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SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

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CHEMISTRY OF RENEWABLES FOR SUSTAINABLE INDUSTRY

Marry Christmas!
may your christmas
be filled with health,
lots of happiness and joy.

May this Coming Year
bring health and happines to you
and your family.
Marry Christmas and Happy New Year 2022!

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DEVELOPMENT STRATEGY OF THE JOURNAL "POLISH TECHNICAL REVIEW" (PTR)

STRATEGIA ROZWOJU CZASOPISMA „POLISH TECHNICAL REVIEW" (PTR)

***Summary**: "Polish Technical Review" is a journal published in accordance with the currently binding standards of "Open Science". Indexing in the ERIH + database confirmed the high quality of the published scientific articles and allowed to increase the reach. However, further development of the quarterly will only be possible as a result of the implementation of the developed ten-point strategy.*

***Keywords**: strategy, development, scientific journal, international databases, citation rate*

***Streszczenie**: „Polish Technical Review" jest czasopismem wydawanym według obecnie obowiązujących standardów „Otwartej Nauki". Jego zaindeksowanie w bazie ERIH+ potwierdziło wysoką jakość publikowanych artykułów naukowych oraz pozwoliło na zwiększenie zasięgów. Jednak dalszy rozwój kwartalnika będzie możliwy tylko w wyniku wdrożenia opracowanej, dziesięciopunktowej strategii.*

***Słowa kluczowe**: strategia, rozwój, czasopismo naukowe, bazy międzynarodowe, cytowalność*

Introduction

The quarterly "Polish Technical Review" (e-ISSN 2657-6716) presents on its pages scientific and technical progress in all areas of Polish science. It plays a key role in the dissemination of Polish scientific research and presents the scientific and professional achievements of Polish scientists and engineers working both in the country and abroad. "Polish Technical Review" popularizes the progress of knowledge, achievements and contemporary problems, as well as the history of concepts and technical achievements, as well as the profiles of outstanding figures in science and technology. The entire journal, and most importantly, scientific articles are published in English (congress) and available free of charge (without technical restrictions) on the journal's website www.polishtechnicalreview.com and the publisher's website www.sigma-not.pl. Since June 27, 2021 "Polish Technical Review" has been indexed in the international database of scientific journals European Reference Index for the Humanities and Social Science (ERIH +). All research papers published in the PTR are marked with Digital Object Identifiers (DOI), and authors of scientific papers are marked with a unique Open Researcher and Contributor ID (ORCID), if they have one. The editorial office operates in accordance with the adopted and applied publishing ethics rules of the COPE Publishing Ethics Committee.

Journal development strategy

The aim of the existence of the journal "Polish Technical Review" is to publish scientific articles of high substantive value and disseminate them to the widest possible extent, which will contribute to the popularization of Polish science and scientists and to increase the citation rates, and thus the journal's position in international databases and its evaluation factors. The efficient and effective development of the quarterly "Polish Technical Review" will be achievable in the near future by implementing ten points of the strategy.

Implementation of the editorial-publishing and anti-plagiarism system

The international standard of scientific journals is the use of editorial-publishing and anti-plagiarism systems that facilitate the work of the editorial team, ensure transparency of the publishing process and check the originality of articles. Thanks to the implementation of the aforementioned systems, the quality of the work of the editorial team (including reviewers) will increase and speed up, and the author will be able to check at any time at what stage his article is. A simplified scheme of work in the editorial-publishing and anti-plagiarism system is shown in Fig. 1. The implementation of systems in editorial offices of scientific journals is an important element in building their prestige and guaranteeing publishing quality.

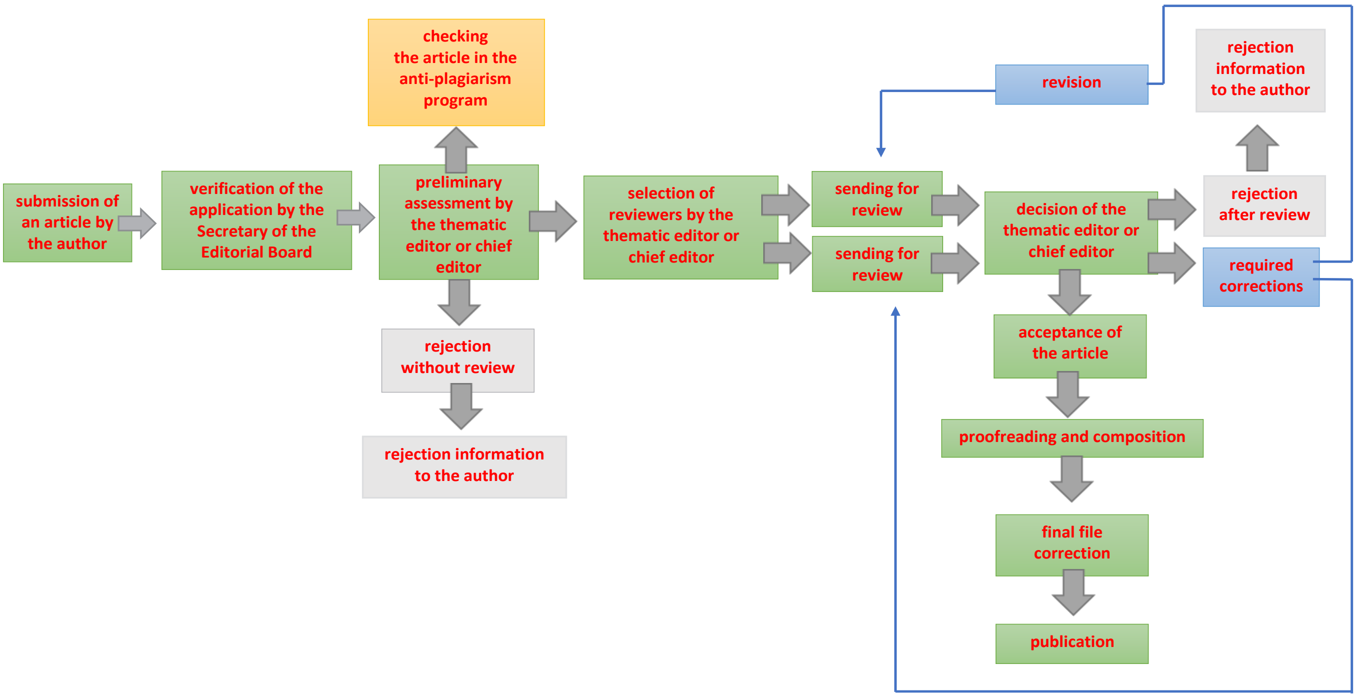

Fig 1. Scheme of work in the editorial and publishing system, including checking the article in the anti-plagiarism system

Increased use of digital article identifiers (DOI) and researchers (ORCID)

The use of DOI and ORCID identifiers is already standard in scientific journals, also in the "Polish Technical Review". However, DOI providers such as CrossRef offer much more possibilities. The PTR editors want to extend their cooperation with CrossRef with the Cited-by service. It consists in adding a script to the source code of a website, which allows you to display the current information about publications citing this article, generated on the basis of data (attachment bibliographies) sent by publishers to the CrossRef website. The next element would be to combine the data on articles published in the PTR and deposited in CrossRef with the ORCID system, which is extremely convenient for the author and ensures an unambiguous attribution of authorship.

