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SOLID BIOMASS CONSUMPTION IN HOUSEHOLDS AND GREENHOUSE GAS EMISSION REDUCTION IN LATVIA

I. Kudrenickis, G. Klavs

Laboratory of Energy System Analysis and Optimisation,
Institute of Physical Energetics,
21 Aizkraukles Str., Rīga, LV-1006, LATVIA
e-mail: energy@edi.lv

Utilisation of biomass is an important factor in reducing emission of greenhouse gases (GHG); at the same time, high efficiency of biomass combustion technologies is to be ensured to minimise the methane (CH_4) emission thus achieving the most efficient reduction in the total GHG emission. The authors analyse the GHG emission breakdown in Latvia among the sectors not included in the EU Emissions Trading Scheme (ETS), and, in the context of emission reduction, evaluate the energy supply in the Latvian household sector, the types of combustion technologies and the used fuels. The trend is considered for the CH_4 emission factor during 1990-2010 in the household sector of EU countries, and the numerical index is calculated which illustrates decoupling the consumption of biomass fuel from CH_4 emission. To evaluate the perspective of CH_4 emission reduction in the Latvian household sector, two scenarios are investigated for efficiency improvement as related to the central heating equipment based on wood fuel.

Keywords: *energy supply, non-ETS, household sector, wood fuel combustion technologies, GHG emission, methane (CH_4) emission, CH_4 emission factor.*

1. INTRODUCTION

European Union Climate and Energy package is binding to cut the EU's overall GHG emission from the sectors not included in the EU Emissions Trading Scheme (ETS) by 10% in 2020 compared to the 2005 emission level, individual targets of GHG emission limits in 2020, ranging from -20% to +20% compared to 2005, are set for member states. The target set for Latvia takes into account the economic development perspective and thus limits the growth of GHG emission from the non-ETS sector to no more than 17% [1]; namely, the Latvian annual emission allocation for the year 2020 is stated 9.617 million tonnes of CO_2-eq [2].

Changes in the GHG emission in Latvia over the years 2005-2010 (Fig.1) are mainly determined by the economic development trend taking place in the country. The economic recession that began in 2008 determined the GHG emission reductions primarily in the sectors of industry and transport, while the economic recovery, which started in 2010, returned the 2008 emission levels. Compared with 2005, the ETS sector emission in 2010 increased by 13.5 percentage points, while

in the non-ETS sector – by 5.3 percentage points. The non-ETS sector emission is determined by subtracting the verified ETS sector emission [3] from the total GHG emission in Latvia [4].

The non-ETS sector accounts for about 3/4 of all GHG emission in Latvia. As shown in Fig. 2, in the case of Latvia the most important contributors to non-ETS sector GHG emission are transport (36%) and agriculture (26%), a significant contribution (9%) is made also by the household sector. The importance of this sector in overall GHG emission reduction is determined not only by the relative contribution to the total non-ETS emission, but also by the ability to carry out the cost-based emission reduction measures.

As known, the main options to reduce the GHG emissions that result from the combustion of fuels are energy efficiency measures and switching to renewable energy sources (RES). In the past 20 years considerable changes in the structure of consumed fuels, significantly increasing biomass consumption and reducing CO_2 emissions, have taken place in Latvia. Undoubtedly, measures to promote a switch of fossil fuel to the RES must continue as an important Latvia's energy and climate policy component. At the same time, the importance of emissions other than CO_2 in the GHG emission balance has to be taken into account. Following the increase in biomass fuel consumption, the article focuses on methane (CH_4) emissions generated in the process of biomass combustion in the household sector of Latvia and their long-term reduction by improvement of the combustion efficiency.

In 2010, Latvia had the fifth highest share of methane emission in the total national GHG emission among the EU Member States [4]. Specifically, CH_4 emission in 2010 accounted for about 20% of the overall non-ETS sector GHG emission in Latvia. Due to the high share of wood fuel consumption, the CH_4 emission currently accounts for about a quarter of the Latvia household sector's GHG emission arising from the direct combustion of fuel, which is a considerable amount in the context of the national climate policy.

