LITHUANIAN ENERGY INSTITUTE
http://www.lei.lt

NATIONAL OPEN ACCESS SCIENTIFIC CENTRE FOR FUTURE ENERGY TECHNOLOGIES

OPEN R & D LITHUANIA

EVALUATION OF EMISSION FACTORS FOR AIR POLLUTANTS FROM BIOMASS COMBUSTION IN LITHUANIA

Inga KONSTANTINAVIČIŪTĖ,
N. STRIUGAS, M. SADECKAS, T. VONŽODAS, N. PEDIŠIUS
Lithuanian energy institute

S. BYČENKIENĖ, K. PLAUŠKAITĖ-ŠUKIENĖ
Center for Physical Sciences and Technology

1st IAEE Online Conference, 7th – 9th June 2021

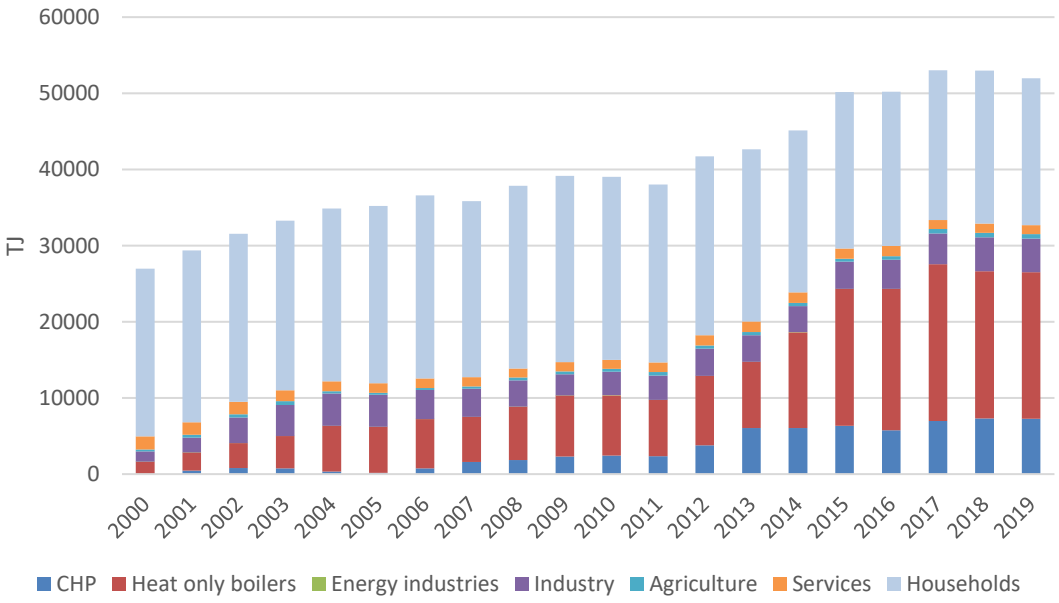
Overview

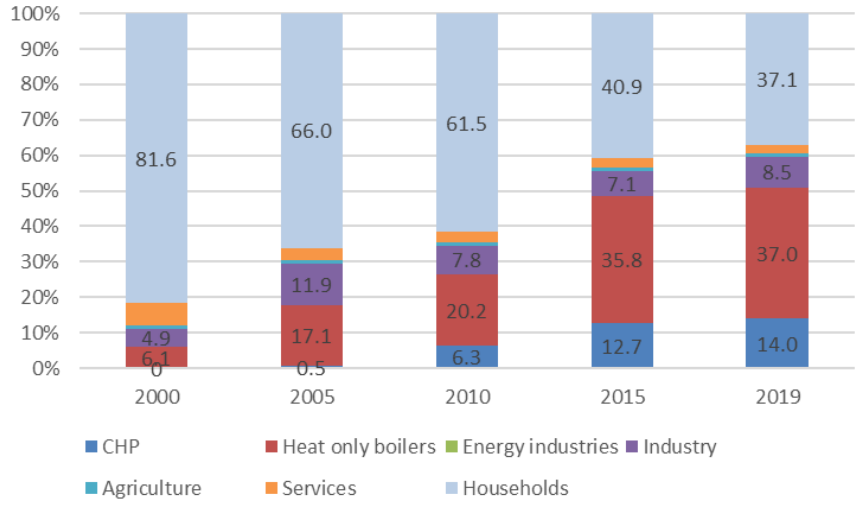
- **Air pollution** is closely linked to climate change – the main driver of climate change is fossil fuel combustion which is also a major contributor to air pollution.
- The United Nations Economic Commission member states signed **the Convention on Long-range Transboundary Air Pollution (CLRTAP)** to improve air quality.
- In compliance with the CLRTAP Lithuania each year provides **a national inventory of air pollutant emissions** according to the relevant source categories.
- After the detailed review of the National inventories for 2017, experts from the European Commission recommended **to use the country specific EFs** for the estimation of air pollutant emissions in the energy sector.
- In order to ensure the reliability and accuracy of data, it was necessary to assess **country specific EFs** according to the fuel type and technology in the energy sector.