Changes in the graphic design of the journal

"Polish Technical Review" is a digital only journal, so there are no technical contraindications for introducing active links (hyperlinks) in the PDF file next to ORCID identifiers and DOI numbers provided in the bibliography, it only requires training of the editors responsible for the composition and composition of the journal. The next step is to change the magazine layout by adding authors' biographies (with hyperlinks to the workplace) and social media profiles. These activities will increase the identification of authors, attachment to the journal and are a simple way of promotion.

Reconstruction of the existing website

On the website www.polishtechnicalreview.com, all PTR numbers from 2019 and published articles are available free of charge without any technical restrictions (in PDF format). In order to increase the reach of the journal, positioning and its receipt:

- post biographies of individual members of the editorial board, along with linking to their external profiles (especially scientific ones);
- include a linked icon of the ORCID identifiers of the researcher and the units with which the authors are affiliated next to each article and author;
- adapt the website to the editing and publishing system, through which the authors will submit the article for publication, and the editors and reviewers will conduct the entire process of processing the article.

Switching to Creative Commons licenses

Creative Commons licenses define the rules under which authors, readers, and publishers may use an article. Basic Creative Commons licenses have one common variant which is attribution (a work must always be labeled with the author's first and last name). The author, instead of the traditional formula "all rights reserved", uses the formula "certain rights reserved", which allows you to use the work to a certain extent, eg copying, republishing, distributing. It is also possible for the authors themselves to post their articles in university repositories and on social networks. The development of an open access journal is closely related to the free flow of scientific information, and it is possible through the implementation and use of the Creative Commons license.

The magazine's appearance in social media, especially addressed to scientists

Social media is poorly used by academic journals because it is treated as an entertainment or more personal medium.

However, for example, Facebook and Twitter should be used by the editorial office to inform about the topics of the next edition, the publication of a new issue, present the profiles of the authors, invite them to publish and be a platform for the exchange of opinions and commenting on articles. Materials for publicly available portals, e.g. Facebook, should be properly prepared, i.e. shorter, concise texts with a link to the full article published in the journal and available on the website. Also, be aware that there are social networking sites for scientists, such as Academia.edu or ResearchGate, and LinkedIn professionals. They have several million users, which is worth using and setting up editorial accounts there, as well as encouraging authors to post articles published in the "Polish Technical Review" on these portals. However, setting up social media accounts is not enough. The quality and regularity of posting the content and replies to the comments left are extremely important, which creates a bond with the users of a given website and builds the magazine's position in the most international information channel, which is the Internet.

Commencement of cooperation with thematic editors

Expanding the team with thematic editors who would manage individual issues or blocks of articles allows for planning the editorial work in advance and assigns responsibility for specific things to a given person (included in the editorial and publishing system diagram, Fig. 1). Thematic editors included in the PTR team will be experts in a specific field, which will positively affect the process of verification of articles, increase the prestige of the journal and expand the circle of collaborators, including those with research units with which subject editors are affiliated.

Applying to other international databases of scientific journals

The implementation of points 1-7 of the presented strategy increases the journal's chance of being indexed in international bibliometric databases. "Polish Technical Review" can potentially be indexed in the following databases: SCOPUS, Web of Science, Google Scholar, EBSCO, DOAJ, ULRICHSWEB Global Serials Directory, Ei Compendex Source List, CEON.

Each of the above-mentioned databases has detailed guidelines on the parameters that a journal should meet in order to be included in them. You should carefully analyze the requirements of each base before sending the application questionnaire. If the journal meets the criteria, an application must be sent immediately, if any deficiencies are found, they must be eliminated – if possible – (which may delay the application process) and then the application must be sent. This will allow you to avoid the grace period imposed by the bases (up to 3 years) for the next application.

Increasing the journal's reach and citation rates

The gradual implementation of the presented strategy (points 1–8) should expand the group of recipients of the "Polish Technical Review", and thus translate into an increase in citations of articles published in the quarterly. If we take into account that since 2019 PTR publishes articles only in English and they are available in an electronic version in open access, the journal is indexed in a larger number of international databases (with full-text versions of articles), presence in repositories and promotion in scientific social media profiles, it can translate into an increase in citation rates.

Promotion of the journal, articles, authors and achievements of Polish science and technology

The multi-channel promotion of a magazine is the most effective way to reach a wide audience with your message. This will be done by social profiles, rebuilding the website, sending a newsletter to subscribers and recipient databases (obtained in accordance with the provisions, in particular the GDPR). Additionally, the editorial office will promote the journal at conferences, congresses, seminars and other events of global reach. It is also worth establishing cooperation with other editorial offices of scientific journals in order to publish information and advertising about PTR in them and on the websites of these journals. Polish Technical Review is open to publishing advertisements of other scientific journals in its pages, because only by joining forces we have the best chance of effective promotion of Polish science in the international arena.

Summing up

The electronic version, open access and the English language have already given the quarterly "Polish Technical Review" a chance to enter the international circulation, which is confirmed by indexing in the ERIH + database. However, the achievements of Polish science and technology deserve even greater appreciation in the world, and this is the goal of the editorial office and of the Polish Technical Review itself, and it will be possible through the implementation of the strategy presented above.