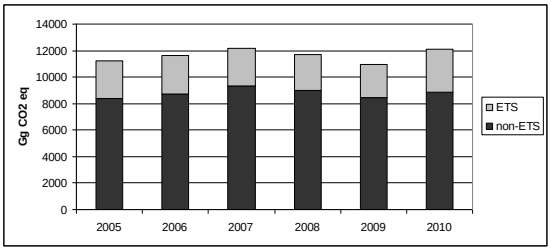

Fig.1. ETS and non-ETS GHG emission in Latvia, 2005 – 2010.

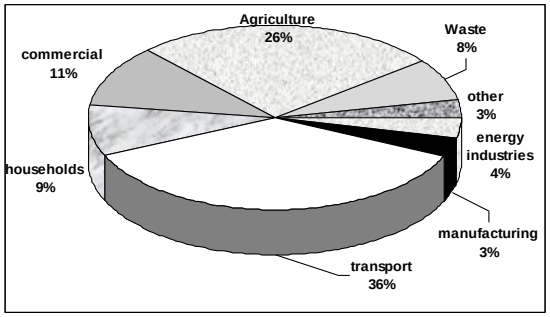

Fig.2. Non-ETS GHG emission breakdown in Latvia, 2010.

2. HOUSEHOLD SECTOR ENERGY SUPPLY AS THE CHALLENGE FOR THE LATVIAN CLIMATE POLICY

Households have important share in the Latvian final energy consumption (FEC). In the past six years (2007-2012) the households' share in the total FEC was 32.3-37.3%. The district heating systems (DHSs) play here an important role, giving slightly more than a quarter of the FEC in the sector (Fig.3, [5]). More than a half of Latvian dwellings are connected to DHSs, but significant is the fact that the relative share of such dwellings slightly decreased in 2001-2010 (Fig.4).

Using the utilities' GHG emission reports [3], the authors have summarised the amount of the annual heat energy produced in those ETS-participating utilities that supply heat for the DHSs. The analysis has shown that from all the heat delivered to DHSs about 80% of the supply was covered by the district heating utilities participating in the ETS.

Thus, the energy efficiency improvement measures for the multi-apartment buildings, which are traditionally taken in the household sector, could provide the largest contribution to the GHG emission reduction particularly in the ETS sector and, to a lesser extent, affect the non-ETS sector. This conclusion is also confirmed by the ongoing implementation of ERDF co-financed apartment building insulation projects. The authors' assessment, using publicly available data [6], shows that from the total eligible costs of the so-far contracted building insulation projects ~ 60% are used in the cities whose district heating utilities participate in the ETS.

An important feature of the situation in Latvia is a relatively high share of biomass fuel used in DHSs outside the ETS. The authors' assessment carried out using statistical data [3, 5] shows that in 2010 the wood biomass made up about 40% in the total fuel consumption of the DHSs not participating in the ETS.

These factors must be respected when evaluating the impact of energy efficiency measures as well as of RES implementation measures on the reduction of GHG emission in the Latvian households in particular and in the non-ETS sector in general.

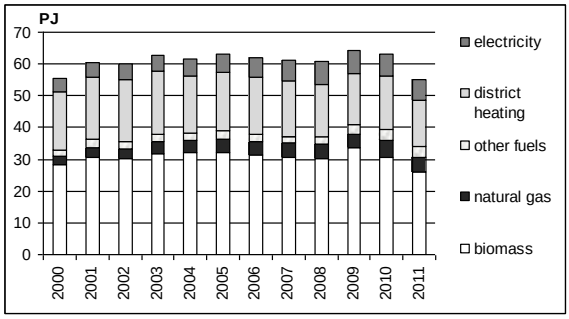

Fig.3. Final energy consumption in the Latvian household sector, 2000-2011.

3. TECHNOLOGIES AND FUELS USED FOR HOUSEHOLD HEATING

Fuel combustion in 2000-ies formed ~ 60% of the total household FEC in Latvia (Fig.3), with wood as the dominant fuel (~ 80% of all fuel consumed). In 2010, the share of biomass fuel in the total fuel consumption in the household

sector in Latvia was the 2nd highest in the EU (after Estonia) and significantly higher than both the EU-15 average (~ 15%) and the EU-12 average (~ 33%) [4].

