Challenges and Issues of Modern Science, 3 (2024). ISSN: 3083-5704
URL: https://cims.fti.dp.ua/j/article/view/199
PURL: https://purl.org/cims/2403.035

Assessment of air pollutants when burning alternative fuels

Olena Levytska, Artem Sikorsky

Purpose. The aim of the work is to identify potential agricultural waste that can become energy sources, which will significantly reduce the cost of the operation of small and medium-sized boilers and provide cost savings for small and medium-sized businesses. **Design / Method / Approach.** An analytical review of scientific articles, information from Internet resources is carried out in order to determine the most common and suitable for the purposes of energy production using agricultural waste, as well as the experience of enterprises in the production of alternative fuels is analyzed. **Findings.** The analysis of information sources has shown that wood waste, straw, flax fescue, sunflower husks can be attributed to secondary raw materials that can be used as an energy resource. Technologies for obtaining briquettes and pellets are applicable to such waste and can be used for the operation of low- and medium-sized boiler units. The calculations carried out by the researchers show that emissions from the incineration of the industrial gases such as processed coke-oven and blast-furnace gases and also solid waste are comparable and for a number of chemicals are less than during the combustion of popular fuel oils. **Theoretical Implications**. Assessment of pollutant emissions from the combustion of different types of fuels will show the level of environmental impact and stimulate the scientific search for the most optimal and environmentally friendly fuels. **Practical Implications.** The studies conducted by the authors stimulate the choice of alternative energy sources, which is an economically profitable and environmentally sound action. **Originality / Value.** The comparative characteristics of alternative and traditional fuels are relevant due to the exhaustibility of traditional fuels. In addition, the use of waste as an energy resource leads to the abolition or reduction of costs associated with waste management and eliminates the cost of money for the extraction of energy resources. **Research Limitations / Future Research.** In the future, it is planned to expand the range of alternative energy sources and analyze emissions from their combustion. Of course, an important stage of the research will be the comparison of emissions from the combustion of the studied fuels and traditionally used in the energy industry fuels. **Paper Type.** Practitioner Paper.

Keywords:

agricultural waste, alternative energy sources, secondary raw materials, air pollutants

Contributor Details:

Olena Levytska, Cand.Sc., Assoc.Prof., Oles Honchar Dnipro National University: Dnipro, UA, LLevi@ukr.net

Artem Sikorsky, Undergraduate student, Oles Honchar Dnipro National University: Dnipro, UA, sikorskiy707@gmail.com

Energy sources can be classified into two main types: traditional and alternative. The former includes minerals such as gas, oil, and coal, while the latter often includes resources such as sun, water, and wind. The main difference between the two is renewability in nature: traditional sources are exhaustive, while alternative ones are infinite. Also today, alternative sources include by-products and waste from industrial and craft production.

The benefits of using resource-efficient technologies are recalled in the article (Trus et al., 2024). Articles (Alonso-Almeida et al., 2016; García-Pozo et al., 2015; García-Pozo et al., 2016) talks about using of materials including energy and surface area per unit output. Combustion products of traditional and alternative fuels (oxides of carbon, nitrogen, sulfur compounds, methane, etc.) significantly affect the quality of atmospheric air (Levytska, 2024).

In article (Levytska et al., 2021) air pollutants were assessed when burning natural and industrial gases. Thuswise, interdisciplinary international consortium of research centre (ArcelorMittal Global R&D Asturias and Maizières, Centro Sviluppo Materiali, Swerea MEFOS, VDEh-Betriegsits) has successfully implemented project aimed at expanding the use of blast-furnace gas in steel-making furnaces (V. Cuervo-Piñera et al., 2017).

Research Question

The most important tasks of the work were the selection of optimal alternative energy sources for the combustion of small and medium-sized boilers, the assessment of emissions in the atmosphere during the combustion of alternative fires and the assessment of the environmental impact of alternative fires.

Blast-furnace and coke-oven gases are obtained as co-products in metallurgical and cake and by-product processes. Synthesis of these gases is not accompanied by waste generation and exploitation of soil ecosystems. In Ukraine, vacuum-carbonate, arsenic-soda and mono-ethanolamine purification methods, integrated purification of coke-oven gas from hydrogen sulphide and ammonia with ammonia decompounding using high-efficient catalysts have been developed. Wood waste is often used for the operation of the industrial boilers. We are talking about waste from wood processing and furniture production workshops, used wooden containers. With proper drying, the raw material has sufficient thermal characteristics, does not contain extremely hazardous substances in its composition.

