’ (Bergek et al. 2008). Clearly a new bioenergy system will emerge, faster gain acceptance and competitive advantage if it utilizes (partially or fully) resources and/or infrastructure from a similar incumbent system. This can also lower associated costs and uncertainty risks.

In nearly all UA straw-to-energy cases, bailers are owned by agricultural enterprises (Voytenko & Peck 2009; Voytenko & Peck 2011b) that grow feedstock and supply straw to their boilers or to the municipal ones. In two cases, bailers are rented by the farmers from their neighbours (Belay 2009; Demydov 2009), which demonstrates equipment sharing

between straw-supply chain actors. On the other hand, the absence of baling tradition for straw handling in UA (Geletukha 2000) and insufficient number of bailers in rural areas are among the technological constraints for the agro-bioenergy sector development.

5.1.3. Financial and economic factors

Economic analysis of energy sources in UA (Dolinski & Geletukha 2010; Geletukha & Zheliezna 2010b) has shown that agro-biomass fuels – and straw in particular – were competitive with conventional ones. With a continuous increase in tariffs for NG from Russia, forecasted increase of these for UA population (Geletukha & Zheliezna 2002; Ukrayinska pravda 2010) and removal of a cross-subsidisation scheme, bioenergy is more likely to become competitive with conventional energy sources in UA. Feed-in-tariff for electricity with its relatively high value for bioenergy (13.45 € cents/kWh) is likely to improve competitiveness of green electricity, especially if its discussed flaws were removed.

Major constraining factors are linked to biomass installation investment costs, which require sufficient individual funding capacities whereas finance markets are poorly developed in UA (Geletukha & Dolinsky 2009; Geletukha & Zheliezna 2010c). UA rural actors (i.e. farmers and municipalities), who are key potential owners of such boilers, often cannot afford investing in an agro-biomass fired installation due to financial reasons (Geletukha & Dolinsky 2009; Geletukha & Zheliezna 2010c; Raslavicius et al. 2011). Although some funding national bodies (e.g. the National Environmental Investment Agency) and possibilities to participate in international funding schemes exist, potential financiers are limited in UA (Yerkhov 2010).

5.1.4. Capacity and knowledge-based factors

An important facilitating factor for the development of the bioenergy sector in UA is the existence of the national bioenergy leader SEC Biomass (Geletukha & Dolinsky 2009; SEC Biomass 2003; SEC Biomass 2011). The organisation is involved in bioenergy R&D and business activities in UA; carries out demonstration projects; conducts a continuous dialogue

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with political leaders in UA; organises educational workshops on bioenergy, energy efficient technologies, Kyoto mechanisms etc. SEC Biomass organises an annual international conference “Biomass to Energy”, which is a networking platform for bioenergy actors in UA and other EiTs.

One of the constraining factors for bioenergy development is the absence of a strong and influential national bioenergy association (NBA) in UA. Moreover, UA’s agricultural sector lacks strong and well-established farmer associations, which could become precursors for local and national straw supplier associations as it happened, for example, in Denmark (DK) (Hinge 2009; Skøtt & Hansen 2000; Voytenko & Peck 2011a; Voytenko & Peck 2011b). According to Aldrich and Fiol (1994), institutional legitimacy⁹ can only be achieved collectively when founders of a new activity are not working in isolation but form industry councils, cooperative alliances, trade associations, and other vehicles for collective action. Thus establishment of meaningful collective action forms is one strategy to move the system from its formative development phase to the intermediate one, which is required for UA’s bioenergy sector.

Since the majority of functioning straw-fired installations in UA are privately owned, not much participation of local authorities can be noted (Voytenko & Peck 2011b). Often they demonstrate a low degree of cooperation and interest. Another complication to UA’s agro-bioenergy sector establishment is added by market incumbents with opposing interests, who lobby for conventional fuels (Antonik 2010; Belay 2009; Yerkhov 2010). On the other hand, the existence of local and sub-regional actors with energy needs (Dolinski & Geletukha 2010) and the interest of national and foreign actors in bioenergy business development in UA (Larsson 2008; SEC Biomass 2011; SEC Biomass 2006; Svintsitskiy 2009) are among important facilitating factors for the agro-bioenergy sector establishment.

