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GREENHOUSE GAS MITIGATION POTENTIAL OF FOREST BIOFUEL ORIGINATED IN LATVIA

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Latvia is one of the largest exporters of pellets in Europe, and at the same time share of biofuel in energy production in Latvia is also one of the largest between the developed countries. Rapid increase of biofuel production and export raises questions about sustainability of forest sector and contribution of the forest biofuel produced in Latvia to the greenhouse gas (GHG) balance in Europe. Sustainability of forest biofuel is broadly discussed issue in Baltic states; particularly, due to continuous increase of production and export of wood pellets. GHG mitigation potential of the forest biofuel is one of the sustainability aspects surrounded by multiple speculations, which has to be addressed by comprehensive comparison of GHG fluxes due to production and use of forest biofuel and substituted fossil fuel. Assessment of the GHG mitigation potential of forest biofuel is complex process requiring multiple activity data and assumptions. Particular complexity of calculation is determined by the need to use harmonized approach for the whole calculation period. The assessment of the climate change mitigation in this study is based on the methods applied in National GHG inventory and literature data on GHG emissions due to production and delivery of substituted fossil fuel and forest biomass including demolition wood. According to the study results substitution effect of the forest biofuel in Latvia continuously increases since 2000, mainly due to export of biofuel, reaching 14323 Gg CO₂ eq. in 2020 (by 30% more than the net GHG emissions in Latvia in 2019). Electricity production in pellet factories, in spite of major reduction of GHG emissions in the production process, has minor role in the total substitution effect.

Keywords: greenhouse gas, forest biofuel, substitution effect

INTRODUCTION

The net GHG emissions in Latvia in 2019 was $12.6 \cdot 10^6$ tons CO₂ eq. excluding Land Use, Land Use Change and Forestry (LULUCF) sector and $12.7 \cdot 10^6$ tons CO₂ eq. with LULUCF sector (Ministry of Environmental Protection and Regional Development, 2021a). LULUCF sector in Latvia is a net source of GHG emissions due to GHG emissions from organic soils, mostly, croplands and grasslands (about $4 \cdot 10^6$ tons CO₂ eq.). Similarly to other EU countries Latvia recently approved the target to reach climate neutrality in 2050 by ratification of Paris agreement (UNFCCC, 2015) and even more, agriculture, forestry and other land use (AFOLU) sector has challenging target to reach climate neutrality already in 2035 (European Commission, 2021). According to this strategic target the GHG emissions in Latvia has to be reduced by more than $2.2 \cdot 10^6$ tons CO₂ eq. yr⁻¹ during the following 15 years in comparison to current situation and by more than $6 \cdot 10^6$ tons CO₂ eq. yr⁻¹ if compared to the GHG projections in 2025-2035 (Ministry of Environmental Protection and Regional Development, 2021b). The LULUCF sector will have important role in reaching this target because of considerably potential to decrease GHG emissions and to contribute to the national target by the increase of deliveries of biomass including forest bioenergy and by implementation of the climate change mitigation measures in forest land, cropland, grassland and wetlands.

In spite local consumption of forest biofuel is stagnating during the recent years, it significantly increase in the export markets, particularly due to export of pellets to other European countries substituting coal in their heat & power plants with biomass. This resource is appearing in Latvia's GHG inventory as carbon losses in LULUCF sector (Ministry of Environmental Protection and Regional Development, 2021a). Due to this fact it is important to quantify actual contribution of forest sector to the climate change mitigation and it's potential to contribute to the national GHG balance, if forest biofuel is consumed locally and high GHG emissions due incineration of forest biofuel in households are reduced by modernization of heating systems.

The scope of the study is to estimate GHG emissions due to production and delivery of forest biofuel from Latvia to local and export markets and to evaluate substitution effect of forest biofuel. All kind of forest resources are considered in the study, including recycled wood and underutilized forest resources including harvesting residues, thus providing insight in the actual substitution effect and it's potential to grow.

METHODS

Forest resources in Latvia in the study are evaluated according to activity data and assumptions used in development of forest reference level; particularly, management assumptions (harvest intensity by species, forest regeneration and thinning probabilities) and forest area according to the reference period (2000-2009) and projections of forest growth and utilization rate in 2010-2020 according to assumptions on forest management intensities as set in the forest reference level calculations. Actual "business as usual" scenario is used to estimate forest growth between 2010 and 2018, as well as for the projections of forest growth in 2019-2020 (Lazdiņš et al., 2019; Šņepsts et al., 2018). Data from National GHG inventory are used in calculations of forest growth, harvests and production of HWP (Ministry of Environmental Protection and Regional Development, 2021a).