The main aim of the study

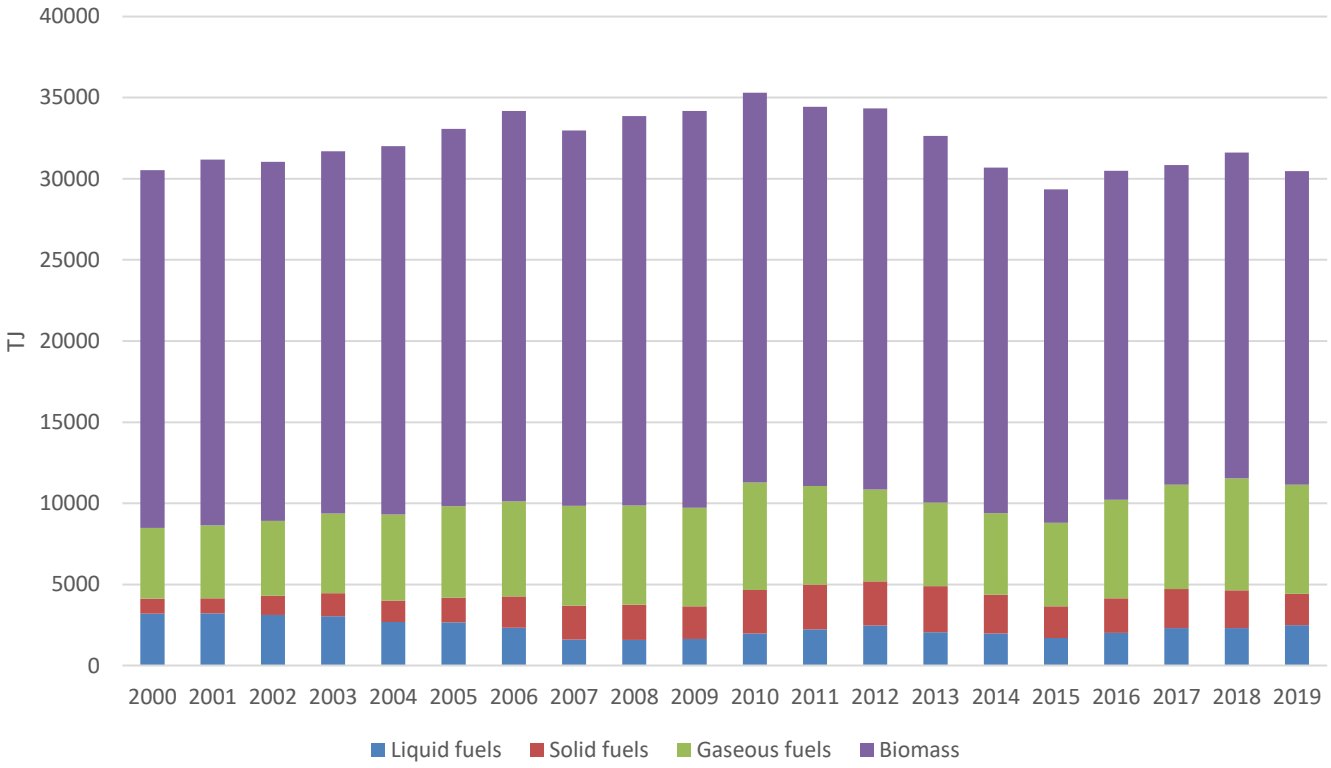
- This study focused **on biomass combustion** as biomass are widely used in all Lithuanian economy sectors, especially in residential sector.
- **The main aim:** to estimate country specific EFs of CO, SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$ from biomass burning in various economic sectors, including residential sector.