Straw is one of the most efficient fuels, used in significant quantities in Denmark. Depending on weather conditions, it can contain up to 20% water, which evaporates during drying or during combustion. Depending on the fertilizers applied, straw can be a source of nitrogen and sulfur. If there are other impurities (compounds of sodium, heavy metals, etc.), from the point of view of environmental safety, it is better not to use the material as fuel.

Flax fescue - woody parts of the stems of spinning plants (flax, hemp, kenaf, etc.) obtained from the trust during its primary processing can also serve as a source of energy. Due to its high energy efficiency and low CO_2 emissions, flaxseed fescues can become a powerful resource in the alternative fuel market.

Sunflower husks - waste during oil production, are also being studied as a

possible source of energy. In particular, fuels are made from waste (as well as from wood waste). With its great potential and prevalence in agriculture, sunflower husks can be an affordable alternative.

The choice between alternative and traditional energy sources remains the main debate in global energy policy. The fuels in question - wood waste, straw, flax fescue and sunflower husks - represent only a drop in the boundless ocean of possibilities. Finding a balance between the use of natural resources and the preservation of the environment is becoming a key task for the development of sustainable and renewable energy. A few questions arise in the process of using traditional fuels. The main driving force on the way of searching for alternative energy sources is the fullness of fossil fuels. Also, traditional fuels become powerful sources of pollutant emissions when burned. How do alternative fuels contribute to environmental pollution? Which fuels are more harmful to the environment? We will try to answer these questions.

Methodology

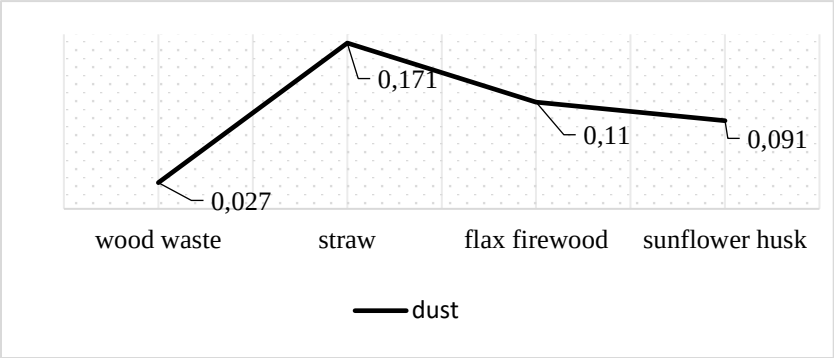
When determining the gross emission of hazardous substances for combustion units, there is used the method of continuous measurements with the application of in-process control devices or as per calculation of the index of hazardous emission. The provided calculations and the introduction of simplified formulas serve as an example for the calculation of emission factors and emissions in assessing the level of safety of existing equipment and can be used in the development of permit documents of enterprises that carry out emissions of harmful substances to the environment. The paper compares emissions of pollutants during the combustion of traditional and alternative fuels.

Discussion and Results

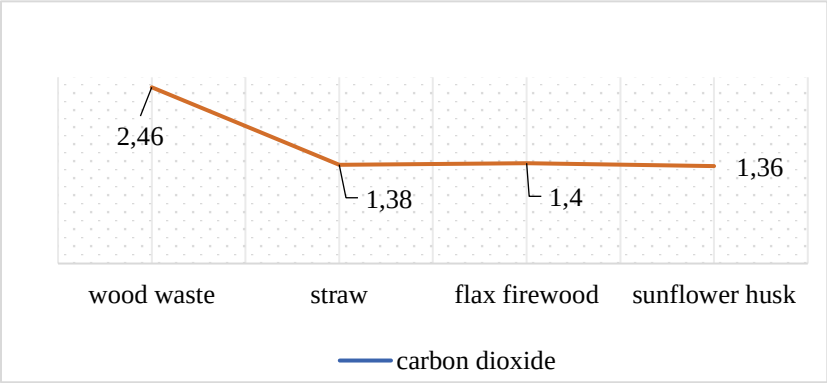
It was shown that the gases used in coke and metallurgical industries, which are used as analogues of natural, are logical to use, but require the installation of treatment systems. The paper defines a formula for calculating the carbon content in natural gas. Coke-oven gas consists of pyrogenic water vapours, coal-tar pitch, methane, hydrogen, carbon oxides and dioxides, nitrogen compounds, ammonia, hydrogen sulphide, ammonocarbonous acid, a large amount of unsaturated aromatic hydrocarbons, naphthaline and other substances.