Forest biofuel resources are evaluated as potential, technically and economically accessible and actually produced resources. Evaluation of forest biofuel resources includes firewood, bark, wood processing residues, harvesting residues, stumps and biomass of small trees extracted in pre-commercial thinning. Potential resources includes all biomass, assuming that all biomass of harvested trees is extracted and utilized in energy sector. Technically accessible biofuel resources excludes production losses in production of stumps and harvesting residues (Lazdāns et al., 2008; LVMI Silava, 2008). GHG emissions due to pellet production are calculated according to literature data (Bergman, 2005; DNR, 2017; EUBIA, 2012; Loo and Koppejan, 2012). Actual biofuel production is determined using national energy and harvesting statistics providing information on firewood and harvesting residues production. Export and import is determined using industry statistics. Fuel consumption in forest operations is based on the Joint Stock company "Latvia's state forests" statistics on fuel consumption in harvesting, literature review on long term transport and IPCC guidelines (IPCC 2006) based emission factors (Eggleston et al., 2006).

Biofuel replacement effect is estimated by comparison of GHG emissions due to production and use of biofuel and GHG emissions due to production and use of fossil fuel. Fuel is divided into households and centralized applications, using different emission factors for households in Latvia. Electricity consumption and production (in case of biomass) is considered in calculation of substitution effect. Electricity CO₂ equivalent assumed in calculation is 0.4 tons CO₂ MWh⁻¹. Where biofuel production technologies can vary, more GHG intensive variant is considered, e.g. it is assumed that all chips are comminuted using diesel chippers. Detailed description of calculation methods is provided in the report by LSFRI Silava (Lazdiņš et al., 2021). The methodology is based on the statistics on forest production, biofuel use, IPCC 2006 defaults for GHG emissions due to fuel consumption in off-road and road transport.

RESULTS OF RESEARCH

Potential resources of forest biofuel includes all biomass, assuming that all biomass of harvested trees is extracted and utilized in energy sector. Potentially available resources reflects species composition in the harvest stock – birch, spruce and pine are dominating. Total potentially available biofuel resources increased from $6.9 \cdot 10^6$ tons in 2000 to $7.9 \cdot 10^6$ tons in 2020. If compared by type of potentially accessible biofuel, then stumps, roundwood processing residues and harvesting residues are dominating. The net calorific value of potentially available biomass increased from 128411 TJ in 2000 to 146964 TJ in 2020. The increase of potentially accessible biomass is associated with changes of species composition in the harvest stock leading to increase of proportion of firewood.

Technically accessible biofuel resources excludes production losses in extraction stumps and harvesting residues (Lazdāns et al., 2008; LVMI Silava, 2008). Total technically accessible forest resources increased from 84576 TJ to 95241 TJ in 2020. Proportion of technically accessible resources, in contrast, slightly decreased – from 66% in 2000 to 65% in 2020.

The potential biofuel resources in Latvia are close to the total energy demand in Latvia. If the demolition wood is accounted, theoretical output of biofuel from biomass originated in Latvia is significantly bigger than the total energy demand; however, technically accessible biofuel resources, including demolition wood, is about two thirds of the total energy demand in Latvia. Due to export of roundwood and biofuel more than half of this amount is produced abroad.

Actually produced biofuel from local resources increased from about 54432 TJ in 2000 to 70726 TJ in 2020. Harvesting residues, in spite of significant technically accessible potential, still have minor role in forest biofuel production. Dominant sources of biofuel are timber processing residues and firewood.

In 2000 actually produced biofuel in 2000 was 54% of the technically accessible resources and in 2020 it increased to 66% of the technically accessible resources; therefore, significant increase of forest biofuel production still can be reached without increase of the harvests. Relatively small utilization rate also confirms that local demand, which is the main output of low grade biofuel, e.g. stumps and harvesting residues, can be significantly increased.