Biomass consumption in Lithuania

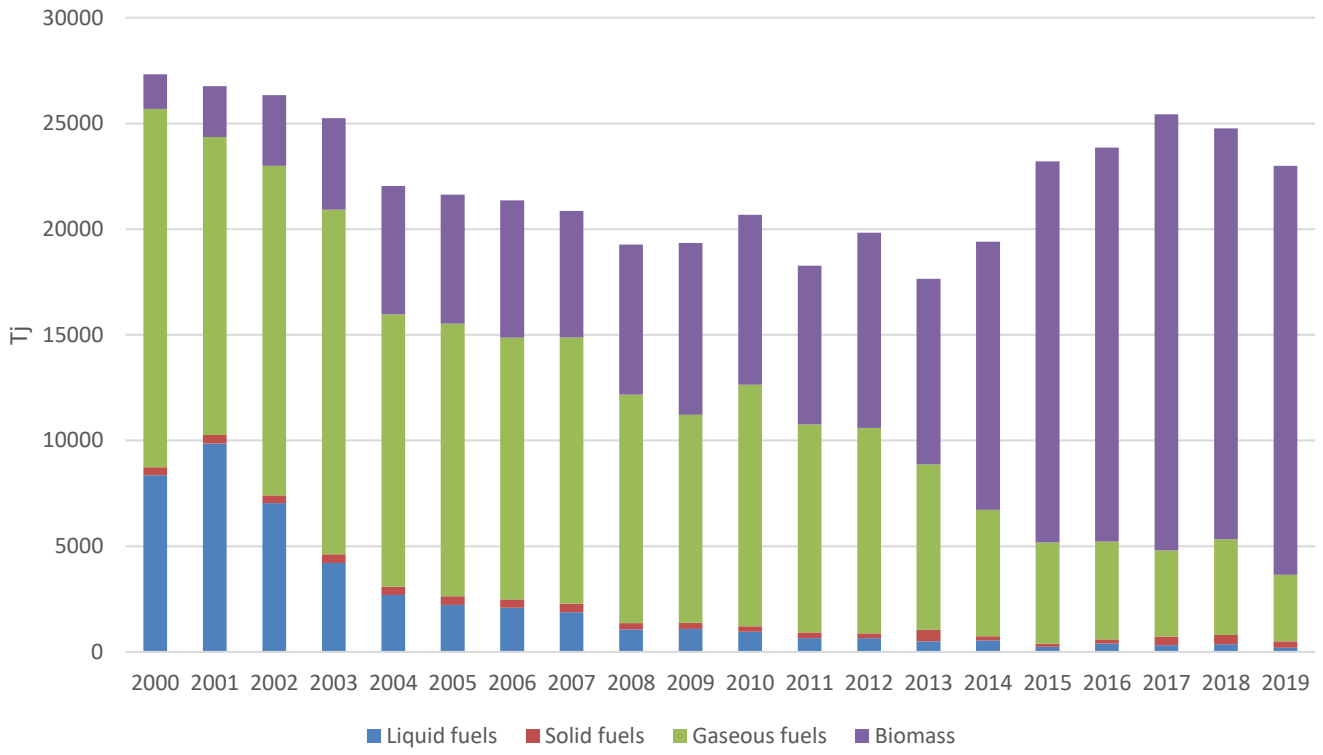




Fuel consumption in residential sector



Fuel consumption in heat only boilers



Measurements

The technologies were **grouped by power** for measurement purposes:

- up to 50 kW,
- 50 kW to 1 MW
- 1 MW to 50 MW

Emissions were measured from **26 different biomass technologies** (of which 15 in residential sector).