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CHEMISTRY OF RENEWABLES FOR SUSTAINABLE INDUSTRY

CHEMIA SUROWCÓW ODNAWIALNYCH DLA ZMODERNIZOWANEGO PRZEMYSŁU

***Summary**: Chemistry as a basic science and chemical industry as the principal provider of innovative materials for practically all sectors of contemporary economy, are in the center of unprecedented and revolutionary technical and social changes. These changes are necessary for mitigating climate disturbances and environmental deterioration, which threaten the future of humanity. In reference to recent international initiatives, like the UN Sustainable Development Goals, which underline the need for global economic changes based on recovery and circularity principles, we offer some comments on area of research and development. They are concerned with a mandatory transition from un-renewable fossil-based industries, like the petrochemical one, to new sources of energy and carbon-rich materials generated by novel processes compatible with zero GHG emission prospects.*

Our discussion is focused on biomass as a universal feedstock capable of satisfying global needs for energy as well as chemical materials from commodity to specialty. Secondly, principle drivers of innovation in the fields of new chemical reactions and processes, like catalysis are discussed. The discussion includes a recent strive for new functional materials in reference to all levels of their structural organization, from single atoms and surface phenomena, through nano-constructs and mesopore composites, to macro-molecular and supra-molecular aggregates. Finally, the need for a further development of innovation and feasibility assessment methods, based on green chemistry principles is mentioned. It is a condition for an efficient cooperation in biomass related international R&D projects, which have to be based on the harmonization of unified evaluation principles.

***Keywords**: Carbon dioxide industrial emissions and utilization; Biomass as chemical industry feedstock; Lignocellulose biomass conversions; Furan platform chemicals*

***Streszczenie**: Chemia, jedna z podstawowych nauk przyrodniczych oraz przemysł chemiczny, który zapewnia innowacyjne i nowoczesne materiały dla praktycznie wszystkich sektorów współczesnej gospodarki, znalazły się w centrum unikalnych i rewolucyjnych zmian ekonomicznych. Zmiany te, dotyczą nie tylko techniki i technologii, ale także mają znaczące skutki społeczne. Są one niezbędne w celu zminimalizowania dalszego pogarszania się klimatu oraz stanu naturalnego środowiska – zjawisk, które zagrażają przyszłości ludzkiego gatunku. Ostatnie inicjatywy, takie jak „UN Sustainable Development Goals", kładą nacisk na potrzebę globalnych przemian gospodarczych opartych o zasady regeneracji i cykliczności. W odniesieniu do tych inicjatyw i rozwoju znanych nam dziedzin chemii omawiamy obiecujące kierunki badań i rozwoju (R&D) związane z krótkoterminowymi cyklami organicznych związków węgla w kontekście transformacji od surowców nieodnawialnych (paliwa kopalne), do ekonomii nowych źródeł energii oraz materiałów organicznych, wytworzonych przez nowe procesy zgodne z wymaganiem zerowej emisji gazów cieplarnianych.*

Nasza dyskusja kładzie nacisk na biomasę jako uniwersalny surowiec, zaspokajający globalne potrzeby energetyczne oraz będący źródłem wszelkiego rodzaju produktów chemicznych. Ponadto, artykuł zawiera rozważania na temat podstawowych czynników innowacyjnych w zakresie nowych procesów i reakcji chemicznych, włącznie z nowymi katalizatorami. Do omawianych problemów i zjawisk należą próby wytwarzania nowych materiałów z uwzględnieniem różnych poziomów organizacji strukturalnej od pojedyńczych atomów, poprzez nanokonstrukty i mezokompozyty aż do agregatów makro i supra-molekularnych. W końcu, niezbędność dalszego postepu innowacyjnego oraz metod oceny wykonalności, wynikające z reguł zielonej chemii są także wspomniane. Jest to warunek konieczny do osiągnięcia skutecznej współpracy w zakresie miedzynarodowych projektow badawczych (R&D), które muszą bazować na harmonizacji ujednoliconych zasad oceny.

***Słowa kluczowe**: Przemysłowe emisje i utylizacja dwutlenku węgla, Biomasa jako surowiec dla przemysłu chemicznego, Przemiany biomasy lignocelulozowej, Chemikalia platformy furanu*

Introduction

The idea of rational management of earth material resources, which are finite, is not new [1–4]. Nevertheless, a massive social interest in closely related matters as preservation of environment and stabilization of climatic changes has become noticeable as a global force only recently, after a long series of appeals voiced through international expert gatherings (Stockholm 1972; Kioto 1997; Rio de Janeiro 1992 and 2012; Paris 2015 and 2021, Glasgow 2021). A recent initiative of the UN, popularized as sustainable development goals (SDG) has a form of manifesto, indicating 17 basic goals (accompanied by a list of 169 more specific targets and more than 300 indicators), which need to be achieved in near future in order to secure further development of human civilization in time of overpopulation and critical depletion of fossil resources of energy, fuels and chemicals. (Fig. 1; Fig. 2). [5–8] The EU follows with similar directives and recent program known as European Green Deal (EU Climate Target Plan 2030), which is focused on radical reduction of the atmospheric content of greenhouse effect gases (GHG), switch of industrial sectors to sustainable development mode and adapting it to the circular economy (CE) and bioeconomy BE) principles [9–16]. It is believed, although not without reservations, that these measures should secure a safety margin of global increase in average temperature and desirable climatic stabilization, but there is already a considerable amount of controversy concerning detailed means required for achievement of SDG [17, 18].

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all at all ages.
4. Ensure inclusive and quality education for all and promote lifelong learning.
5. Achieve gender equality and empower all women and girls.
6. Ensure access to water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote inclusive and sustainable economic growth, employment and decent work for all.
9. Build resilient infrastructure, promote sustainable industrialization and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources.
15. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
16. Promote just, peaceful and inclusive societies.
17. Revitalize the global partnership for sustainable development.

Fig. 1. Basic sustainable development goals listed by the UN

It is generally agreed that present climatic crisis is produced by the increasing content of GHG in the atmosphere, with a decisive input coming from carbon dioxide. It has in turn led to a significant redistribution of preindustrially existing carbon pools. A recent report of the Intergovernmental Panel on Climate Change [19] on the physical science basis of climate change leaves no shade of a doubt that tiny changes in the atmospheric GHG content, resulting from industrial activities, will bring about irreversible and catastrophic changes if not properly attended [20–23]. The present estimate of elemental carbon stock include 800 Gt (atmosphere); 40 000 Gt (hydrosphere); 2 500 Gt (biosphere); and 65 mln Gt (lithosphere ; including 4 000 Gt of high energy fossil materials such as coal oil and natural gas).