Based on the surveys on energy consumption in households carried out by the Central Statistical Bureau of Latvia [7], types of heat delivery, combustion technologies used and their age, and types of fuel were analyzed.

The total number of combustion equipment in Latvian households was about 400 thousand in 2010. With the development of new family houses during the period of 2000-2008, the share of dwellings with central heating almost doubled, reaching 19.5% in 2010 (Fig. 4). Wood was used in ~ 56% of Latvian dwellings with stoves or central heating combustion equipment (Fig.5). However, over the last decade, the share of the dwellings using wood fuel has slightly decreased. In that period an active introduction of natural-gas heating was observed: in 2010 it was used in slightly more than 30% of Latvian dwellings with fuel combustion equipment, other types of fuel as well as electricity being less used for heating in Latvia.

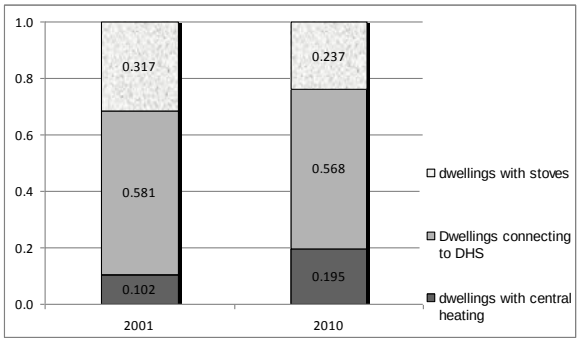

Fig.4. The breakdown of dwellings in Latvia according to the type of heating.*inside:dwellings connected*

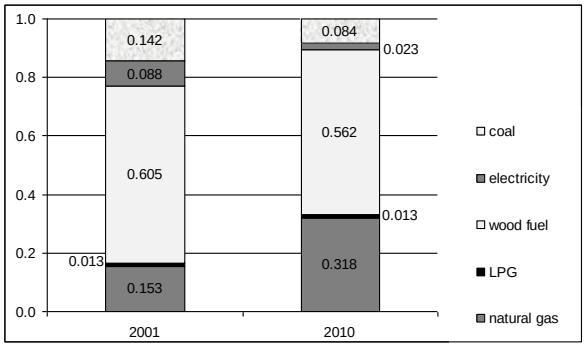

Fig.5. The breakdown of dwellings with stoves and central heating equipment in Latvia according to the type of fuel.

One of the key factors is the age of wood fuel equipment. In 2010, slightly above 69% of the total number of room stoves and 26% of the total number of boilers were older than 16 years. Compared to the situation in 2001, it can be concluded that the age breakdown for equipment has not changed significantly, being replaced only due to the end of technical lifetime. Up to the time when the Climate Change

Financial Instrument (CCFI)[1] sub-programme took effect in 2011/2012, there had been no national support programmes focusing on the implementation of efficient household biomass boilers. Under the framework of the CCFI sub-programme the introduction of 487 new biomass heating technologies into the household sector was co-financed [8]. However, this figure is a negligible contribution when assessing the situation in Latvia as a whole, and attention should be directed both to providing a long-term framework of financial support and to creation of other forms of assistance.

4. CH_4 EMISSIONS FROM BIOMASS IN HOUSEHOLD SECTOR OF LATVIA: CURRENT SITUATION AND PERSPECTIVES

Analysis of GHG emissions in the household sector of Latvia is performed using the data from the National Inventory Report [4] and measurements of CH_4 emissions from household combustion equipment [9, 10]. Historically, from 1990 to 1995 the consumption of wood fuel in Latvian households increased significantly, which resulted in reduced CO_2 and total GHG emissions, but at the same time in increased CH_4 emissions. The growth in GHG emissions since 2000 (Fig.6) is explained by increase in the total heated area.