In **residential** sector emissions were measured in different types of biomass heating equipment:

- automatic stoves,
- manual stoves,
- fireplaces.

Equipment used for measurements

The concentration of air pollutants was measured by:

- Portable gas analyser - Testo 350 XL
- Combustion product analyser - Gasmet DX 4000
- Absorption tubes
- Gas chromatograph with quadrupole mass spectrometer Agilent 7890A GS
- Automatic particulate matter collector with impactor - TCR Tecora isostatic Basic HV

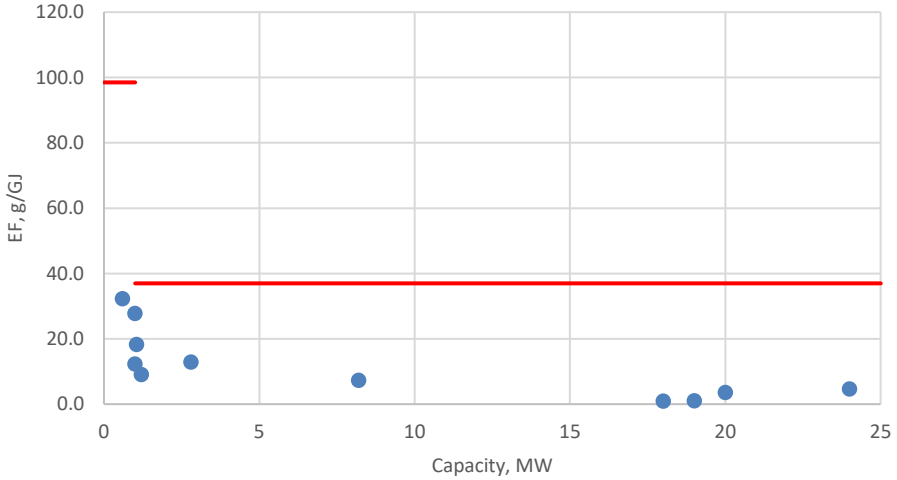
Equipment used for measurements

- Measurements of **CO, SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$** emissions during the combustion process were caried out in various economic sectors, including residential sector.
- A comparative analysis of EFs was performed by combining the results of measurements in all sectors of the economy, i.e. without assessing in which sector the technology is operated (excluding residential sector). Differentiation was performed only according to **the type of fuel and power**.
- All measurements were made **at maximum capacity** of the units.

The methodology for evaluation the EFs

I step. Concentration		
Indicator	Concentration	Volume flow rate
Mark	A	B
Unit	mg/m^3	Nm^3/h
II step. Fuel data		
Indicator	Heating value	Fuel consumption
Mark	C	D
Unit	MJ/kg	kg/h
III step. Air pollutants		
Indicator	Emissions	
Mark	E=A x B	
Unit	mg/h	
IV step. Emission factor		
Indicator	Emission factor	
Mark	$F=E/(CxD)/10^3$	
Unit	g/GJ	

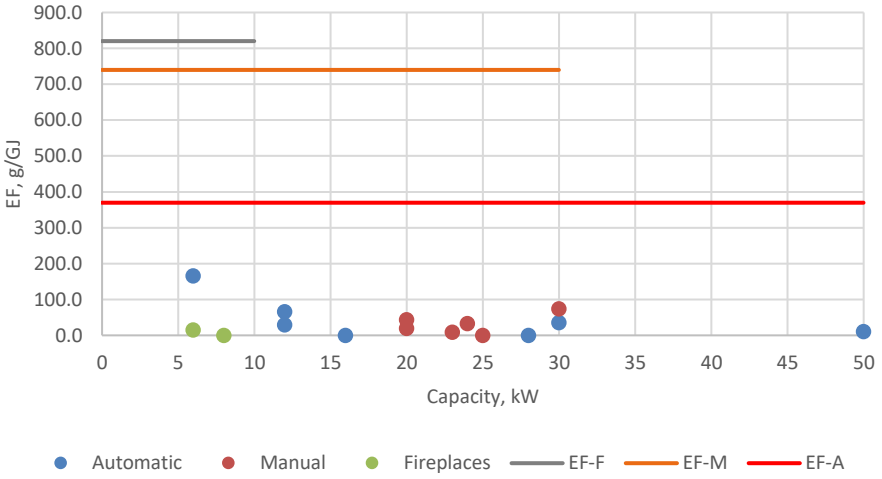
$PM_{2.5}$ EFs for biomass technologies (1-50 MW)