The role of actors and human resources are important in the transition towards straw-to-energy in UA. Many farm managers owning straw-fired installations have higher education and sometimes a PhD degree (Voytenko 2011). Often a determining role for the success of the project is attributed to its enthusiastic leaders. On the other hand, the lack of awareness, knowledge and expertise on bioenergy among key stakeholders

are important constraints for bioenergy business startup in UA (Butenko 2009; Geletukha 2000; Geletukha & Dolinsky 2009).

A number of 'good practices' of straw-to-energy exist in UA (Voytenko 2011; Voytenko & Peck 2011b). All of these involve knowledgeable and enthusiastic prime movers, successful foreign cooperation, attempts of equipment sharing and development of written straw supply contracts. These are among facilitating factors for the establishment of UA's agro-industrial bioenergy sector.

5.2. Facilitating and hindering factors for straw-to-energy in Lithuania

5.2.1. Political and legislative factors

The legal basis for RE and bioenergy production and use in LU is being established. The major provisions of the *Law on Energy from Renewable Sources* are not effective yet, however, from 2012 it should become the key framework for sustainable development and use of RE. This Law is to encourage continuous technological development, innovation and consumption of RE, which is particularly important considering international obligations by LU. Its other aims include environmental protection, substitution of fossil energy and reduction of energy imports.

The *Legal Act #1474 to the Law On Electric Energy* promotes power plants below 10 MW. Network operators are obliged to secure priority rights for the transmission of renewable electricity. Operators of smaller plants using renewable electricity do not pay for the reserve power at the prices set by the National Control Commission for Prices and Energy (NCCPE). From 2010 this Law introduced green certificates to promote the purchase of energy from renewables and waste. For power plants below 10 MW, which use energy production and purchase incentives, a 40% reduction on the grid connection tax is applied to compensate the operators for incurred expenses and the reorganisation of their energy networks.

The *Law on Heat Sector* sets the amount of electrical energy purchased by the distribution networks operators as proportionate to the share of installed capacity and thermal power, as well as to the amount of thermal

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energy sold. The purchase rules are applied to CHP plants on biomass, if biomass constitutes at least 70% in the fuel balance, and if the rate of nominal electric and thermal capacity is at least 0.23. The Law guarantees purchase electricity prices until 2020, setting them at 6.4 or 7.0 € cents/kWh¹⁰. While purchasing heat from independent suppliers and under equal heat prices, the priority should be given to renewable heat. However, the energy purchase from CHP plants has not been completely settled. The amount of purchased electricity is proportionate to the amount of energy provided to the consumer, with this amount not being the same at the end of the year. This limits the maximum installed electrical capacity since there is no compulsory purchase of thermal energy. Moreover, it prolongs the return time on investments due to smaller income from the energy sale.

5.2.2. Technical and technological factors

LU has national manufacturers of small straw-fired boilers (<1 MW) and of straw pelletising equipment. Straw firing technology of 1-5 MW is mainly imported from DK. Automatic HOBs that supply DH only start to emerge in the country with two functioning installations at present. LU has a vast DH network, however, a significant biomass fuel share (>=40%) is only used in 23% of all districts in LU while 54% of them do not use any biomass at all. Thus the potential to replace NG systems with straw-firing HOBs remains unlocked.

In LU about 90% of the collected straw is pressed in round bales (Genutis 2006), which is viewed as a less efficient way of straw handling than rectangular bales application (Hinge 2009). This is a result of long-term EU support grants for farmers, which stimulated agricultural equipment purchase and thus mass acquisition of round bailers due to their lower price and locally established agricultural practices.

5.2.3. Financial and economic factors

Key factors determining the rate of straw-fired HOB adoption in LU are cost related. Since all HOBs in LU are imported, the investment risk is high, which reduces straw competitiveness with other solid biofuels, e.g.

wood waste. To the extent possible the banks should reduce transaction costs to make loans more attractive and less risky, and thus support the implementation of straw-to-energy projects. Furthermore the efforts to reduce bureaucratic procedures, enhance access to loans, eliminate unnecessarily restrictive labour practices, and expand the availability of market-related information will stimulate the expansion of straw-fired HOBs and their adoption in rural LU. Currently all of the above activities are in their initial stage of development in LU.