In 2000 about $7 \cdot 10^6$ m³ of roundwood processing residues were produced. The most of it was produced abroad, from exported roundwood. In 2020 situation is opposite – 76% of the wood processing residues from locally originated roundwood is produced in Latvia. Calorific value of roundwood processing residues increased from 56517 TJ in 2000 to

58624 TJ in 2020. In spite the totals did not changed significantly, the structure of production is now significantly different – the most of the residues are produced and transferred to biofuel in Latvia, avoiding GHG emissions due to long transport distances of raw materials.

The proportion of biofuel from the net energy demand in Latvia is rather stable – 44% in 2000 and 40% in 2020. The share of biofuel is relatively high in Latvia in comparison to other EU countries; however, it is not increasing for 2 decades in spite of abundant amount of resources, which can be accessed without increase of intensity of utilization of forest resources. Biofuel historically is one of the most significant type of energy sources in Latvia. The role of biomass increased since early 90ths and stagnated from 2000 to 2010. During the last decade the increase of biofuel consumption revived reaching 67919 TJ in 2020 (Figure 1). Dominant type of biofuel in local consumption is firewood; however, proportion of wood chips is growing. In spite the total consumption of biofuel in Latvia did not increased significantly during 20 years, the structure of the consumption is changing – biofuel consumption in households reduces and industrial and centralized applications grows, reaching about 70% in 2020 (Figure 1).

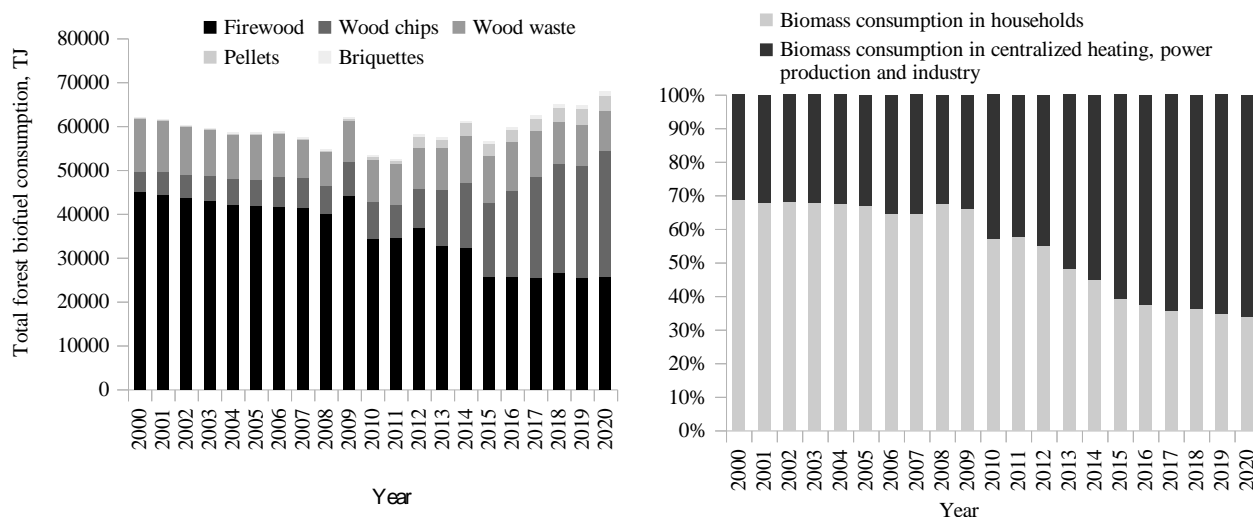


Figure 1. Forest biofuel consumption in Latvia by type of biofuel (on left side) and type of consumer (on right side).

GHG emissions due to consumption of biofuel in Latvia significantly decreased since 2000 – from 306 Gg CO₂ eq. to 232 Gg CO₂ eq. (by 25%). The most of the emissions are associated with old heating systems in households. Share of GHG emissions due to incineration of imported biofuel started to growth during the last decade and reached about 18% of the total emissions due to incineration of biofuel in Latvia. Export of biofuel and utilization of demolition wood and processing residues of exported logs is another source of GHG emissions due to incineration of biomass. These emissions increased from 56 Gg CO₂ eq. in 2000 to 168 Gg CO₂ in 2020, mainly due to significantly increased export of wood pellets. The total GHG emissions due to utilization of forest biofuel originated in Latvia slightly decreased since 2000 (from 362 Gg CO₂ eq. to 357 Gg CO₂ in 2020), in spite of significant growth of the biofuel consumption, particularly, in the export markets. The reduction of GHG emissions is mainly associated with the decrease of biofuel consumption in inefficient heating systems in households. However, there is still significant GHG mitigation potential in modernization of out-wearied and outdated heating systems. About 69% of GHG emissions due to incineration of biomass in households can be avoided by modernization of heating systems, reaching about 100 Gg CO₂ eq. in 2020.