1-50 MW

$PM_{2.5}$ EF for biomass combustion technologies (1-50 MW) varied in a broad range from 1 to 32.3 g/GJ and for residential technologies – 0.1-165.4 g/GJ.

The amount of PM depends on the composition of fuel and ash, the type of technology and its mode of operation. PM can be strongly influenced by many factors related to the specifics of the technology (ash rate, amount, flow rate of combustion products through the fuel bed, etc.).



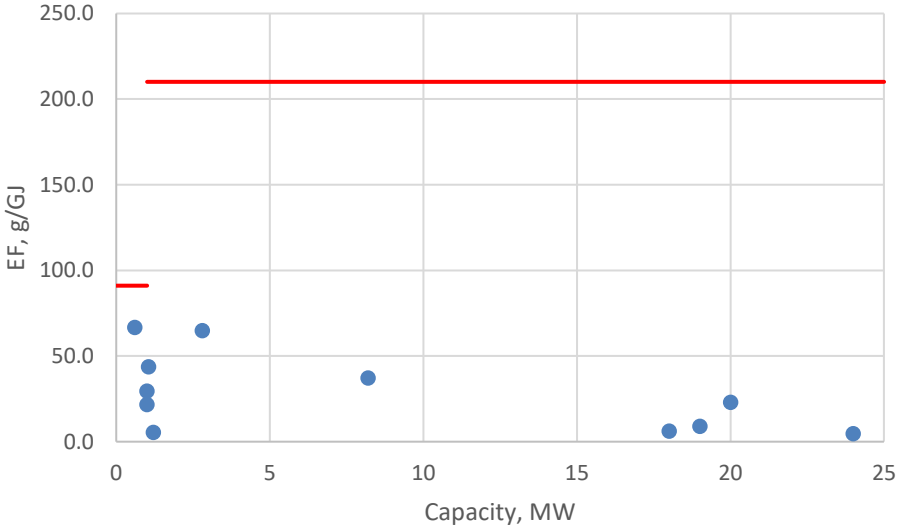
<50 kW

Comparison of determined $PM_{2.5}$ EF with default EF values

Technology	Default EF (EMEP), g/GJ	95% confidence interval (EMEP)		Evaluated EF, g/GJ	95% confidence interval	
		Min	Max		Min	Max
Residential biomass combustion technologies (up to 50 kW)						
Fireplaces	820	410	1640	17.3	13.2	21.3
Manual stoves (<50 kW)	740	370	1480	25.9	8.4	51.1
Automatic stoves (<50 kW)	370	285	740	13.2	3.3	45.7
Biomass combustion technologies (1-50 MW)						
Boilers (50 kW – 1 MW)	98,5	38,5	154	27.7	4.2	39.7
Boilers (1 - 25 MW)	37	18	74	5.9	3.0	11.4

The evaluation of country specific EFs were based on median which better than average reveals the position of the data in the row containing the exclusions.