The value of straw fuel depends on supply amounts and demand. One of the main factors determining straw availability are weather conditions: poor conditions lead to lower yields, and thus higher demand and prices.

Another important constraint for the development of biomass based heating is the lack of financial resources (e.g. investment capacity) and funding support (e.g. subsidies) to switch from traditional fuel to biomass (Rosende et al. 2010). DH companies in LU are mainly owned by municipalities but some of them are rented on the long term by private companies. CHP plants can also be owned by a DH company or a private company. However, clear and transparent procedures for private capital to enter the DH sector are missing (Rosende et al. 2010). At the same time, during the period of 2007-2013 the EU Cohesion Fund allocates ca. 37 M € for the modernisation of existing construction and connection of new boiler houses and CHP plants, which could open new opportunities for biomass-fired installations.

5.2.4 Capacity and knowledge-based factors

In 2020 16.7 PJ (0.4 Mtoe) of DH in LU are expected to be produced from solid biomass (Rosende et al. 2010) with about the same figure for the heat in the non-DH sector. Heat production from solid biomass in off-grid systems is expected to grow steadily and remain the dominant renewable heat technology contributing ca. 66% in total renewable heat output in 2020.

In LU no decrease in rural population and no modernisation or more economical use of heating installations has been reported over years. If the current levels of solid biomass use for off-grid house heating prevail, substantially higher biomass quantities could be allocated for DH

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adding up to a potential 70% share of heat supply from biomass in 2020 (Rosende et al. 2010).

In most cases in LU many varied authorities of local, regional and national levels are involved in granting final permits for a bioenergy project startup. As such important constraining factors to the adoption and expansion of biomass-to-energy systems include bureaucratic and time-consuming procedures linked to obtaining construction and environmental permits. Moreover, since bioenergy activities are not envisioned by the spatial planning rules and procedures, every bioenergy project and its alternative must be evaluated individually (Rosende et al. 2010). In addition, the entire legal framework of spatial planning is currently not adapted to the development of bioenergy projects (e.g. no priority zones for bioenergy activities are envisioned, and only general procedures exist, which results in time inefficiency). A potential solution to the 'bureaucracy problem' could be a reduction in the number of authorities responsible for granting permits and financial support. Project developers appear to be more positive when a single body coordinates several administrative procedures (Rosende et al. 2010).

Universities and research institutions in LU are important capacity builders and knowledge providers on biomass and straw-to-energy systems. The following areas are studied: straw technology conversion and energy generation (Aleksandras Stulginskis University, Kaunas University of Technology etc.) (Katinas et al. 2007); technology development for the pollutant formation reduction with an emphasis on fuel combustion including straw (Institute of Agro-Engineering, Lithuanian Energy Institute) (Kavaliauskas 2005; Kavaliauskas & Katinas 2004; Slanciauskas 2006a; Slanciauskas 2006b; Urbonas & Urboniene 2002); experimental advancement of straw-firing technology and its compliance with EU norms and requirements (Slanciauskas 2006a).

5.3. Comparison of straw-to-energy in Ukraine and Lithuania

Both UA and LU are post-Soviet transition economies, which significantly depend on imports of energy (mainly NG from Russia) and are located on energy transportation routes between Asia and Europe. While

UA is a non-EU country, LU is a EU member state, which entails applicability of EU binding legislation to its economic sectors. While in UA the major drivers for the development of RE and bioenergy are linked to energy security enhancement and to certain extent rural development and environmental improvement, in LU in addition to these factors an important contribution is made by the requirements to comply with EU targets in RE and the bioenergy sector. Thus not surprisingly LU has a more advanced legal support mechanisms for different forms of energy from renewables and biomass.

