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BRANCHES: *Boosting rural bioeconomy networks following multi-actors approaches*

# The practice of using fast-growing energy plants for biofuel and emerging problems in Lithuania

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# ENERGY FORESTRY AND FAST-GROWING PLANTS IN LITHUANIA

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# INTRODUCTION

- *Forest and wood biomass* are woody perennial plants.
- Compared to other types of biomass, the biomass of woody plants has a high energy value and a good energy balance, i.e. the ratio between the energy obtained from the fuel and the energy used for cultivation, harvesting and transportation.
- Forest and wood biomass is further divided into: firewood, low value and logging waste.

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# INTRODUCTION

- *A separate type of plants is distinguished* - plantations of short rotation or woody plant plantations.
- These plantations use intensive technology to specially breed and grow very high productivity plants for obtaining raw materials provided by the forest.
- Willows, dogwoods, blinds, hybrid poplars, birches, aspens, alders, etc. are mostly grown in the plantations.
- It is estimated that the growth of woody plants grown with intensive technology in plantations is from 7 to 20 t/ha of dry biomass per year.

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# INTRODUCTION

- There are more than 5000 ha of cultivated willow (*Salix Viminalis*) plantations in Lithuania, which were started to be used as a hard bio-fuel.
- Therefore, with increasing uptake of renewable energy sources the research of new technologies and their development is necessary.
- Wood, quick-growing trees, bushes, willow, poplar and other energy plants are the most important renewable energy sources in Lithuania and now compose a substantial part of the local fuel.

Fig. 1. Willow plantation growing in the fields of Noreikupis, Sakiai District

# Methods of conversion of woody plants to energy

There are three known ways of converting woody plants into energy:
**Thermochemical conversion**:

- ***Combustion*** – used to heat water or generate steam in a turbine;
- ***Gasification*** – used to produce flammable gas that can be burned in boilers or used as fuel in engines or gas turbines;
- ***Pyrolysis*** – can be applied to convert plant into gas, oil or charcoal fuel.

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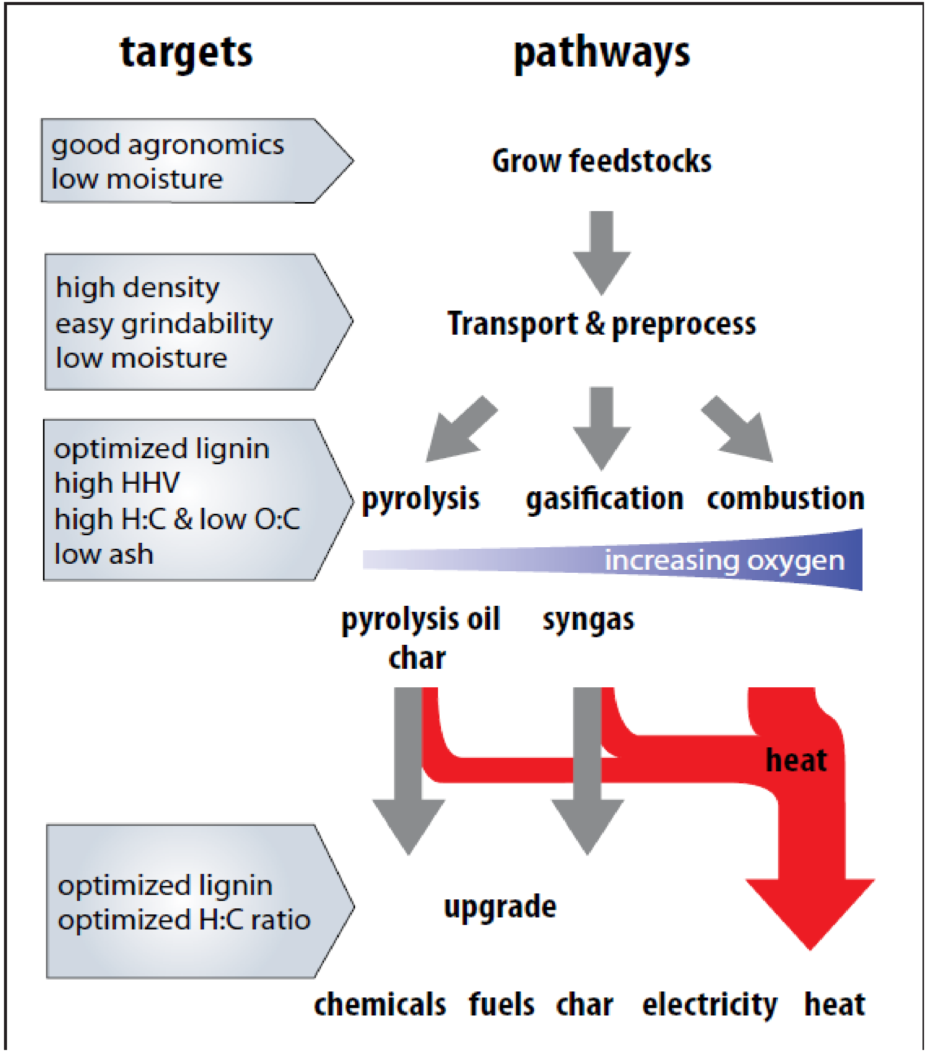
Overview of the steps involved in growing, transporting, processing, and converting biomass into thermochemical energy products



# Use of woody plants conversion methods to energy

- **Burning** and **gasification** are the more common methods of conversion of woody plants these days.