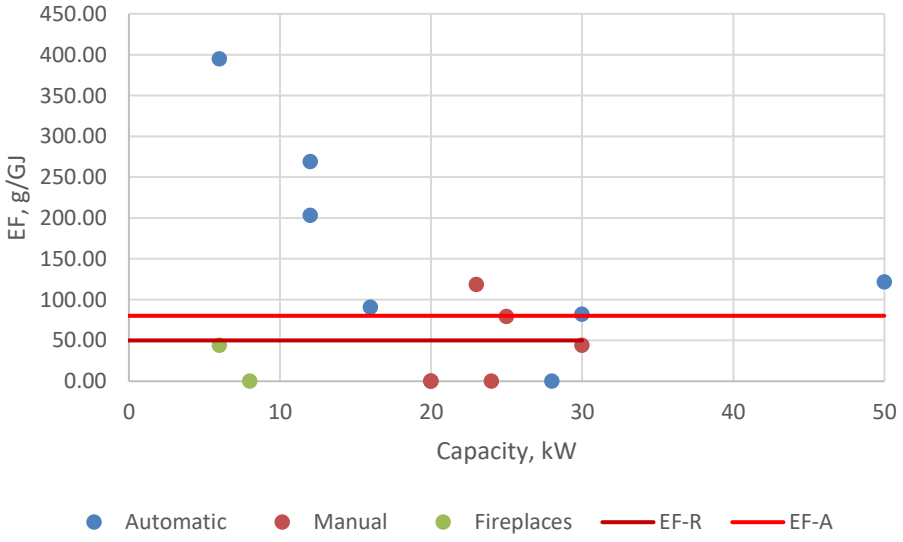
NOx EFs for biomass combustion technologies



1-50 MW

NOx EF for biomass combustion technologies (1-50 MW) varied from 4.6 to 66.7 g/GJ and for residential technologies – 0.01-394.7 g/GJ.

NOx EF depends on the type of fuel used and the quality of the combustion process. To improve the combustion process, a new type of burners is used, with a specific function of fuel and air gradation and internal recirculation of combustion products.
One of the simpler and cheaper means used in practice is smoke recirculation. The use of smoke recirculation can reduce the NOx concentration up to 30%.

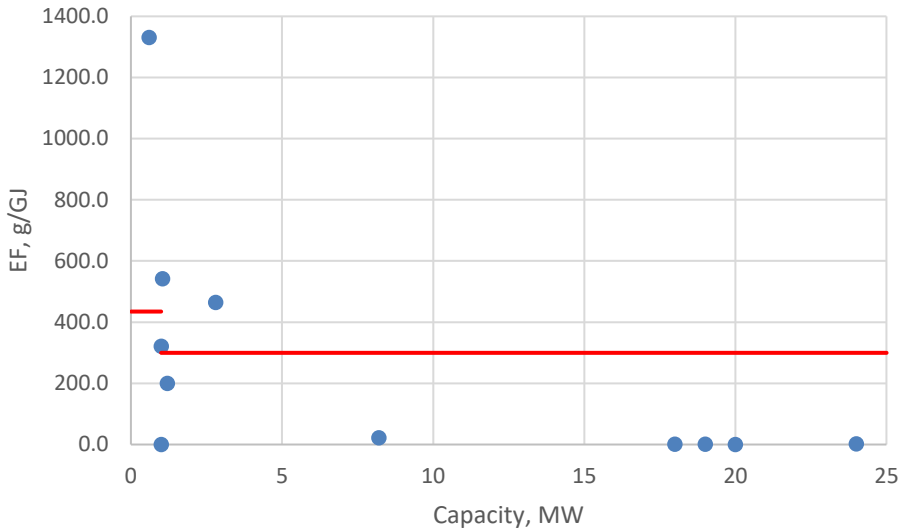


<50 kW

Comparison of determined NOx EF with default EF values

Technology	Default EF (EMEP), g/GJ	95% confidence interval (EMEP)		Evaluated EF, g/GJ	95% confidence interval	
		Min	Max		Min	Max
Residential biomass combustion technologies (up to 50 kW)						
Fireplaces	50	30	150	38.9	29.2	48.6
Manual stoves (<50 kW)	50	30	150	37.4	13.9	83.1
Automatic stoves (<50 kW)	80	30	150	81.8	39.1	123.3
Biomass combustion technologies (1-50 MW)						
Boilers (50 kW – 1 MW)	91	20	120	29.6	12.2	66.6
Boilers (1 - 25 MW)	210	50	300	16.0	8.8	39.8