The value of sulfur-dioxide emission index for blast-furnace gas is higher. But the emission of this pollutant in the process of combustion of blast-furnace gas is significantly lower than the similar emission in the process of combustion of coke-oven gas as a result of much lesser lower wet heating values. Mercury emission indexes and emissions are low. When comparing emissions of the above gases, mercury emissions are substantially lower for the natural gas.

Thus, alternative fuels have both advantages and disadvantages in comparison with natural gas. However, by using purification systems in the processes of obtaining and burning these gases, it is possible to use them for production purposes and premises heating (Fig. 1 a, b, c).



a



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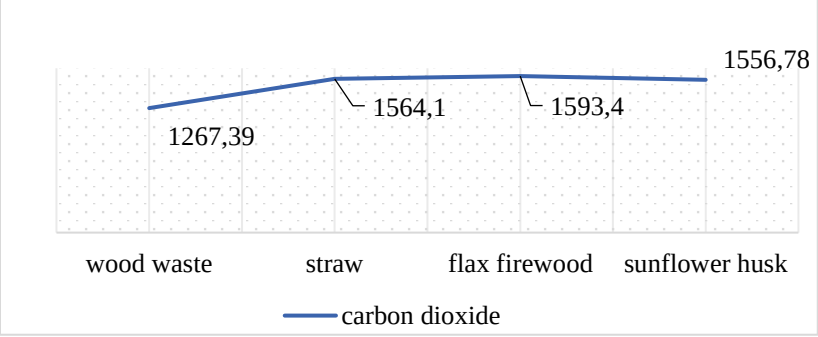

c

Figure 1 – Emissions of: a – dust; b – NOx; c – carbon dioxide (Source: Author)

The paper compares emissions of pollutants during the combustion of solid alternative fuels (Fig. 1 a, b, c).

Dust (suspended solid particles) formed during the combustion of solid fuels are captured by cyclones, the efficiency of which can reach 95.5%–99.8%. Therefore, in the calculations, we will take the average value of the specified range – 98%. When using gaseous fuels, there will be no emissions of these pollutants.

The highest emission rates will be when using straw. A high value of dust emission is typical for straw and flax fescue.

The practice of operation of power equipment shows that nitrogen treatment equipment is practically not used in Ukraine. In terms of nitrogen oxide emissions, wood waste has the highest values.

Emissions from power equipment today are practically not purified from methane and NMVOCs. Therefore, no calculated corrections are made when determining the emission indicators of these compounds. Sulfur dioxide emissions when burning straw will be 2 kg per ton of fuel, when burning sunflower husks – 3.2 kg per ton of fuel.

Slightly lower values for the emission of carbon dioxide, methane, NMVOC are determined for wood waste.

It is important to note that when gaseous fuels are burned, there will be no emissions of suspended particulate matter. It should also be noted that natural gas and wood waste do not contain sulfur-containing compounds, which ensures the absence of sulfur dioxide in flue gases when fuels are burned. However, when gases are burned, mercury compounds can be released in trace amounts.

These calculations add relevant information that will be useful in today's discussions about the exhaustibility and replacement of non-renewable energy sources, the safety of alternative renewable fuels and their advantages in comparison with non-renewable ones.

Conclusions

Solid alternative fuels are rapidly gaining popularity. There are fewer and fewer skeptics on this issue. Countries with leading economies, namely Denmark, Norway, Sweden, have competitive technologies for processing solid waste. The most suitable industry that is becoming an irreplaceable supplier of energy resources is agriculture. Every year, tons of waste after growing grain, harvesting sunflowers, corn, flax are sent to the production of pellets and briquettes.

Woodworking is another resource for obtaining fuel. Eco-friendly wooden log cabins, wood in the interior is becoming popular with consumers around the world. Of course, even the waste from this production produces quality fuel. In addition, attention should be paid to household waste. Overflowing landfills in different parts of the world, sometimes near the ocean coast, can become a quality resource for obtaining biogas. This will solve the problem of emissions of pollutants into the air that are formed after the fermentation of organic waste.

It should be noted that when burning natural gas, there will be no emissions of suspended particulate matter and sulfur dioxide. When natural gas is burned, mercury is present in the emissions in trace amounts. Thus, each type of fuel under

consideration has a negative impact on the environment. Considering the emissions of pollutants during the combustion of the considered types of fuels, it can be noted that among non-renewable fuels, it is natural gas that has advantages over fuel oils. When comparing non-renewable fuels with biomass, the latter is safer from an environmental point of view. With the provision of rational fuel combustion regimes and the reduction of emissions of suspended particulate matter, methane and NMVOC, the prospects for the use of alternative fuels will be indisputable.

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