During the last decade pellet industry became the most significant consumer of forest biofuel and source of GHG emissions, particularly, if energy sources consumed during production and delivery of raw materials is considered. Electricity consumption is another significant source of GHG emissions considering high proportion of fossil sources in the electricity production. The net GHG emissions due to pellet production, including direct fuel consumption, production and delivery of raw materials and electricity consumption, reached 280 Gg CO₂ eq. in 2020; however, pellet factories are also significant potential source of electricity produced from renewable sources. If pellet industry is used to full extend for electricity production, the annual production potential would reach about 803 GWh_{el.} yr⁻¹, turning pellet industry into net sink of CO₂ removals (104 Gg CO₂ eq.). Production and delivery of raw materials for pellet production creates about 20% of the net GHG emissions due to pellet production (38 Gg CO₂ eq. in 2020).

Total GHG emissions due to roundwood production and delivery in Latvia, excluding firewood production and bark, increased from 119 Gg CO₂ eq. in 2000 to 139 Gg CO₂ eq. About 60% of the emissions are created by road transport. Additionally, 31 Gg CO₂ eq. in 2000 and 42 Gg CO₂ eq. is created by firewood production.

GHG emissions due to production of harvesting residues and bark increased from 6.3 Gg CO₂ in 2000 to 11 Gg CO₂ eq. in 2020, mainly due to increase of production of harvesting residues. Total GHG emissions due to roundwood and forest biofuel production in 2000 were 157 Gg CO₂ eq. and in 2020 – 192 Gg CO₂ eq. This calculation includes harvesting, forwarding, comminution and primary road transport. GHG emissions due to biofuel production are 27% of the total logging related GHG emissions. If compared to the total GHG emissions in Latvia, excluding LULUCF sector,

roundwood production and delivery created 1.6% of the total emissions and biofuel production – 0.4% of the total emissions in 2000 and 1.7% and 0.5%, accordingly, in 2020.

Roundwood is processed locally and externally. GHG emissions due to local processing of locally originated wood significantly increased due to development of wood processing industry in Latvia and reduction of export of logs. Considering that the most of HWP are exported, demolition wood mainly originates abroad. Here in calculation GHG emissions due to comminution and transport of demolition wood is accounted according to origin and place of processing of roundwood. In 2000 GHG emissions due to production of biofuel from timber residues and demolition wood originated from locally grown and processed logs were 10 Gg CO₂ eq. and 52 Gg CO₂ eq.

GHG emissions due to production of biofuel from timber residues and demolition wood originated from locally grown and exported logs in 2000 were 21 Gg CO₂ eq. and in 2020 they reached 26 Gg CO₂ eq. after significant increase between 2001 and 2018. GHG emissions due to production of biofuel from pulpwood processing residues remains stable after continuous increase till 2010. GHG emissions due to processing of demolition wood continuously increases due to significant input into the HWP carbon pool during previous years. GHG emissions due to roundwood processing significantly decreases till 2020 due to reduction of export of roundwood from Latvia.

GHG emissions due to processing of imported logs and demolition wood originated from imported logs increased from 0.6 Gg CO₂ eq. in 2000 to 5.3 Gg CO₂ eq in 2020 with significant decrease during the period of the economic crisis in 2008-2011.

Total GHG emissions due to production of timber processing residues and demolition wood increased from 32 Gg CO₂ eq. in 2000 to 83 Gg CO₂ eq. in 2020.

Substitution effect of forest biofuel is calculated assuming that instead of biofuel coal is used, which corresponds to historical situation in Latvia, as well as in the export markets. GHG emissions due to use of fossil fuel instead of forest biofuel locally would reach 5947 Gg CO₂ eq., mostly due to CO₂ emissions, which are compensated by forest growth in case of utilization of forest biofuel. In 2020 these emissions would decrease to 5748 Gg CO₂ eq. GHG emissions due to substitution of biofuel originated in Latvia with coal would reach 4308 Gg CO₂ eq. in 2000 and 7327 Gg CO₂ eq.