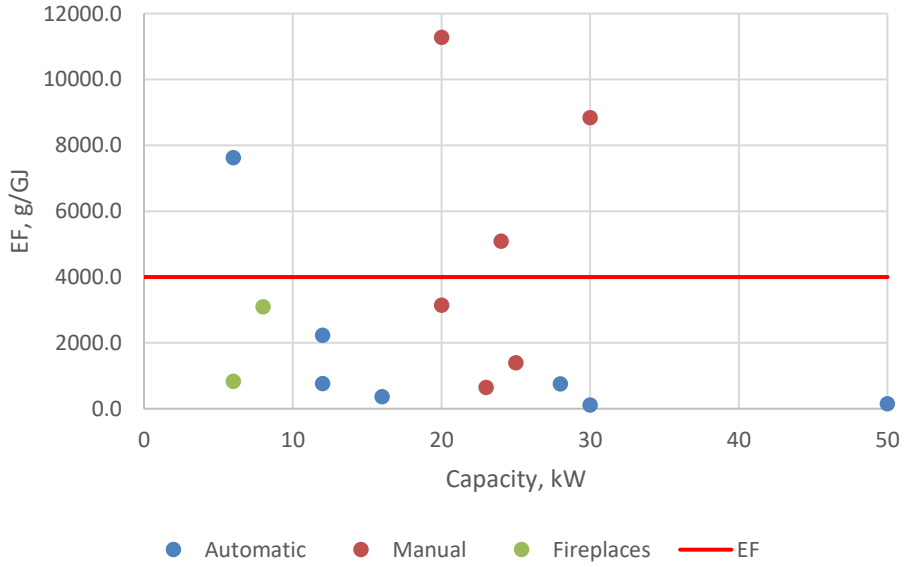
CO EFs for biomass combustion technologies



1-50 MW

CO EF for biomass combustion technologies (1-50 MW) varied from 0.1 to 1331 g/GJ and for residential technologies – 120-11280 g/GJ.

The comparative analysis showed very outstanding value of CO EF measured in 0.6 MW boiler.
The values of CO EFs determined in other boilers are significantly lower than the default values.
Measurement results showed extremely low emissions if full combustion of biomass have been ensured.