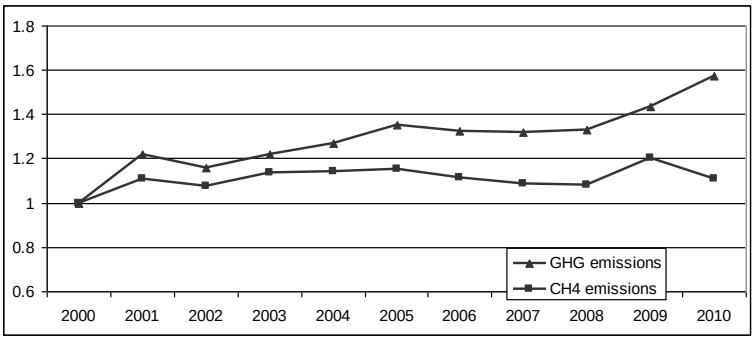

Fig.6. Total GHG and methane emissions dynamics in households of Latvia (year 2000 = 1).

The growth in the biomass fuel consumption and the associated increase in the methane emissions were also observed in other new member states of EU. In EU-12 countries in total, the absolute consumption of biomass in the household sector in 2010 as compared with 1990 increased approx. 3.6 times, and, thanks to that, the GHG total emissions linked to the direct combustion of fuels in the households decreased by about ~ 30%, while methane emissions increased. The dynamics of development in different countries varies: in 2010, CH_4 emissions associated with biomass combustion accounted for more than 10% of the total household sector GHG emissions in Estonia, Latvia, Lithuania, Bulgaria, and Romania. Thus, the situation in the EU-12 countries is different from that for the

[1] Latvia is actively participating in the GHG emissions trading mechanism under UNFCCC Kyoto Protocol and has receipts from the sale of GHG emissions under procedures pursuant to Article 17 of the Protocol. These receipts were partly allocated for CO_2 emissions reduction by implementing renewables-based effective heat and electricity production technologies in the household sector [8].

EU-15 countries: the latter in the total CH_4 emissions from biomass had a share of only ~ 1% of the total household sector GHG emissions [11]; however, the CH_4 emissions gave in 2010 a substantial contribution – more than 5% of the total household sector GHG emissions in Sweden, Finland, and Portugal.

The methane emission assessment in the national GHG inventory depends on the implied CH_4 emission factor. Table 1 illustrates the relevant trend in different EU countries: such EU-15 countries as Austria, Denmark, France, Germany, Sweden, and also Switzerland, based on technology assessment, implied lower CH_4 emission factors for the household sector compared to the default value of 300 kg/TJ_{fuel} (defined by IPCC Guidelines) and reduced them in the course of time. Most of the other EU countries use this default value[2]. As noted in [12], accurate estimation of CH_4 emissions depends on the combustion conditions, technology and emissions control policy as well as on the fuel characteristics; therefore, caution should be used when comparing the implied emission factors across the countries. Also, the numerical index (the right column) is calculated by the authors to characterise the change in the biomass consumption *vs.* that in CH_4 emissions; the index value > 1.0 implies that the decoupling has taken place.

Applying the default value of the emission factor, important is the question of its conformity with the actually used wood fuel combustion technologies. In Latvia, so far a detailed enough inventory has not been done for the household combustion equipment. The measurement of CH_4 concentration ratio in flue gas [9,10] is one of the few in Latvia. Measurements of the type were done for small capacity (several tens kW) 3-5 years old household combustion equipment as well as for relatively high capacity (~ 1-2 MW) automated combustion units. Different types of wood fuel were studied – firewood, wood waste, wood chips, briquettes, pellets. The average concentrations of CH_4, CO and NO_x in flue gas were measured 30 min after reaching the stable regime. Measurements by gas analyzers showed that only few peaks of CH_4 concentration in flue gas could be registered as caused by volley emissions, with the total average amount of CH_4 emissions being low. Thus, for the integral determination of the average concentration of CH_4 a proportional sample (continuous filling of flue gas into a special airtight volume within an hour) was collected and tested using a Fourier's infrared spectrometer *IR Prestige-21* [9,10].