Although anthroposphere (reduced carbon stored in fuels, polymers, etc.) amounts to only ca. 2–3 Gt and anthropogenic CO_2 emissions are of the order of 10 Gt per year, they manage to disturb the steady state global carbon balance and cause dangerous average temperature increase. Naturally, a close look at biosphere and biomass circulation is needed in order to mitigate effectively detrimental atmospheric changes induced by the excessive GHG presence. Every organic substance which derived from photosynthetic process, directly or indirectly, can be considered biomass, and a part of biological carbon cycles which are very short, in geological time scale. Estimates of the global amount of organic carbon are approximate since diverse and heterogeneous materials have to be assessed. Although mass units are customarily applied for the purpose, the energy equivalents are also frequently present in statistical data. It is assumed that earth biosphere (all kingdoms of life) consists of ca 550 Gt of carbon (Gt C), of which terrestrial plants are biggest part (ca. 450 Gt C), followed by bacteria and archea (70 and 7 Gt C respectively), marine biota (6 Gt C) and land animals (2 Gt C). The biosphere has 33 000 EJ energetic potential capacity, equal to ca 80 world annual energy consumption equivalents [24, 25].

Presently, the net-zero-CO_2 emission state needs to be introduced as a necessary measure to save the earth biodiversity and protect the environment capacity to support human population of present size. Obviously, the goals of programs defined in the documents and treaties quoted at the beginning of the paragraph, like 55% global GHG emission reduction before year 2030, can not be achieved by pursuing economy based on nonrenewable resources of energy and materials. Our sustainable future

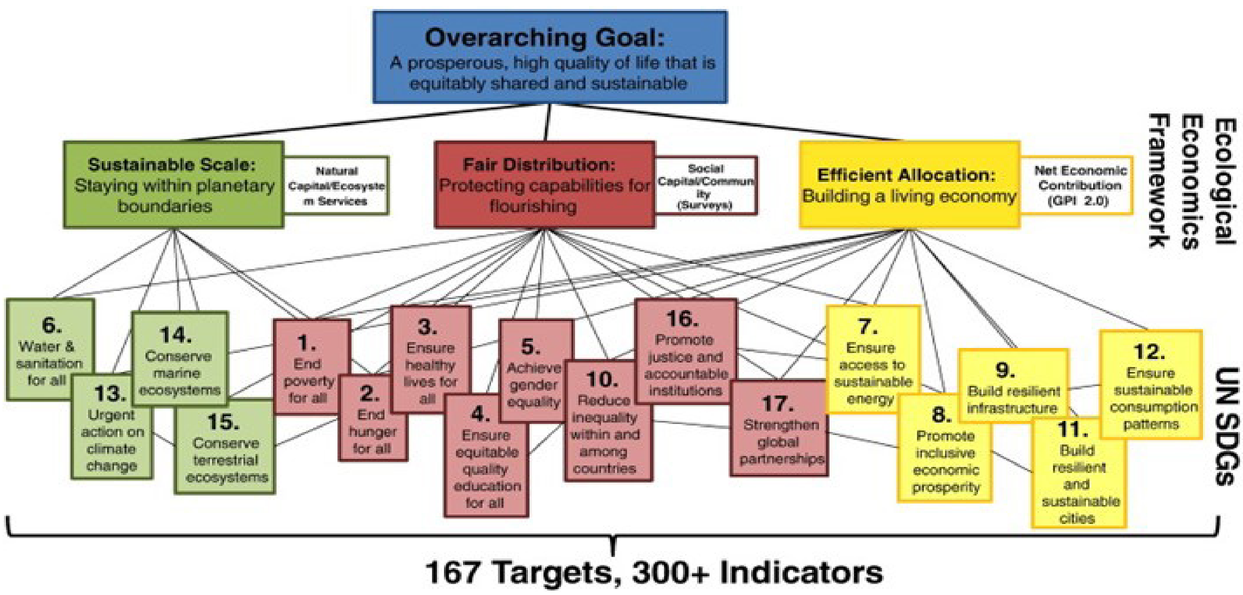

Fig. 2 Graphic network of the UN's proposed targets

requires immediate implementation of radical reduction of CO_2 emissions. Assuming more or less stable human population size, it can be practically achieved only in two ways: by capture of industrial waste carbon for immediate utilization (CCU) or for effective storage (CCS) [26–28]. Both options are already technically validated but remain the matter of vigorous dispute since they require different immediate resources, some long term investments and considerable energy inputs. Also, their short term and strategic consequences can vary greatly. While sharing an interest for carbon capture as the immediate climatic crisis remedy, we should be more concerned with strategic perspectives of chemical industry based on de-fossilized feedstock and clean energy, preferably solar, truly renewable in astronomical scale (the sun provide more than 10^5 TW).

Captured carbon dioxide of industrial (or atmospheric) origin can be a reasonable starting material for low molecular weight commodity chemicals, like syngas, methanol or ethylene (provided adequate supply of green hydrogen is secured), but is somewhat less viable as the requirement for carbon chain length (and structural complexity) of the end product increases. Therefore, this presentation is focused on sustainable chemistry based on lignocellulosic biomass (LCB), which is a renewable feedstock, available in considerable variety of forms, of collective mass suitable for an array of processes aggregated under umbrella term – biorefining [29–30]. The following short review of biorefineries utility for perspective platform industrial chemicals suitable for circular economy (CE) is preceded by short outlook of the present day chemical industry, which contributes (in form of energy, fuels and materials) to nearly every marketable products used in our everyday life. For example, industrial sectors operating chemical processes deliver very wide array of materials ranging in scale from billion tons per annum (steel, cement and other construction materials), through Mt/y commodities (petrochemicals, ammonia, fuels, plastics, processed agricultural crops) to specialty chemicals (solvents, monomers, catalysts etc.), and pharmaceuticals, which are applied in very small doses but their high market value and importance for healthcare makes them significant part of economy. In the last decade the value of sold chemicals increased from ca. 500 bln Euro in 2010 to 657 bln in 2019 and 649 bln in 2020 [Eurostat 2021]. Versatility of the chemical industry products is stunning. European Chemical Agency (ECHA) lists over 106 000 commercially manufactured chemicals, while globally there are at least 350 thousand chemical products on the markets (including some mixtures and compositions), which creates paramount complications with their technical specifications, life cycle assessments, as well as toxicological and environmental safety evaluation, and corresponding regulations [31, 32]. While experimental chemistry is principally based on measurements and their interpretations, we owe an extension of quantitative perspective of industrial chemistry towards economical and social consequences of its activity to green chemistry movement which introduced atom economy calculations, followed up by techno-economical assessment (TEA) and product life cycle analysis (LCA) as principal tools of evaluation [33, 34].