Incineration related net reduction of GHG emissions due substitution of fossil fuel with forest biomass originated in Latvia was 9893 Gg CO₂ eq. in 2000 and in 2020 it increased to 12675 Gg CO₂ eq. (Figure 2). The proportion of externally substituted GHG emissions continuously increase. The substitution effect due to local consumption is rather stable since 2000. Total replacement effect 2020 is nearly twice bigger than the total GHG emissions without LULUCF sector in Latvia, and substitution of fossil fuel due to roundwood and forest biofuel export in 2018 is nearly as big as the net GHG emissions in Latvia in 2018.

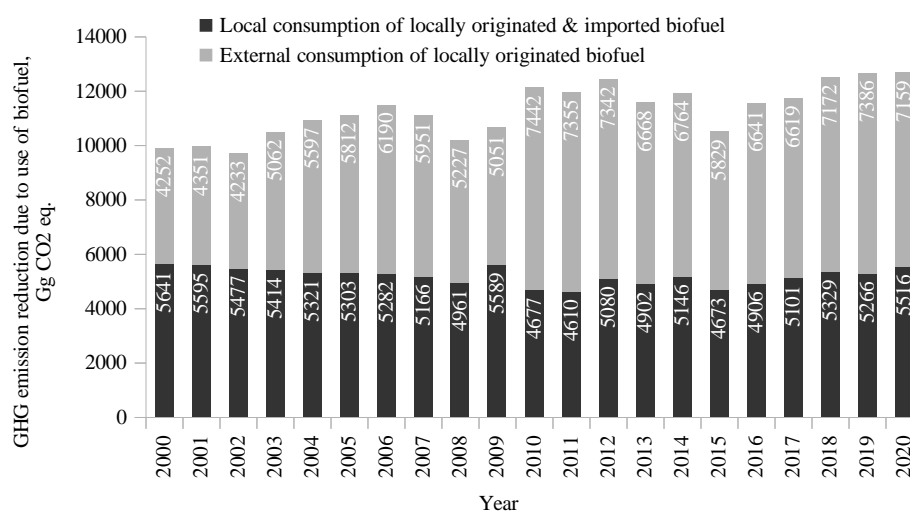


Figure 2. Fuel incineration related reduction of GHG emissions due to substitution of fossil fuel.

The potential GHG emissions due to production and delivery of locally substituted fossil fuel (coal and crude oil) would reach 817 Gg CO₂ eq. in 2000 and 796 Gg CO₂ eq. Potential GHG emissions due to production and delivery of fossil fuel substituted by forest biomass originated in Latvia are about twice higher than locally substantiated GHG emissions. They would reach 794 Gg CO₂ eq. in 2000 and 1351 Gg CO₂ eq. in 2020. Considerably higher GHG emissions in case if fossil fuel would not be substituted by forest biofuel are associated with origin of fossil – coal, which is imported from China, is associated with significant emissions due to output of methane into atmosphere.

The potential GHG emissions due to production, delivery and incineration of locally substituted fossil fuel would reach 6764 Gg CO₂ eq. in 2000 and 6544 Gg CO₂ eq. in 2020. This value corresponds to about half of the total GHG emissions in Latvia. The proportion of the substituted fossil fuel in households is continuously decreasing due to reduction of fuel consumption.

The potential GHG emissions due to production, delivery and incineration of fossil substituted by exported fuel would reach 5102 Gg CO₂ eq. in 2000 and 8678 Gg CO₂ eq. in 2020.

GHG emissions due to production of forest biofuel and delivery for local market, including pellet production

facilities, increased from 120 Gg CO₂ in 2000 to 291 Gg CO₂ in 2020). The increase is mainly associated with electricity consumption in pellet factories. The second biggest source is production and delivery of wood processing residues, which is also the largest source of the utilized biomass resources. GHG emissions due to production of forest biofuel and delivery for external market, including deliveries of pellets, increased from 203 Gg CO₂ in 2000 to 300 Gg CO₂ in 2020. Similarly, as for local market, the increase of GHG emissions is mainly associated with electricity consumption in pellet factories. Total GHG emissions due to production and delivery of locally consumed and exported biofuel increased from 189 Gg CO₂ eq. in 2000 to 314 Gg CO₂ eq. in 2020.