- **Pyrolysis** is not so widely used.

- The preparation and use of biomass for **combustion** has been discussed in previous reports, so we will discuss **gasification** in more detail.

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# THE EXPERIMENTAL STUDY OF THE EFFICIENCY OF THE GASIFICATION PROCESS OF FAST-GROWING WILLOW BIOMASS

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# MATERIALS AND METHODS

- The purpose of the research is to study the features of energy conversion of a fast-growing willow *Salix Viminalis* biomass by means of a small size downdraft gasifier.
- Two experimental plants were used for this purpose. The influence of fuel fraction sizes and the reduction zone parameters of a gasifier on the quality of the received generator gas was studied.
- The diameter of a reduction zone equalled 200 mm, and the height (the working length) of the reduction zone could change from 40 to 160 mm.
- The height to diameter ratio H/D was chosen as a parameter of a reduction zone (Table 1).

Table 1. The reduction zone characteristics

| **The reduction zone height *H*, mm** | **The reduction zone diameter *D*, mm** | ***H*/*D*, mm/mm** |
|---|---|---|
| 40 | 200 | 0.2 |
| 100 | 200 | 0.5 |
| 160 | 200 | 0.8 |

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# MATERIALS AND METHODS

The influence of fuel fraction sizes and the reduction zone parameters of a gasifier on the quality of the received generator gas was studied on the first plant.

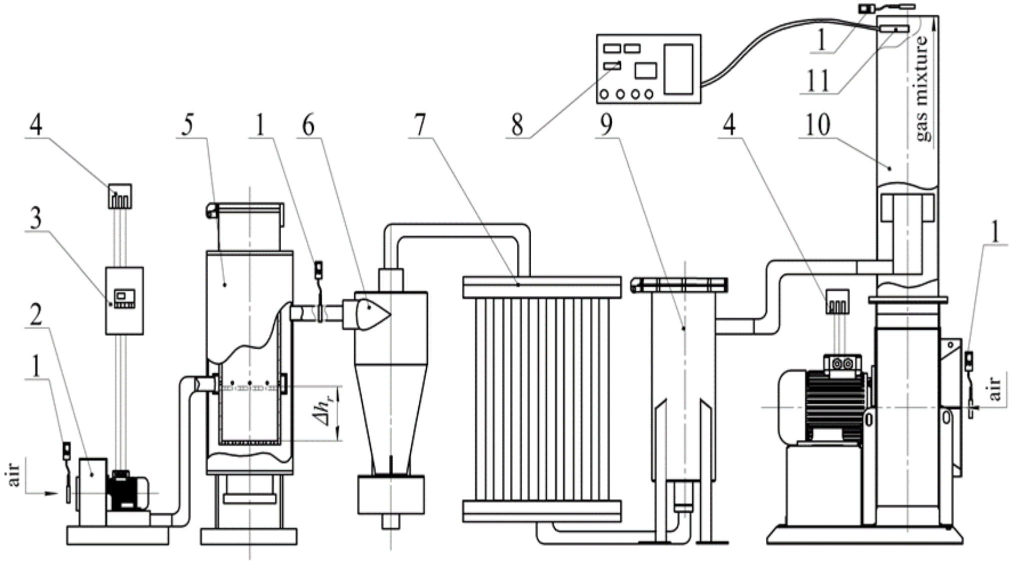


*Figure 1*. Scheme of a plant number 1 for conducting a research: 1 – an anemometer, 2 – an air blower (an oxidant blower), 3 – a frequency converter, 4 – an electric power source, 5 – a downdraft gasifier, 6 – an intermediate purification filter, 7 – a cooler, 8 – a chemical analyzer of gas content, 9 – a filter for a final gas purification, 10 – a mixer, 11 – an analyzer sensor 8

# MATERIALS AND METHODS

In the research a fuel biomass of a fast-growing willow *Salix Viminalis* was devided into four fractions according to the geometrical sizes (Fig. 2). The fuel pellets that were made of a ground biomass of a fast-growing willow were used as well.


