Application of online training in the education of specialists for the production of second generation biofuels

O V Fedorova¹, E L Akim², A G Kuznetsov² and A A Pekarets³

¹ Departament of Distance Learning Technologies, Saint-Petersburg State University of Industrial Technologies and Design, 4 Ivana Chernykh Street, Saint-Petersburg 198095, Russian Federation
² Pulp and Composites Technology Department, Higher School of Technology and Energy of Saint-Petersburg State University of Industrial Technologies and Design, 4 Ivana Chernykh Street, Saint-Petersburg 198095, Russian Federation
³ LLC «Lesnaya Tekhnologicheskaya Company», 1 Zvezdochka Street, Kachug 666201, Russian Federation

* Corresponding author’s e-mail: odo.gturp@mail.ru

Abstract. In a circular economy, wood is a valuable product, the use of which must be rational. Integrated wood processing includes the use of production waste, for example, when sawing and planning. Raw materials for the production of pellets and fuel briquettes are sawdust, shavings, slabs. The production of second generation fuels is an extension of the life cycle of forestry and woodworking products. The production of pellets made by pressing crushed wood particles has changed the technology of energy use of wood in the ECE region. And, in turn, there was a need for specialists and new jobs.

1. Introduction
Today Russia is one of the world’s leading producers of second-generation biofuels. The second generation biofuel includes fuel made from non-food renewable raw materials such as sawdust, straw, algae. Sawdust is more widely used in the world for the production of solid biofuel pellets and briquettes. In Russia, the production of pellets and briquettes has exceeded 2 million tons per year [1-3].

Along with domestic pellets, pellets are widely used in thermal power plants for the production of "green energy". The general interest in the production and use of biofuels in the world in the 21st century is due to the adoption of the Kyoto and then the Paris agreements, which provide for the reduction of greenhouse gas emissions and, above all, carbon dioxide.

It is believed that a possible global catastrophe can be prevented by two methods of reducing greenhouse gas emissions:
1. changing the structure of the fuel balance of the countries of the world through the transition to less "dirty" technologies (transition from coal combustion to gas combustion, the use of nuclear power plants and hydroelectric power plants, wind energy, etc.),
2. widespread introduction of energy-saving technologies and treatment facilities.

However, it should be noted that both ways to reduce harmful emissions are costly.
The main difficulty is that the market alone cannot solve this problem. This is due to the fact that the benefits of reducing pollution levels are received by the whole society, while the costs of modernizing production must be borne by individual entrepreneurs. Thus, in the conditions of a "clean" market, the fight against pollution is not profitable for an entrepreneur, since it will only bring him losses. Consequently, measures of state and international regulation are needed. Since the airspace is the same for the entire planet, the main role in the fight against atmospheric pollution is assigned by an international agreement within the framework of the Kyoto Protocol.

At the same time, carbon dioxide generated by burning wood is not included in the total quotas for carbon dioxide emissions, because wood during its biosynthesis absorbs it from the atmosphere. As a result, the production of composite materials for energy purposes – wood briquettes and pellets – is one of the most important areas of wood biorefining [4, 5].

A circular economy is an economic system of closed loops, in which raw materials, components and products lose their value as little as possible, renewable energy sources are used, and systems thinking is at the core.

Describing the basic principles of a circular economy in the world, the 3-R scheme is often used.

- Reduce (minimal use of raw materials);
- Reuse (maximum reuse of products and components);
- Recycle (reuse of high quality raw materials).

Circular economy aims to change the classic linear production model by focusing on products and services that minimize waste and other types of pollution.

Also, this type of economy is considered as part of the "Fourth Industrial Revolution", as a result of which the rationality of the use of resources, including natural resources, will generally increase, the economy will become more transparent, predictable, and its development will be rapid and systemic.

Fossil fuels such as coal and oil are the most common sources of energy. However, they belong to non-renewable sources, which means that one day we will exhaust them. Fossil fuels take millions of years to form through various geological processes. Their extraction process is also very expensive. Greenhouse gas (GHG) emissions from fossil fuels are causing global warming. Thus, there is a strong demand for some renewable energy sources that need to be cost effective and environmentally friendly in nature. And one of these sources is biofuels.

Bioprocessing - the processing of biomass into a range of marketable products and bioenergy / biofuels, is an innovative and efficient approach to using available biomass resources for synergistic co-production of energy, heat and biofuels along with food and feed ingredients, pharmaceuticals, chemicals, materials, minerals, etc. [6].