For decades, the chemical industry in Poland (as well as its sub-sectors) has been a subject of experts' debates addressing permanent systemic problems. However, the urgent need for radical and rapid reaction to pressures exerted by the global climatic crisis was brought up as a topic of wider social dispute only recently [21, 23, 35, 36]. Despite of persistent crisis resulting from preserving the state subsidized coal economy, there are continuous sound attempts, carried out by Polish Chamber of Chemical Industry (PIPC; *www.pipc.org.pl*) to discuss problems (and also perspectives) of the local chemical sector enterprises in the wider context of the EU Council policy and EU Chemical Chamber (cefic; *www.cefic.org*) initiatives and programs. PIPC publishes annual reports on sectorial productions and markets and presents local initiatives compatible with European policy of decarbonization, renewable energy, industrial recycling and sustainable economy, securing forum for innovating initiatives, scientific as well as industrial.

CE (the economy which is environmentally and materially renewable) is based on a stakeholders (society, government, business enterprise) point of view, considering feature network of: resource availability and management, speed of waste generation and increase in environmental risk, product design and LCA, technical efficiency of employed processes, and economic benefits through circular rather than linear exploitation of resources. A detailed discussion of the topics involved leads to a conclusion that such fundamental transformation of the global economy as "decarbonization" and ban on the use of fossil resources for energy, fuel and chemical production, could not be achieved without the massive innovation in literally every industrial segment. This, in turn, cannot be created without the involvement of basic science. Chemistry is a perfect example of basic science of fundamental importance to applications such as chemical engineering, material sciences and chemical industry, which delivers most of the commodities supporting contemporary technical civilization and everyday life of the planet population. Frequently called "central science" for its capability of interpreting transformation of matter on the atomic and molecular level [37], chemistry as an academic enterprise has attained admirable level of perfection in assembly of the most complicated molecules, natural and designed by inventive minds, in numbers running over hundreds of millions of individual chemical entities [38]. In our opinion, the key role of chemistry in general and chemical synthesis in particular, in the new sustainable technological future has not been sufficiently discussed and stressed as a necessary and complementary component of search for renewable energy sources.

The need for replacing petrochemical processes (employing non-renewable hydrocarbon as substrates) used thus far for making indispensable chemicals (basic, intermediate, polymeric, agrochemical, pharmaceutical, etc.) with renewable (biomass; LCB) resources is necessary and urgent. Therefore, we would like to present shortly the potential of modern chemical synthesis, based on chemo- and bio- catalyses in transformation of renewable LCB into chemicals through assorted dedicated processes, focusing on innovations concerning basic chemistry as well as well as process design and engineering [39, 40]. Since radically novel chemical industry needs to be established in place of traditionally practiced transformations of oil, natural gas, and coal, the question of science literacy and in particular chemical education comes to mind as an important factor shaping attitudes of today policy makers and future social forces. To this end we have elected to precede the biorefinery discussion with reflections on chemistry image in general and its evolution in direction of sustainability supportive force through propagation of the green chemistry principles. Finally, we would like to discuss some novel methodical openings in organic synthesis, which offer new perspectives for application in biorefinery chemistry, in respect to commodity chemicals, as well as to high value intermediates, new drug leads and pharmaceuticals. Apart from new applications in catalysis, a trend to fortify existing chemical knowledge with AI methods, such as large database mining, extensive algorithm operation applications, neural networks and machine learning systems will be mentioned as tools, which enhance functionality of synthetic methodology generated through collecting experimental laboratory data of generations of traditional chemists.

Carbon dioxide dual label: greenhouse gas and/or valuable commodity?

Our environment, including carbon cycles and climate changes, is studied on the planetary scale, within Earth System Science. The studies have accumulated a large amount of current and historical data describing accurately trends like a steady growth of the CO_2 atmospheric content, which correlates with its industrial emissions [16, 20, 23, 25]. The capacity of biosphere for photosynthetic fixation of atmospheric CO_2 is huge as evidenced by global biomass generation which is in excess of 10^9 t/y and steady photosynthetic production of oxygen at 290 000 Tg/y. Carbon, which is the essential element of life, makes up only 0.03 % by weight of our planet but its partition between reservoirs and sinks is very uneven, in favor of geological deposits. Indeed, 99.95% of carbon is located in crust and mantle, 0.049% is dissolved inorganic carbon, while terrestrial and marine biospheres combined contain only tiny 0.00064%. Incidentally, the same fraction: 0.00064% is present among atmospheric trace gases (like CO_2 and CH_4) [41, 42]. During the recent two centuries or so atmospheric CO_2 levels rose from pre-industrial 180 to over 400 ppm. Consequently, a continuous rise of average temperature (over 2°C global average from the pre-industrial period) has been observed, threatening climate stability, land and water resources, and eventually sustenance of the human race [21, 22]. Although human made carbon dioxide fraction of the carbon cycle (37.1 Gt in 2018, projected to increase annually by 10% until 2040) seems small, it is by no means insignificant. Consequently, programs that enable achieving zero GHG emission economy in a foreseeable period of time are of critical importance [8-10]. An apparent priority of the atmospheric carbon dioxide sequestration has led to considerable amounts of research. Initially, it was classified as carbon capture and storage (CCS; CO_2 capture exercised as: absorption, adsorption or membrane technology process), and subsequently as more prospective carbon capture and utilization (CCU) [26, 27]. In fact CO_2 capturing at a source of emissions, transportation, compression to supercritical condition, and geological storage (primary form of CCS) is a considerable technical problem in itself, not to mention prospective containment safety issues.

Alternatively, sorbent technologies can be applied for storage, e.g. mineralization with alkaline materials or reversible salt formation with monomethanolamine as the most common dedicated solvent. Some direct utilization may include soft drink carbonization; food refrigeration and storage; welding protection; fire extinguishers, etc. Physical sorption seems more suitable for small scale applications. However, new solutions are constantly developed - graphene-type materials are promising, with current capacity of ca. 0.07 mol/g (it corresponds to over 3 g of CO_2 per g of ther material) and other types of molecular sieves (e.g. MOFs, zeolites) may also be applied for storage [43, 44]. Considerable part of CO_2 industrial applications derives from its particular physicochemical properties which makes it suitable as heat transfer medium, supercritical fluid (sc CO_2), extraction or reaction solvent, etc.