*Figure 2*. Fractional composition of the fuel from the biomass of a fast-growing willow Salix Viminalis:
1 – a large fraction, 2 – a medium fraction, 3 – a small fraction, 4 – a very small fraction, 5 – fuel pellets

# MATERIALS AND METHODS

The second experimental plant was built on the basis of a downdraft gasifier. The height of the reduction zone of a generator equalled 110 mm (H/D=0.55). The fuel with fraction №3 was loaded into a gasifier.

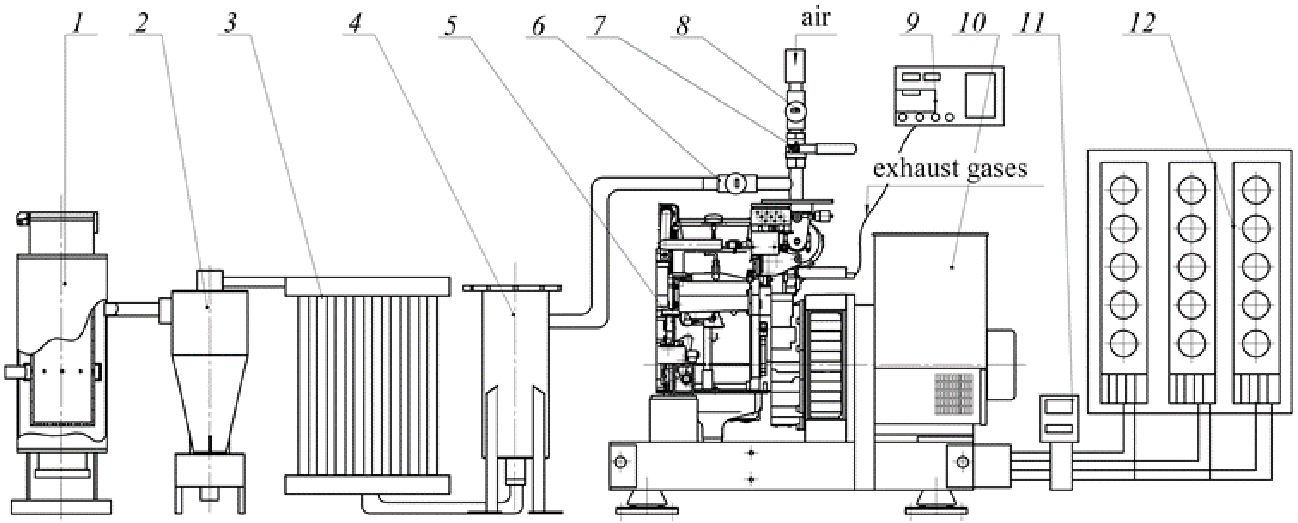


*Figure 3*. Scheme of a plant number 2 for conducting a research: 1 – a downdraft gasifier; 2 – a filter for intermediate gas purification; 3 – a refrigerator; 4 – a filter for a final gas purification; 5 – an internal combustion engine; 6 – a gas meter; 7 –a mixer for regulating the air supply into the engine; 8 – an air meter; 9 – an analyzer of the chemical composition of exhaust gases; 10 – an electric generator; 11 – wattmeter; 12 – a stand electrical load consumer

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# RESULTS AND DISCUSSION

As a result of the data analysis of the experimental studies of the gasification process of a fast-growing willow Salix Viminalis was received an empirical equation (1) that describes the dynamics of change in CO concentration depending on the sizes of fuel fractions and on the geometric sizes of the reduction zone:

$$C_{CO} = -18.27 + 80.80\frac{H}{D} + 53.61SVR - 59.03\left(\frac{H}{D}\right)^2 - 21.02\frac{H}{D}SVR - 31.34SVR^2 \qquad (1)$$

where: $C_{CO}$ – the concentration of carbon monoxide ($CO$), %;

$H/D$ – the height to the reduction zone diameter ratio, mm/mm;

$SVR$ – the ratio of the full side area to the volume of a fuel fraction, $mm^{-1}$.

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# RESULTS AND DISCUSSION

Visually the equation (1) can be shown in graphs (Figure 4-6).