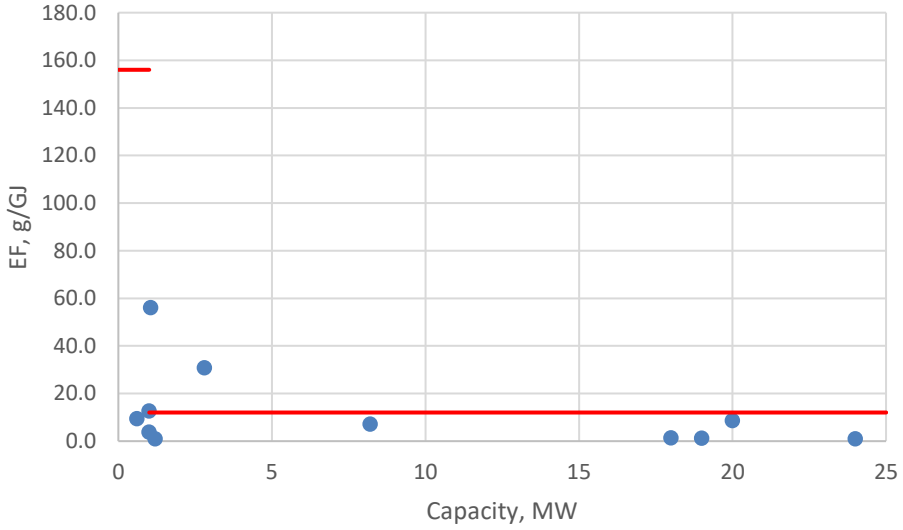


<50 kW

Comparison of determined CO EF with default EF values

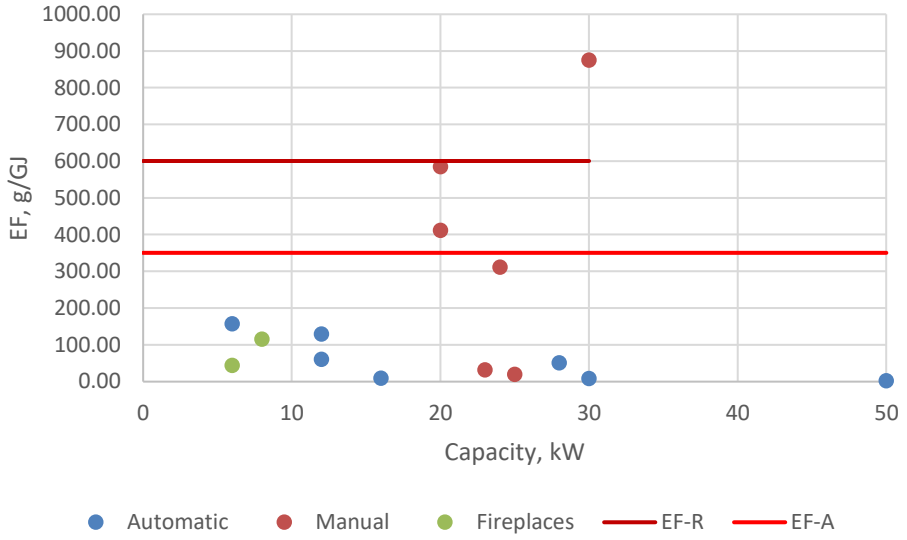
Technology	Default EF (EMEP), g/GJ	95% confidence interval (EMEP)		Evaluated EF, g/GJ	95% confidence interval	
		Min	Max		Min	Max
Residential biomass combustion technologies (up to 50 kW)						
Fireplaces	4000	1000	10000	1970.6	116.0	3823.9
Manual stoves (<50 kW)	4000	1000	10000	4120.1	1686.4	8455.6
Automatic stoves (<50 kW)	4000	1000	10000	370.3	133.0	1727.1
Biomass combustion technologies (1-50 MW)						
Boilers (50 kW – 1 MW)	435	5	4000	320.8	37.0	1064.6
Boilers (1 - 25 MW)	300	50	4000	11.6	-	311.3

NMVOC EFs for biomass combustion technologies



1-50 MW

NMVOC EF for biomass combustion technologies (1-50 MW) varied from 0.9 to 56 g/GJ and for residential technologies – 2.4-875.2 g/GJ.



<50 kW

Comparison of determined CO EF with default EF values

Technology	Default EF (EMEP), g/GJ	95% confidence interval (EMEP)		Evaluated EF, g/GJ	95% confidence interval	
		Min	Max		Min	Max
Residential biomass combustion technologies (up to 50 kW)						
Fireplaces	600	20	3000	79.8	11.9	147.7
Manual stoves (<50 kW)	600	20	3000	361.5	108.4	636.4
Automatic stoves (<50 kW)	350	100	2000	27.9	12.0	55.0
Biomass combustion technologies (1-50 MW)						
Boilers (50 kW – 1 MW)	156	5	400	7.1	1.9	15.3
Boilers (1 - 25 MW)	12	5	300	4.2	-	27.2

Conclusions

- Obtained research results will **reduce uncertainties** of air pollution emissions data and increase accounting reliability.
- Air pollutants emissions depend on the fuel type, on the boiler operating mode, on the optimization of combustion process and other technical features therefore evaluation of **country-specific EFs will ensure more accurate accounting of national emissions.**
- Performed analysis showed that boilers have extremely low $PM_{2.5}$ emissions when complete biomass combustion is ensured.
- Biomass boilers (>10 MW) **with installed condensing economizers** behind multicyclones ensure very high suspended particles (including $PM_{2.5}$) **emissions reduction efficiency** (up to 99%).
- Measurements showed that **modern residential biomass boilers** (<50 kW) has low $PM_{2.5}$ emissions, in particular boilers with flexible control of fuel and air supply.

LITHUANIAN ENERGY INSTITUTE
http://www.lei.lt

NATIONAL OPEN ACCESS SCIENTIFIC CENTRE FOR FUTURE ENERGY TECHNOLOGIES

OPEN R & D LITHUANIA

Thank you for the attention

Inga Konstantinavičiūtė

E-mail: inga.konstantinaviciute@lei.lt