The measurements described in [9,10] were carried out on the limited number of equipment items, while to obtain representative results the number of measurements should be greater; at the same time, these results would be of interest in the context of the national GHG emissions projection. In particular, the results of [9,10] indicate that the CH_4 emission factor for relatively new household biomass combustion equipment in Latvia is ~ 100 kg/TJ_{fuel} and even lower, that is, significantly lesser than the default value used in the national GHG inventory for the common stock. Important, the interpretation of the results requires emphasising that they correspond to a stable wood fuel combustion regime, thus in the whole

[2] Slightly higher factor than the default value is used in UK (316 kg/TJ), Greece and Italy (320 kg/TJ), and Spain (326 kg/TJ) [4].

cycle the CH_4 emissions will be higher while the equipment operation is reaching the stationary state. CH_4 emissions from non-automated household equipment depend heavily on the maintenance of optimal burning.

Table 1

CH_4 emission factor for household sector biomass combustion (implied for GHG inventory), and the calculated index characterising decoupling of biomass consumption from CH_4 emissions

	CH_4 emission factor for biomass combustion in household sector, kg/TJ_{fuel}						Change in biomass consumption *vs.* change in CH_4 emissions, 2010 - 1990
	1990	1995	2000	2005	2009	2010	
Austria	256	228	166	144	126	126	2.03
Denmark	235	224	216	164	134	127	1.85
France	497	497	428	315	212	191	2.61
Germany	123	123	111	100	100	100	1.23
Sweden	279	274	275	246	232	232	1.21
Switzerland	213	185	152	121	96	92	2.32
Finland	200	200	200	200	199	198	~1.00
Norway	260	259	259	258	258	258	~ 1.00
Other EU countries							1.00

To assess the perspective of CH_4 emission reduction for the household sector in Latvia, this was modelled on two scenarios. The first one (autonomous technology substitution) is a gradual replacement of technically outdated central heating biomass boilers with new ones. In this scenario, in the year 2020, 37% of the currently operated boilers are still in use. In the second scenario, it is assumed that the replacement of outdated boilers is stimulated with special support programmes, and by 2020 only 22% of now in-service boilers will remain. Assuming cautiously that for new equipment the CH_4 emission factor will not exceed 150 kg/TJ_{fuel}, the potential reductions in emissions of CH_4 from biomass combustion in households could be estimated for a constant level of biomass fuel consumption.

Figure 7*a* shows a relative achievable reduction in CH_4 emissions from biomass-based central heating. As can be seen, even in the 1st scenario the CH_4 emissions can be reduced by one third, while the 2nd scenario provides the possibility to reduce these emissions by about additional 10 percentage points. However, as the model deals with the central heating equipment only and does not address the replacement of stoves (having a significant share in Latvia household heating), then, as shown in Fig.7*b*, the total relative achievable CH_4 emissions reduction will be lower. In general, the implementation of the financial support/fiscal policy (scenario 2) can reduce the total CH_4 emissions from biomass combustion in Latvian households by about additional 3 percentage points. Achieving greater reductions would require additional promotion of replacement of currently operational stoves with more efficient ones or central heating boilers.