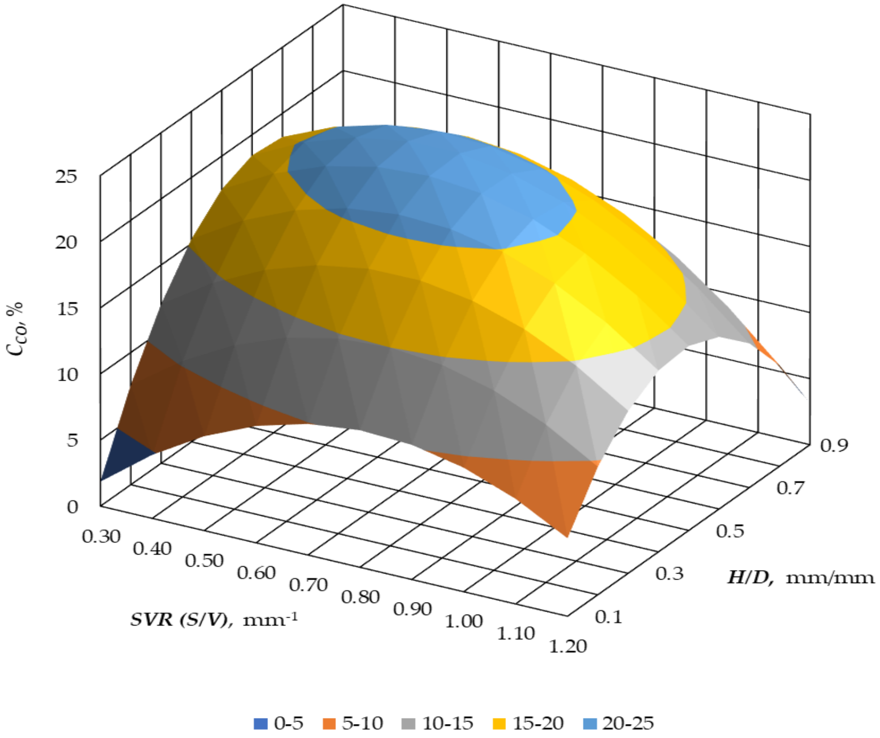


Figure 4. Graphic image of the dependence of CO concentration in the received gas on the ratio indicators of height to the reduction zone diameter (H/D) and on the ratio of the full side area (S) to the volume (V) of a fuel fraction (SVR)

# RESULTS AND DISCUSSION

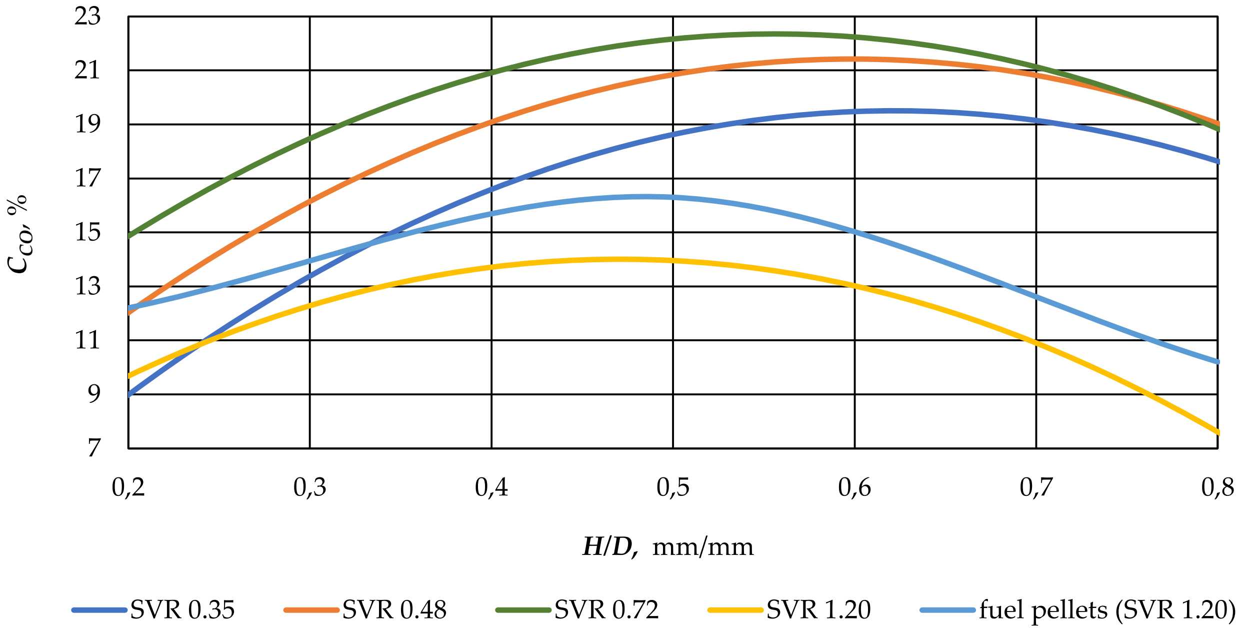


Figure 5. Graphic image of the dependence of CO concentration in the received gas on the ratio indicators of height to the reduction zone diameter (H/D)