The net reduction of GHG emissions due to substitution of fossil fuel with forest biofuel in 2000 was 11165 Gg CO₂ eq. and in 2020 it increased to 14323 Gg CO₂ (Figure 3). The substitution effect of forest biofuel during the recent decade is significantly bigger than the net GHG emissions in Latvia in the same period. The most of the increase of the substitution effect is associated with utilization of exported biofuel and biofuel produced from exported logs.

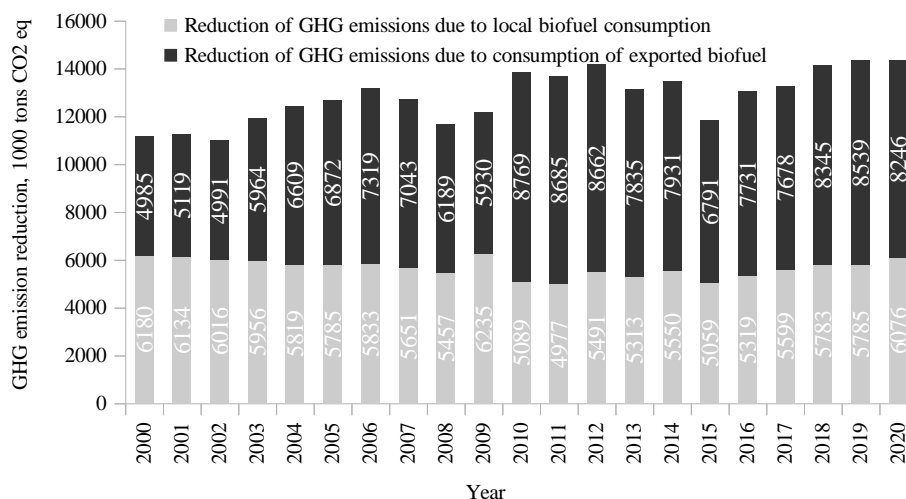


Figure 3: Reduction of GHG emissions in energy sector due to use of forest biofuel originated in Latvia.

CONCLUSIONS

1. The net calorific value of potentially accessible biofuel in Latvia, except demolition wood and biofuel produced from imported raw materials, in 2020 reached 128411 TJ. This value does not include biofuel, which could be produced in forests with management restrictions. The most significant sources of biomass, except demolition wood are wood processing residues, stumps and harvesting residues. Technically accessible resources of biomass are 65% of the theoretically available; the most significant reduction of resources due to technical issues is characteristic for stump biofuel.

2. Production of biofuel in Latvia significantly increased since 2000; particularly, harvesting residues is relatively new type of biofuel. In 2020 production of forest biofuel from local sources increased to about 70726 TJ (66% of technically accessible resources), excluding demolition wood, imported biofuel and biofuel produced from imported roundwood. Dominant primary sources are timber processing residues and firewood. Biofuel is 44% of the net energy demand in Latvia; however, it is not increasing during the last decades in spite of increasing amount of raw materials. Structure of biofuel production significantly changed, and pellets produced mainly for external markets are becoming dominant type of biofuel.

3. GHG emissions due to local consumption of biofuel in Latvia in 2018 reached 232 Gg CO₂ eq. (3% of the total emissions in energy sector), excluding international transport. The most of the emissions are associated with use of biofuel in households, where significant emission reduction (by 69%) can be reached by modernization of heating systems. Import of biofuel contributes to 18% of the net GHG emissions due to consumption of biofuel in Latvia. Total GHG emissions due to consumption of biofuel originated in Latvia in 2020 reached 362 Gg CO₂ eq. GHG emissions due to biofuel production reached 543 Gg CO₂ eq. in 2020; nearly half of it is associated with pellet production. Additionally, GHG emissions due to production and delivery of imported biofuel in 2020 was 101 Gg CO₂ eq.

4. Substitution effect of the forest biofuel continuously increases since 2000, mainly due to export of biofuel, reaching 14323 Gg CO₂ eq. in 2020. Electricity production in pellet factories, in spite of major reduction of GHG emissions due to biofuel production, has minor role in the total substitution effect.

5. Biofuel originated in Latvia have significant role in reaching climate neutrality target in Latvia and EU and maintaining resilient deliveries of sustainable forest biofuel. Use of forest biomass in energy sector still have significant potential to grow; particularly, utilization of low grade biofuel.

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