CCU prospects in the chemical industry span from various forms of chemical reduction, powered by thermal, electrical or solar energy to biochemical fixation (photosynthesis, earlier called assimilation) performed by organisms like cyanobacteria, algae or higher plants [45, 46]. Interestingly, a study evaluating 14 selected technologies of CO_2 utilization was recently offered by Polish scientists in the coal power plant in Jaworzno. That critical CCU implementation study covered technical as well as economic analysis of the particular medium size facility placed in the industrial region, in relation to the European Emission Trading Scheme system (EU ETS) and local reform plans. The study indicated a strong influence of non-technical issues on the results of final assessment [47].

Before discussing the possible reactions of CO_2 we must note that thermodynamically it is an exceptionally stable compound. It is due to the presence of two carbon-oxygen double bonds in a very small molecule. Elemental nitrogen consists of similarly thermodynamically very stable molecules. The synthesis of ammonia from nitrogen (and hydrogen) is rightly considered one of the greatest accomplishments of chemical engineering and industry. Transforming CO_2 into useful chemicals is an equally difficult task. It demands that cheap (hopefully solar) energy is available. Note also that two stages of the utilization of CO_2 are possible: one or both C=O bonds can be broken.

It seems that a short review of CO_2 chemistry and remediation should begin with a reminder of its basic redox properties. The single electron reduction, resulting in the disturbance of molecular geometry from linear, non-charged molecule to the bent anion-radical has the standard potential of + 1.90 V and is practically of no use for chemical transformations, except in the semiconductor catalysis. Multi-electron proton assisted reductions are observed in a more favorable range of electrochemical potential. Consequently, they found appropriate catalytic enhancement conditions and wide practical applications [17; 48–50]. The potentials of applicable processes are:

$CO_2 + 2H+ + 2e^-$ ->	$CO + H_2O$	$E^0 = -0.53$ V
$CO_2 + H_2O + 2e^-$ ->	$CO + 2OH^-$	$E = -0.93$ V
$CO_2 + 4H^+ + 4e^-$ ->	$CH_2O + H_2O$	$E = -0.07$ V
$CO_2 + 3H_2O + 4e^-$ ->	$CH_2O + 4OH^-$	$E = -0.90$ V
$CO_2 + 2H^+ + 2e^-$ ->	HCO_2H	$E^0 = -0.61$ V
$CO_2 + H_2O + 2e^-$ ->	$HCO_2^- + OH^-$	$E = -1.08$ V
$CO_2 + 6H^+ + 6e^-$ ->	$CH_3OH + H_2O$	$E^0 = -0.38$ V
$CO_2 + 5H_2O + 6e^-$ ->	$CH_3OH + 6OH^-$	$E = - 0.81$ V
$CO_2 + 8H^+ + 8e^-$ ->	$CH_4 + 2H_2O$	$E = +0.17$ V
$CO_2 + 6H_2O + 8e^-$ ->	$CH_4 + 8OH^-$	$E = -0.66$ V

where values of redox potential quoted refer to either equilibrium potential (E^0) or standard equilibrium potential (E) for aqueous solutions.

In fact, each entry from the above list of conversion of CO_2 to high energy products corresponds to a bunch of experimental procedures and variously designed technical processes. They may differ in employed catalysts, molecular mechanisms, modes of electron transfer, overall efficiency, etc. For example, at first complexes of the noble metals (Pd, Ru, Pt) were favored as hetero- and homogeneous catalysts for CO_2 hydrogenation, while recently there is more focus on easily available complexes of transition metals (Fe, Co, Ni, Cu, Mn) [51]. Thus, although chemically stable and useless as an immediate energy source, the notorious GHG – carbon dioxide, can be considered as a feedstock of renewable carbon. Note, however, that carbon dioxide utilization in a traditional industrial mode would require a reduction agent (e.g. hydrogen) and energy, which according to principles of de-fossilization and CE, must also be free from fossil C-trace [52, 53].

Traditional industrial applications of carbon oxides, such as Sabatier methanation, Kolbe carboxylation of phenols, and Fisher-Tropsch synthesis (FTS) of hydrocarbon fuels are still utilized chemical technologies [51]. The discovery of natural gas (composed mainly of methane) and coal oxidative conversion to syngas (consisting of CO/H_2 mixture) provided a novel fuel, and also a reducing agent suitable for many synthetic applications. The FTS process for liquid fuel manufacturing was described and patented in 1920-ies. This Fe or Co catalyzed moderately high temperature (160–200°C) and pressure (10–40 bar) process was developed to 0.6 mln t/a capacity in the 2nd world war time Germany [54, 55]. Another commodities made from carbon dioxide are: urea - 170 mln tons and methanol - 65 mln tons per annum).

The current R&D on CO_2 reduction reactions (CRR) turned to low temperature variants and biomass-based feedstock, looking for scale and end product optimization under such cost determining factors as local electric power and hydrogen prices. Regardless of the obvious and unsolved need for green energy in the post-petrochemical era, chemistry of renewable low molecular weight carbon synthons has advanced considerably, mainly due to a remarkable progress in both, chemical and enzymatic catalysis. Thus CO_2 ability to act as a mild oxidative and dehydrogenative agent under suitable catalysis has been exploited for syngas production and in various hydrocarbon reforming processes [56, 57]. Examples include already mentioned reduction of CO_2 to carbon monoxide, carbonate, methanol and follow up MOL (methanol to olefin) family of processes, production of methane, ethylene, etc [58, 59]. A large majority of these reduction reactions are highly endothermic and require much energy. Nevertheless, such reactions as organic carbonate (or carbamate) formation can be completed at much milder conditions. Presently, overall inorganic carbonates market is twice as big as that of organic products, by volume.