# RESULTS AND DISCUSSION

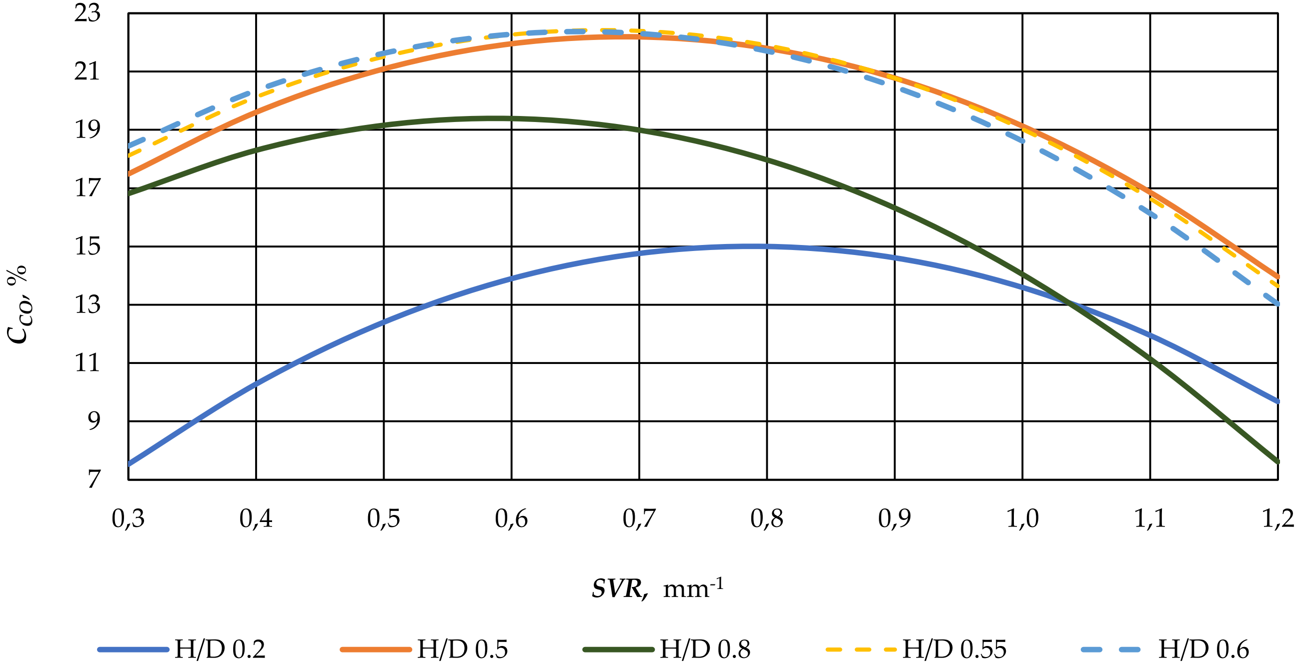


Figure 6. Graphic image of the dependence of CO concentration in the received gas on the ratio of the full side area (S) to the volume (V) of a fuel fraction (SVR)

# RESULTS AND DISCUSSION

- The analytical study of the graphs (Figure 4-6) show, that the maximal CO concentration in gas equals 22.2…22.3%. The maximal CO concentration is observed when using a small fuel fraction SRV – 0.7…0.72 $mm^{-1}$ and when keeping to the ratio of height to reduction zone diameter H/D at the level of 0.5…0.6. Such a ratio for a given experimental gasifier is achieved when the reduction zone height is within 100 mm - 120 mm.

- When the reduction zone height is more than 120 mm the resistance for the air flow (oxidizer) rises and it results in gas quality deterioration (CO concentration decreases). If the reduction zone height is less than 100 mm the CO concentration decreases as well, it can be explained by the fact that under a low height of a reduction zone the producer gas does not pass in full.

- Due to the decrease of the fuel fraction the intensity of gas formation increases and the process of gas renewal improves. But when the fuel fraction is very small there is a significant increase in the resistance for the air flow and, as a result, the process of gas formation slows down and its quality deteriorates.

# RESULTS AND DISCUSSION

- The authors also studied the efficiency of using the gas received in the process of gasification of the fast-growing willow biomass for the work of small-scale gasoline generators.
- The analysis of the results and their comparison with the previous results of the authors' research is given in Figures 7-8.