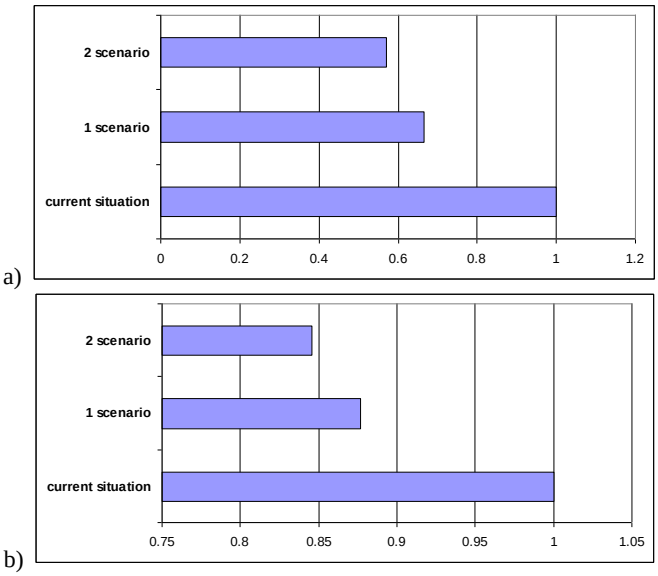

Fig.7. Modelled CH_4 emission benchmarks in 2020 from biomass combustion in the household sector of Latvia:
a) benchmarks related to CH_4 emissions from biomass-based central heating;
b) benchmarks related to CH_4 emissions from the total biomass combustion in households (central heating plus stoves).

5. CONCLUSIONS

1. In the development of national non-ETS climate policies the role of limitation on methane emissions will definitely increase, especially in the countries like Latvia, with a high share of biomass combusted in the household sector. Increased use of wood fuels replacing fossil fuels provides a major contribution to the reduction of GHG emissions; at the same time, it is necessary to enforce the policy for neutralising the increase in methane emissions thus achieving more efficient reduction in the total GHG emissions.

2. Analysis of the final energy consumption in the Latvian household sector indicates that no significant increase in the biomass share could be expected in the future due to already reached "saturation". Thus targeted efforts focused on phasing-in the efficient biomass combustion boilers in households are especially important. Development of National Regulations regarding performance and emission limits of small-scale household central heating boilers along with their labelling are important instruments, especially in the context of synergy between the goals of a national climate policy and the clean air policy.

3. Evaluation of perspectives for methane emission reduction in the household sector indicates that in Latvia in the last decade the autonomous trend for replacement of central heating biomass combustion technology is weak owing to the end of the equipment technical lifetime; however, even in this scenario a significant decrease in methane emissions could be expected by 2020. To achieve the most efficient emission reduction, the scenario with support measures to foster the substitution of efficient equipment for outdated biomass combustion equipment is required.

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CIETĀS BIOMASAS PATĒRIŅŠ UN SILTUMNĪCEFEKTA GĀZU EMISIJU SAMAZINĀŠANAS PERSPEKTĪVA LATVIJAS MĀJSAIMNIECĪBĀS

I. Kudreņickis, G. Klāvs

K o p s a v i l k u m s

Biomasas izmantošana ir viens no principiālajiem virzieniem siltumnīcefekta gāzu (SEG) emisiju samazināšanā. Maksimāla SEG emisiju samazinājuma panākšanai ir nepieciešams nodrošināt biomasas sadedzināšanas iekārtu augstu efektivitāti, lai minimizētu ar biomasas kurināmā patēriņu saistīto metāna (CH_4) emisiju pieaugumu. Autori raksturo Eiropas Savienības (ES) Emisiju kvotu tirdzniecības sistēmas (ETS) un tajā neietilpstošo sektoru (ne-ETS) nozīmi Latvijas SEG emisiju veidošanā, SEG emisiju relatīvo sadalījumu atbilstoši dažādiem ne-ETS sektoriem un SEG emisiju samazināšanas kontekstā analizē Latvijas mājsaimniecību sektora energoapgādi, patērēto kurināmo un izmantotās kurināmā sadedzināšanas tehnoloģijas. Rakstā ir demonstrēta SEG emisiju inventarizācijā pielietotā CH_4 emisiju specifiskā faktora mājsaimniecību sektora koksnes kurināmajam skaitlisko vērtību dinamika 1990-2010 gados dažādās ES valstīs. Salīdzinot kurināmā patēriņa un CH_4 emisiju apjoma izmaiņas, ir aprēķināts skaitliskais rādītājs, kas raksturo biomasas kurināmā patēriņa un CH_4 emisiju „atsaisti" ES valstīs analizējamā laika posmā. Lai kvantitatīvi novērtētu CH_4 emisiju samazināšanas perspektīvu Latvijas mājsaimniecību sektorā, autori analizē divus attīstības scenārijus, kas paredz dažādus mājsaimniecību centrālajā apkurē izmantoto koksnes sadedzināšanas iekārtu efektivitātes pieaugumus.

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