The R&D on chemical conversions of CO_2 enjoys a continuous and growing interest. When split into thermochemical hydrogenation, electrochemical reduction, and photochemical reduction categories, the number of publications revealed by bibliometric analysis in the last few years topped 1000 per year in the first two groups. Attention to photochemical reduction is much weaker, but it is exactly the category likely to bring a breakthrough results by coupling synthetic biology constructs to visible light energy collectors [60, 61]. The three proposed mechanistic paths of CO_2 reductions are called: formaldehyde, carbene and glyoxal pathways. Each one is composed of chain of ionic and/or radical species leading to the ultimate reduction product – methane. The four intermediate reduction products are – carbon monoxide, formic acid, formaldehyde and methanol. The last compound deserves special attention as a commodity chemical of multiple applications, as well as a fuel candidate, hydrogen carrier, and precursor of solvents and monomeric substrates for biodegradable polymers. A variety of catalysts, heterogeneous and homogenous, are applicable to MeOH synthesis, from syngas as well as from CO_2 (following pioneering $ZnO–CrO_3$ catalyst operating in 320–450°C and 250–350 bar, commercialized by BASF), and also for its thermal reforming in which hydrogen can be recovered. It has been pointed out, in juxtaposition to the "hydrogen economy" proposal, that "methanol economy" is much safer and more efficient [62]. As a proof, the CRI demonstration facility was launched in Iceland, named George A. Olah Renewable Methanol Plant, with production capacity of 4000 t/y, which recycles ca 5600 t of CO_2 per annum.

Interestingly, methanol can also be obtained directly by catalytic oxidation of methane, another GHG threatening climate stability. For that purpose Mo and V based catalysts have been developed [63]. It is also worth mentioning that natural biocatalyst – enzyme methane monooxidase exists and can be expressed in suitable microorganisms for the whole cell biotransformation of industrial significance [63].

It has been postulated that algal biomass farming on land, using air enriched with CO_2 and solar energy can be used for synthesis of fuels or their precursors with higher efficiency than that accomplished at LCB biofarms. Another area of an increased interest is the production of formic acid (HCO_2H), easily obtainable from CO_2 by chemical, biocatalytic or electrochemical reduction, as a convenient, safe and efficient source of molecular hydrogen [64, 65]. The relevant processes are based on either decarboxylation/dehydrogenation or decarbonylation/dehydrogenation decomposition and are catalyzed by a variety of iridium and ruthenium complexes. Organocatalysis, microbial electrosynthesis (MES) and the use of acetogenic bacteria from genus *Clostridium*, which can produce alcohols and organic acids directly from CO_2 and H_2, are other currently pursued concepts [66, 67]. Natural photosynthesis, which efficiently produces ca 115 Gt of biomass from atmospheric CO_2 every year remains yet unattainable inspiration for an efficient human designed mimicking system. Although currently at least six different autotrophic carbon-fixing pathways are known [68], attempts to improve the key steps around the enzyme catalyzing condensation of ribulose 1,5-diphosphate with carbon dioxide (Rubisco) [71] by bioengineering are not particularly encouraging. It appears that CO_2 biosequestration with the help of algal farming (carried out on land unfit for agricultural production) is a viable solution, at least in short and medium term perspective. It is due to a very good biomass productivity and high yield of lipidic (oily) metabolites accumulation [45-46]. Biomass in not necessarily the most desirable product of the CO_2 biocatalytic conversion. Thus, while algal biomass resulting from CO_2 sequestration can be considered a suitable feedstock for biorefineries offering various biofuels, simpler photoautotrophic organisms – cyanobacteria – can produce such important value added chemicals (VAC) as β-hydroxybutyrate and its polymers (biodegradable PHB{poly(hydroxybutyrate}) directly from such inexpensive feedstocks as carbon dioxide or syngas [69].

Another example of industrial flue gases or various forms of syngas utilization for the so called cell factory carbon source (much cheaper than regular industrial bacterial fermentation carbon sources) is the production of an important industrial chemical: ethanol. It has been traditionally obtained from sugar rich materials (as sugar cane or fermentable starch crops). Recently, it became available from a variety of technical processes based on non-edible agricultural materials (e.g. LCB), including direct fermentation of syngas with the aid of *Clostridium* type bacteria, which deploy Wood-Ljungdahl reductive pathway called solventogenesis [70]. In a long run, green synthesis powered by solar light as the carbon-free energy, aided by either biocatalysis or chemical catalysis (or both) will end up as the target mode of biorefineries operation. [71, 72]. Also, a significant progress in genetic and metabolic engineering of microorganisms to suit bioproduction processes of assembling value added chemicals directly from CO_2 (or formate as C_1 equivalent) by acetogens like heterotrophic E. coli, achieved very recently [73] indicate a vast capability of yet untouched innovation areas based on metabolomics.

Biorefineries – essential part of modern economy

Higher forms of life on earth depend on metabolism of autotrophic organisms, which developed ability to use solar energy to split water into elements (H_2 and O_2) and utilize it as a hydrogen source for reductive assimilation of atmospheric carbon dioxide [24, 25, 60, 68, 71]. In the follow up biochemical cycle processes thousands of newly formed small molecules are gradually assembled in plant cells into bio-macromolecules, like proteins and nucleic acids, which we recognize as the essence of life. Plants, both growing, and beyond their vegetation cycles are classified as biomass and recognized for multiple applications, as food and energy sources, construction materials, etc. The technical civilization emerged couple of centuries ago from mastering extensive exploitation of fossilized biomass as a feedstock for energy and industry. However, modern ideas of sustainable development stress the urgent need for rational managements of the earth resources and their recovery and circulation [20–22].

One of the wanders of life, which happens to be available affordably in vast quantity and also renewable within annual solar cycle, is lignocellulosic biomass (LCB; agricultural or forestry materials and wastes are good examples of it). It is composed mainly of three biopolymers: cellulose (30–50 % by weight), hemicellulose 20–40 %) and lignin (15–25 %), interwoven into sturdy constructs, which render to plants their structural stability and environmental resistance. From the chemical standpoint, LCB basically consists of polysaccharides, containing hexoses (C6 monosaccharides like D-glucose, the monomer of cellulose) and pentoses (C5 monosaccharides, mainly xylose), which feature many structural and functional characteristics. They include susceptibility to fungal and bacterial degradation, often described as fermentation (a set of processes exploited for food processing and conservation from the outset of humanity). Sugars as part of organic matter attracted an interest of life scientists in many fields, developing into specialties like multi-branch carbohydrate chemistry omnipresent in biochemistry and medical sciences, glycobiology, organic chemistry of sugars, industrial carbohydrates, etc., all blossoming in the previous century. While traditional carbohydrate chemistry/biochemistry accumulated vast amount of scientific data concerning individual sugars, their chemistry, functions and possible applications, knowledge of the composite structural biopolymer – LCB, featuring considerable resistance to chemical and biological deconstruction, largely lagged behind advances of the mainstream sugar chemistry. The last decades, on the other hand have faced explosive development of interest in LCB as a prospective replacement of unrenewable fossil resources, under the banner of biorefineries [11, 12, 16, 29, 30, 74–78] (Among hundreds of relevant references, there are some excellent texts published in Polish [79, 80]).