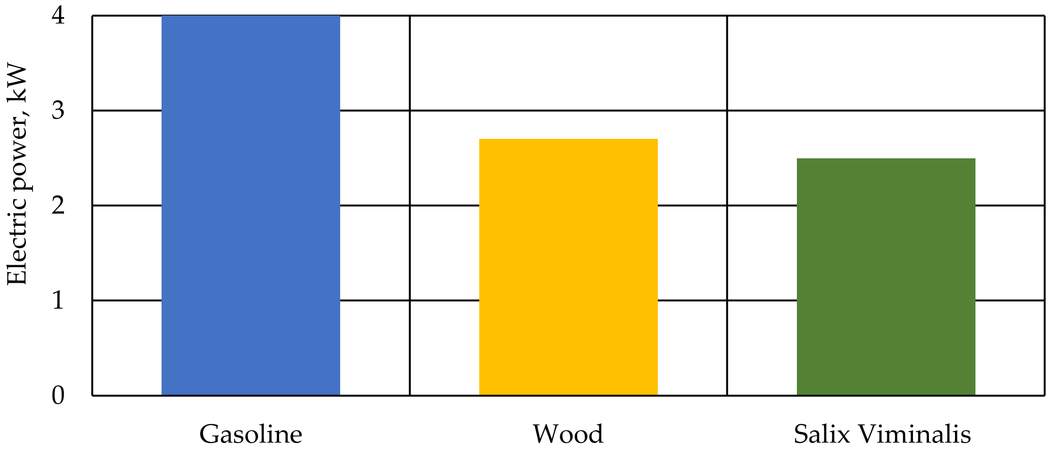


Figure 7. Power generator capacity

Determined maximal electric power when using the gas received from the fast-growing willow biomass equalled 2.4 kW.

# RESULTS AND DISCUSSION

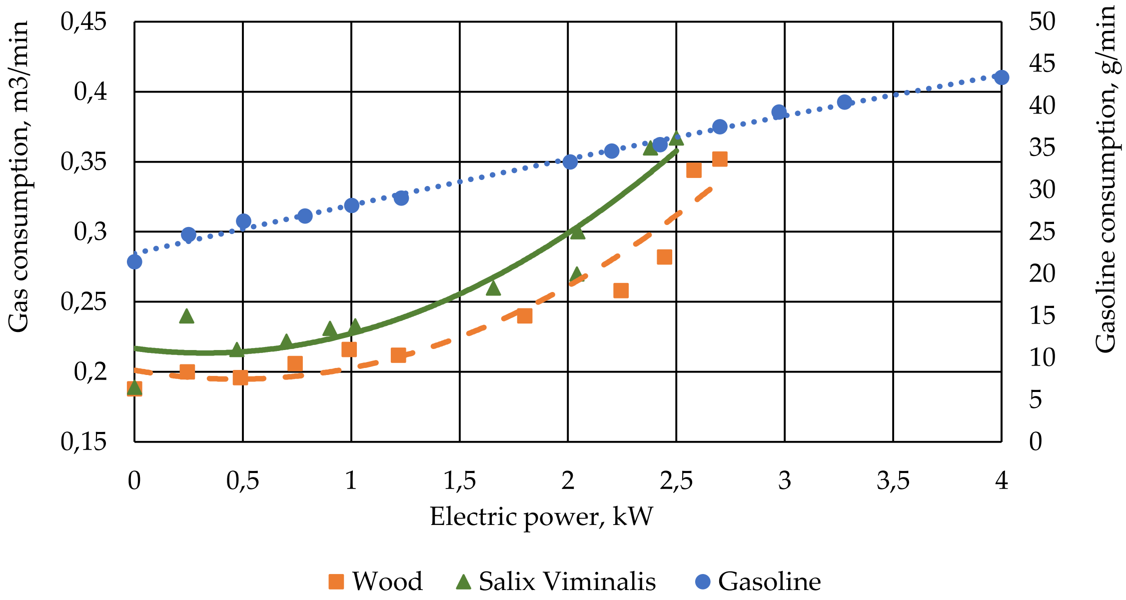


Figure 8. Fuel consumption

The consumption of the gas that was received from a fast-growing willow was somewhat higher (by 6.7% on the average) as compared with the consumption of the gas received from the hard woods biomass (Figure 8).

# Problems arising from harvesting and using the biomass of fast-growing plants for various purposes:

- Usually fast-growing plants are not harvested in time and overgrow;
- Than they are harvested as forest timber;
- After the plants are overgrown, it is difficult to prepare and use the soil for recultivation;
- In Lithuania, many energy and forest plantations grow in wetlands, which causes problems to harvest and manage them.

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# FORWARDER 2020
# SUSTAINABLE AND SMART LOGGING

## *WORK IN WETLANDS*

# WP 6 report:
# Field test results in LT

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# FORWARDER 2020

## SUSTAINABLE AND SMART LOGGING

# Objectives of the task

- Evaluation of the prototype and how it meets the requirements of the market and stakeholders;