Both countries have important contributions from agriculture in their economies and thus produce significant quantities of agro-biomass residues and straw in particular. While in both, UA and LU, firewood remains the major biomass-to-energy source, significant potential to use crop residues for energy is somewhat neglected. Millions of tonnes of straw are not used in either of the two countries and are often left or burnt on the fields albeit legal restrictions. Both UA and LU could, however, use these capacities for energy production on various scales from small farm-based boilers to medium DH plants and large CHP plants.

While in UA around 25 farm-based straw-fired boilers are installed throughout the country at present, LU has a larger number of more than 50 similar installations. As of yet, no DH HOBs exist in UA, while two such systems have been successfully installed and are functioning in LU. On the other hand, both UA and LU have vast DH systems as a part of Soviet heritage, which could entail a positive technology spillover between old fossil fuel and new biomass-based DH systems. National manufacturers of straw-fired equipment below 1 MW do not exist in UA and LU. Straw-fired technologies are initially brought from DK and are now either produced under Danish licenses or remain being imported with national experts seeking ways to produce similar equipment.

Neither in UA nor in LU biofuel/ bioenergy markets are established yet; straw is not a commercial energy carrier at present. Important barriers for the transition to biomass and straw-based energy in both contexts include access to funds and financing, including a need for support schemes from the authorities. LU unlike UA has a possibility to apply for/ use EU funds allocated for the proliferation of the bioenergy sector in Europe.

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The most important factors determining straw-fired technology diffusion and expansion (including HOBs) involve political issues (e.g. government support of small and medium decentralised systems), market and economic conditions for successful implementation (e.g. low feedstock prices and high NG prices), international cooperation and reduction of fossil fuels in combination with more mature and common wood-to-energy technology. These are reported (Meijer et al. 2010) to play a key role for a technology breakthrough from its niche market and have been shown here to define straw-to-energy sector establishment in UA and LU.

6. Conclusions

The potential to use crop residues and straw for energy is significant in UA and LU. If developed sustainably, it could help the countries combat their economic, social, environmental and security challenges. However, neither in UA nor in LU agro-bioenergy markets are established yet, although a number of initiatives have emerged recently.

The major *constraining factors* for bioenergy in UA and LU include flaws in legislation; imperfections of incentive-based systems for RE/bioenergy; presence of market incumbents lobbying for conventional fuels; lack of collective action between bioenergy actors; lack of national technology production lines; low access to funds, knowledge and technology by local and sub-regional actors.

The major *facilitating factors* include significant bioenergy potentials; presence of national bioenergy leaders (SEC Biomass in UA and research groups in LU) with a potential for networking, knowledge development and diffusion; existence of national biomass equipment producers; competitiveness and low costs of agro-biofuels; fast payback of biomass boilers; and interest of foreign actors in biomass-to-energy activities.

Notes

- ¹ Bioenergy – energy derived from biomass (Bauen et al. 2009).
- ² Bioenergy co-benefits – ancillary benefits offered by agro-biomass crops, biofuels, and the activities related to their production and use that are in addition to direct

economic revenues from the agricultural or downstream processing activities (Peck & Voytenko 2008).

- 3 Here the authors include straw from grain crops and existing rapeseed plantations.
- 4 2nd generation biofuels are produced from lignocellulosic biomass feedstock using advanced processes of biochemical and thermochemical conversion.
- 5 Alternative fuel is solid, liquid or gas fuel, which is an alternative to traditional fuel and is produced or extracted from non-traditional energy sources.
- 6 UTEM (Yuzhteploelektromontazh) is a group of 15 enterprises that carry out complex projects in the energy sector (<http://www.udem.com.ua/en/index.php>).
- 7 1 Euro = 10.95 UAH as of 14 October 2011.
- 8 The independent research consultancy SIA "VIRSMA" (Latvia) identified a straw pellet calorific value of 4 111 Kcal/kg and density of 610.7 kg/m.
- 9 Legitimacy is a generalised perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions (Suchman 1995).
- 10 6.4 € cents/kWh for the power plants in operation before 1 Jan 2008; 7.0 € cents/kWh – for those in operation after 1 Jan 2008.

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