Circular economy is an economy that is regenerative in design and aims to ensure that products, components and materials always remain as useful and useful as possible, distinguishing between technical and biological cycles. The circular economy mainly focuses on the efficient use of scarce resources and ensures that those resources are reused for as long as possible. Bioprocessing is one of the key incentive strategies of the circular economy, which is a closed cycle of raw materials from biomass (reuse of forestry, agricultural, recycling and post-consumption waste), minerals, water and carbon. Thus, bioremediation is the optimal strategy for large-scale sustainable use of biomass in the bioeconomy. This will lead to competitive co-production of food / feed ingredients, bioproducts and bioenergy combined with optimal socio-economic and environmental impacts (efficient use of resources, reduction of GHG emissions, etc.) [6].

Bioprocessing is not completely innovative. Thousands of years ago, the production of vegetable oils, beer and wine already required pretreatment, separation and processing steps; while papermaking began around AD 100. Today, traditional industrial biorefineries are still mainly found in the food and paper industries [6].

The use of biomass for non-food and feed applications is expected to shift from an energy-based approach to a more productive approach over the next 10-20 years. However, it is also expected that in the longer term, some of the biomass resources will still be used for the production of advanced biofuels for transport (heavy-duty road transport, aviation and shipping) and bioenergy [6].
2. Methods and Materials

According to experts and analysts the prospects for bioenergy are enormous. The production volumes of wood pellets in Russia will only grow, but in many regions the problem of waste disposal has not been resolved. In addition to new legislative initiatives prohibiting the disposal of wood waste, the state encourages businesses to process wood waste. For example, forestry projects that claim the state support should be waste-free.

Every year new pellet production facilities arise in Russia – both small and rather impressive in scale. Plans for the construction of such enterprises are regularly announced in almost every region. At the same time, the raw material potential is still several times higher than the needs of existing enterprises [7].

In Russia, the share of biofuels in fuel and energy production is 3-5%, while in Finland it is at least 25%, and in Sweden – at least 30%. In almost all Russian regions, biofuels are experiencing the strongest competitive pressure from traditional fuels – coal and natural gas, which are used by most Russian power plants and boiler houses. In many areas, this fuel is cheaper than wood pellets, and besides, it is familiar. In addition, equipment designed to run on fuel oil, coal and gas is operated at Russian power facilities, which is explained by the high share of district heating in Russian heat supply. From time to time, the government speaks about the advisability of transferring municipal boiler houses to biofuel, but for that, the local authorities must have funds for the modernization of boiler houses [8, 9].

In addition to the listed problems, there is one more. It is the training of specialists. Today there are not enough qualified specialists in this area. The training of qualified specialists includes an integrated approach. First of all, it is necessary to understand what kind of wood is in a particular region, and whether it is suitable for the production of pellets, whether it is sufficient for the production to be profitable. The quality of the products is also affected by the composition of the wood, and only a specialist understands this issue. Our university has extensive experience in training specialists in the field of forestry and pulp and paper industries [10]. Together with the Russian pellet council training program for the personnel of pellet and briquette production has been drawn up. The training is designed to train technologists, technicians, economists, biofuel line operators. The program represents a course on the basics of bioenergy and the production of pellets / fuel briquettes, including a series of lectures and practical exercises. Today the following specialists are most in demand: wood processing engineer, biofuel production technologist, electrical and mechanical engineer of industrial equipment in biofuel production, heat and gas supply, ventilation and air conditioning engineer in biofuel production, design engineer for biofuel production, biofuel economist, production, analytical chemist. An integrated approach allows participants to get not only theoretical knowledge, but also practical skills in wood chemistry, including microscopy, production technology, heat power engineering, economics and logistics in Russia and worldwide. In order to cover most of the audience, we use a blended learning format, the theoretical part is held in a distance format, and practical classes are face-to-face.

Online classes today are not only active teaching methods, but also interactive ones, which include solving real production problems, role-playing games, joint solution of difficult life situations. Learning then becomes effective when trainees understand the meaning of the tasks performed. This applies not only to those who improve their qualifications, but also to students who come to study again. Today’s students want to gain knowledge in practice, they do not have enough only theoretical knowledge, they want to understand what are the advantages of their future profession. Our experience shows that the involvement of students in the game with the description of real situations gives a higher percentage of assignments and assimilation of the material. If this game is competitive, then the effectiveness of training increases. Interactive methods make it possible not only to listen to or read educational material, but also to assimilate it through the use of pedagogical techniques through involvement. If this is a team game, then a degree of responsibility appears, since each participant is assigned his own role and it is impossible not to fulfill it. Dramatization through online training of freelance situations makes it possible not to be afraid of making mistakes and makes it possible to gain
invaluable experience that will be remembered by itself. Learning through a case - technology is a modern direction that gives pleasure in achieving the goal.