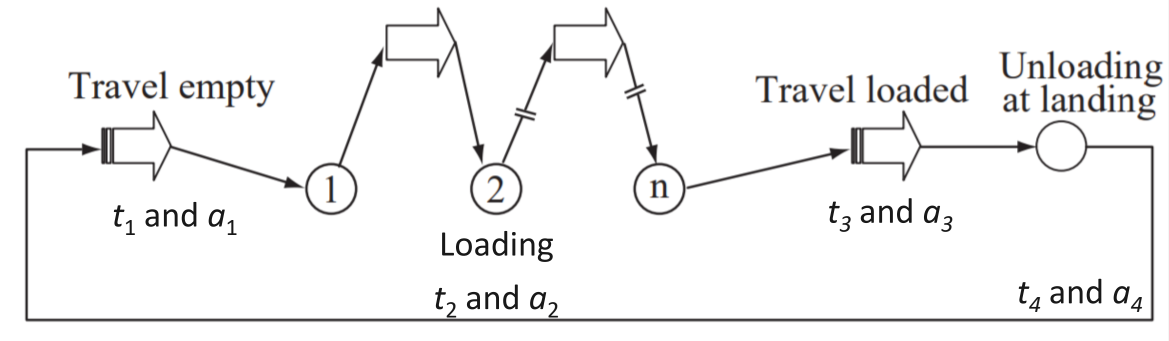
- Forwarder triple axle bogie field tests in wetlands

- Field test of the Proto 2 in Lithuania
  - Evaluation of driver comfort (whole body vibration measurements);
- Demonstration event in Lithuania;

# PROTO 2 with triple Bogie and tracks under Lithuanian conditions

FORWARDER 2020 SUSTAINABLE AND SMART LOGGING

# Typical operations for the evaluation of A(8)



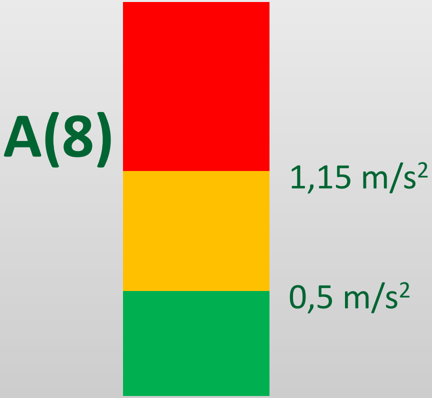

Seat pad accelerometer

*Tiernan et al., 2004*

# Eight hour A(8) calculations

Exposure values according to EU Directive

2002/44/EC




$$A(8) = \sqrt{\frac{1}{T_0}\sum_{i=1}^{n} a_{wv,i}^2 \times T_i} \;, m/s^2$$

**where**:

$T_0$ – reference duration of 8 hours work-shift, s;

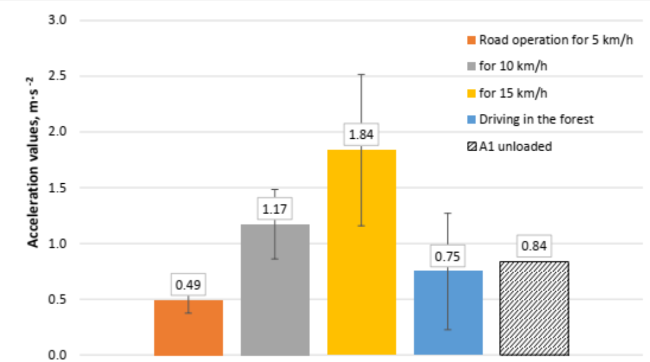
$n$ – number of periods or number of tasks per day.

$a_{wv,i}$ – total (v) weighted (w) acceleration value at $i^{th}$ task or time period, $m \cdot s^2$;

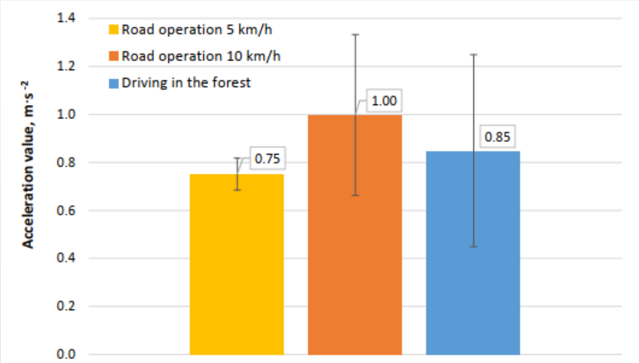
$T_i$ – duration of $i^{th}$ period, s;