Why is the use of gamification so effective in the adult world? The answer is simple, the game is the most effective, attractive and effective way of learning. The game helps you immerse yourself in the world of travel, events and adventures, it allows you to develop logical thinking and find a non-standard solution to the problem. And of course, upon achieving the goal, a reward is supposed, which is also a strong motivational component.

Our training courses are developed taking into account the needs of the modern world, which contain not only relevant information today, but also allow specialists to continuously improve their skills. Distance learning allows you to reduce the time off from work and build an individual approach to each student, taking into account the acquisition of the necessary competencies, adding and removing educational material. Using programs such as Articulate, Storyline, Ispring Suite, etc., we create interactive educational material that is not only useful, but also interesting to learn. Figure 1 shows a fragment of one of the courses in the Articulate program.

![Osmosis Diagram](image)

**Figure 1.** Fragment of training material.

Actively in teaching, we use the principle of game quests, when a student moves from level to level upon reaching a certain goal and receiving a certain number of points. When learning online, the educational material must be divided into logical parts, which will take no more than 20-30 minutes to work on. This time was chosen based on the experience and survey of students as the most effective for the assimilation of the material [11]. Every 10-15 minutes, it is advisable to embed test questions for brainstorming into the training material, in figure 2 an example of interactive test tasks.

Distance learning allows you to diversify the types of test questions, so they can be visualized. Such a presentation of the material allows you to dose information without overloading the students, and it also allows you to return to the most difficult material for re-mastering it. After each topic, it is recommended to create control tasks to assess the degree of assimilation of the material. Control tasks should be individual or group, then the study of educational material increases.

Our experience shows the effectiveness of such work that stimulates mental activity for success.
Distance learning technologies are used at our university since 2012, we have accumulated a lot of positive experience in conducting classes at a distance. To date, all methodological educational material has been translated into electronic format. Our teachers not only actively read online lectures, conduct consultations and interactive laboratory work, but also take state exams and final qualification works with a proctoring system.

Our teachers have extensive experience in the production of pellets and fuel briquettes and are ready to share with those who start their journey in this difficult, but demanded business.

3. Conclusion
An essential point in the production of pellets and fuel briquettes is that it contributes to the maintenance of employment in the forestry sector, in the regions where it is necessary to create jobs. The production of second-generation fuels has influenced the use of low-value waste and residues from timber processing, which has played an important role in protecting natural sites.

References
[1] Akim E L 2019 Note from the Secretariat for the European Forest Week Forêst 2019 international conference (Geneva: UN)
[2] Wertz J L 2018 Hemicelluloses and Lignin in Biorefineries (Boca Raton: CRC Press. Taylor & Francis Group) p 308
[3] Strategic Research and Innovation. Agenda 2030 of the European Forest-Based Sector 2019 (Brussels: The Forest-Based Sector Technology Platform) p 52
[4] Akim E L 2019 Forest Products Annual Market Review 2018–2019– (Geneva: UNECE) p 151
[5] Akim E L 2018 Forest Products Annual Market Review 2017–2018– (Geneva: UNECE) p 153
[6] Godinho R, Morese M 2020 IEA Bioenergy Annual Report 2019 (Paris: IEA Bioenergy) p 144
[7] Akim E L 2016 Biorefining of wood Fibre Chemistry 48 (3) pp 4-13
[8] Pekarets A A 2019 Creation of technology for obtaining fuel and coal briquettes from sawdust of larch wood Forests of Russia: politics, industry, science, education Conf. Proc. (St. Petersburg) vol 2 pp 117–19
[9] Nikolskaya V 2017 Production of fuel pellets in Russia LesPromInform 6 (128)
[10] Fedorova O V 2018 Motivation through Communication in Online Learning Proc. Int. Conf. eLearning Stakeholders and Researchers Summit (Moscow: HSE) pp 163–66
[11] Gromova E N and Fedorova O V 2019 Maintenance of engineering discipline in a distance format on the educational platform Moodle Energy saving and energy efficiency 3 (87) pp 51-54

Figure 2. An example of an interactive test question.