# Whole body vibration results

## Measured vibration acceleration values of unloaded travel

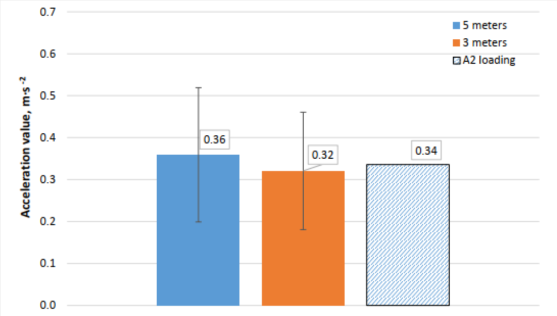



Without tracks

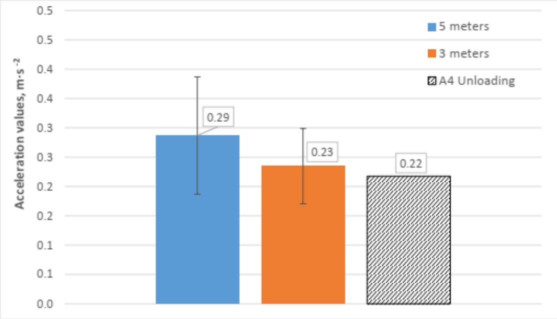



With tracks

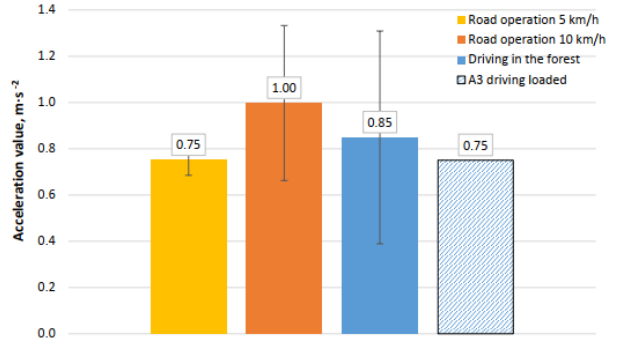
# Whole body vibration results




Vibration acceleration of loading




Vibration acceleration of unloading



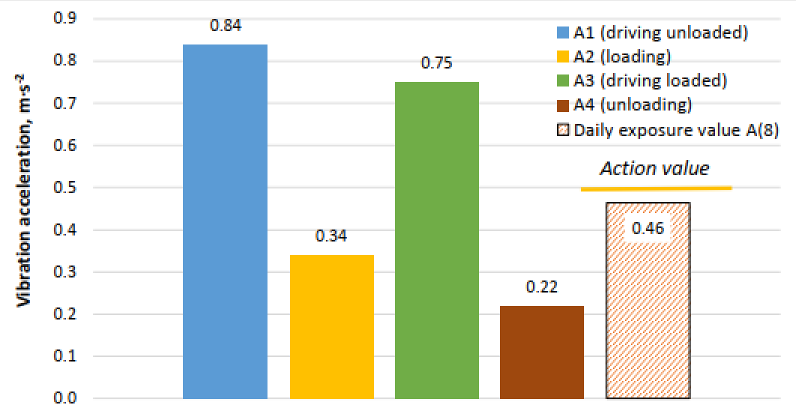

Vibration acceleration of loaded travel



*EU Direktyvq 2002/44/EC*

# Whole body vibration A(8) calculations

FORWARDER 2020 SUSTAINABLE AND SMART LOGGING

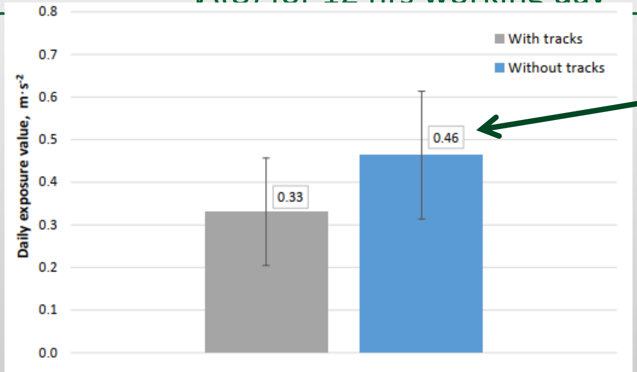



Vibration acceleration values for typical operations of the forwarding cycle and daily vibration exposure

*EU Direktyvq 2002/44/EC*

# Work cycle analysis and calculation

| | Time percentage | Time per 8 hrs, min | Time per 12 hrs, min | $a_{wv}$ |
|---|---|---|---|---|
| Empty transport | 8 | 38,4 | 57,6 | 0,84 |
| Loading | 65 | 312 | 468 | 0,34 |
| Loaded transport | 9 | 43,2 | 64,8 | 0,75 |
| Unloading | 18 | 86,4 | 129,6 | 0,22 |
| | | A(8) for 8 hrs working day | | **0,46** |
| | | A(8) for 12 hrs working day | | **0,63** |



# PROJECT SUMMARY

- Within the project innovations for more efficient forwarders, essential wood extraction and transportation vehicles, were developed and tested in real conditions.
- There were improved efficiency of the machine, reducing the fuel consumption and minimizing the impact on the environment and on the operators' health.
- The Forwarder2020 partners gathered their expertise to advance diverse technologies, which contributed to smart and sustainable logging operations using innovative forestry machines.

# Thank you for your attention!