There are various types of biorefineries, customarily recognized on the basis of the feedstock used, process applied and/or products manufactured. In general, the traditional application of biomass for conversion to energy, even if switched from burning to manufacture biogas or bio oil, is becoming obsolete with advance of new technologies, striving for value chain extension and selective products manufacturing [81–83]. Unlike isolated biopolymers: cellulose, hemicellulose pentosanes, and alkylaromatic lignin, which feature some specific chemical reactivity, their natural conglomerates classified as LCB are known for exceptional recalcitrance towards chemical reactants, as well as biocatalysts. Therefore, practically all types of LCB require some kind of pretreatment before basic biorefinering steps: depolymerization and further biocatalytic or chemical processing [84–86]. Commonly used treatments include: mechanical (grinding, milling, extrusion); physicochemical (steam explosion, ammonia fiber explosion, irradiation, microwave); chemical (alkali, acids, solvolysis, ionic liquids, inorganic catalysts, oxidation); biological (enzymes: cellulose, laccase, pectinase; microorganisms; fungi; bioengineered microorganisms) [87]. An established procedure of LCB pretreatment and fractionation, dedicated to dry high cellulose content biomass, known as Organosolv process, consist of thermal treatment of starting materials with low boiling aqueous alcohol, and a catalyst, in a series of precipitation/filtration operations which afford a water soluble fraction (containing sugars, furan derivatives and organic acids), organosolv lignin, and solid fraction of polysaccharides suitable for enzymatic hydrolysis [83].

Biorefinery industry started launching facilities in EU a decade ago, following new regulatory developments and EU R&D programs with over 80 bln euro funding. In 2017 there were 224 biorefineries operating in Europe, although only 43 so-called second generation, using LCB feedstock, while majority applied agricultural crops for bioethanol fermentation or used various wastes or residues [88]. There is no doubt that biorefineries are to play a major role in development of circular bioeconomy since their various models have already passed proof of principle points and started commercial operation [89]. Nevertheless, a lot of chemical innovation and advanced engineering is still required for design of facilities operating on carbon-free energy and providing advanced materials, like monomers for biodegradable polymers and platform chemicals, selectively.

As we have mentioned, biorefinery is rather flexible term, accommodating various feedstocks, processes and products, as long as renewable resources are valorized into products suitable for circular economy. From such point of view, much of carbon dioxide chemistry discussed above, can also be considered as a kind of biorefinery. Also, algae and cyanobacteria farming, initially developed for oleoproducts and biodiesel fuel, are recently treated more as microbial factories for a variety of secondary metabolites (carotenoids, fatty acids, chlorophyll, antioxidants, biopolymers) for applications as food, feed, nutraceuticals, and even pharmaceutical active substances [90]. The algal biorefinery concept seem to have considerable potential for further development for manufacturing structurally complex biologically active compounds for healthcare, under mild and environment friendly conditions.

Furan platform chemicals (FPC)

Much of the research in the biorefinery area has been focused on biofuels. From that standpoint, LCB as a biorefinary feedstock has a wrong elementary composition (too much oxygen, the proportion of oxygen to carbon is almost 1:1), which should be corrected by hydrogenation. Thus, LCB is a less attractive starting material for manufacturing fuels than hydrocarbons present in the crude oil. Also, carbohydrate chemists are not particularly excited about multiple deoxygenation, since it leads to a loss of chirality, which in natural products domain is a value in itself. On the other hand, using biomass as a substrate allows synthesizing fuels with very specific structures that can be better in terms of exhaust gases composition as compared with gasoline.

Carbohydrates are the main constituents of biomass and biorefineries aim at their conversion into high energy compounds of different chemical characteristic. Thus, at early stages of the process there is an unprecedented complexity of multifunctional substrate composition, which needs to be managed to the point of acceptable selectivity in manufacture of desired products. As LCB gets deconstructed in the initial stages of its processing, monosaccharides formed meet harsh and degrading environment, in which they undergo a variety of irreversible transformations leading in opposite directions: fragmentation into smaller molecules, and condensation/polymerization towards poorly characterized high molecular mass materials, called humins. Thus, a process design of suitable chemical (or biocatalytic) selectivity appears as the key issue in a refinery technology [32–34]. Since our paper is mainly concerned with material production of a new post-petrochemical industry, we decided to select one line of chemicals, FPC – furan platform chemicals, for an illustration of new short carbon cycle pathways, capable to satisfy the demand for industrial commodities within circular economy framework. Somewhat unexpectedly, the example of an industrial process in which agricultural waste is converted selectively into a useful multipurpose chemical of commercial value, has been operational for over a century and came into being as an invention out of economic needs [91-92]. As a consequence of first furfural (FUR) production, furan chemistry was born as an important chapter of heterocyclic compounds field [93, 94] but the idea of biomass as a chemical feedstock (apart from biotechnology) had to wait for its second chance until the climate crisis.

Furfural is a product of hemicellulose depolymerization-dehydration (C-5 sugar platform) and its extensive and versatile chemistry found many practical applications [93, 95-97]. It must be noted, however, that its C-6 analog, obtainable from hexoses (HMF; 5-hydroxymethylfurfural) has a much larger potential, particularly as a monomer of biodegradable functional polymers. It is because HMF is already bifunctional and its functional groups are conveniently differentiated, to allow for the generation of derivatives with easily controlled span of reactivity. Hundreds of compounds can be obtained from HMF by relatively simple chemical transformations and a small selection is presented on the figure below, to illustrate the possibility of ring and chain type variation in the design of future polyesters, polyamides, polyurethanes, polyacetals, etc. HMF like FUR was discovered in XIX century and both compounds are on DOE's top 10 list of biobased chemicals for industrial use but the commercialization of the more promising one (HMF) is still in the demonstration phase. It is estimated that at present bioerfinery HMF and array of its derivatives would cost three time as much as the same products obtained from petrochemicals [98, 99]. Nevertheless, R & D studies on HMF production, both from model and real biomass feedstock remain a hot research area as evidenced by an avalanche of current publications [100-105]. Naturally, it is expected that the cost of HMF will dramatically drop with rapidly increasing production.

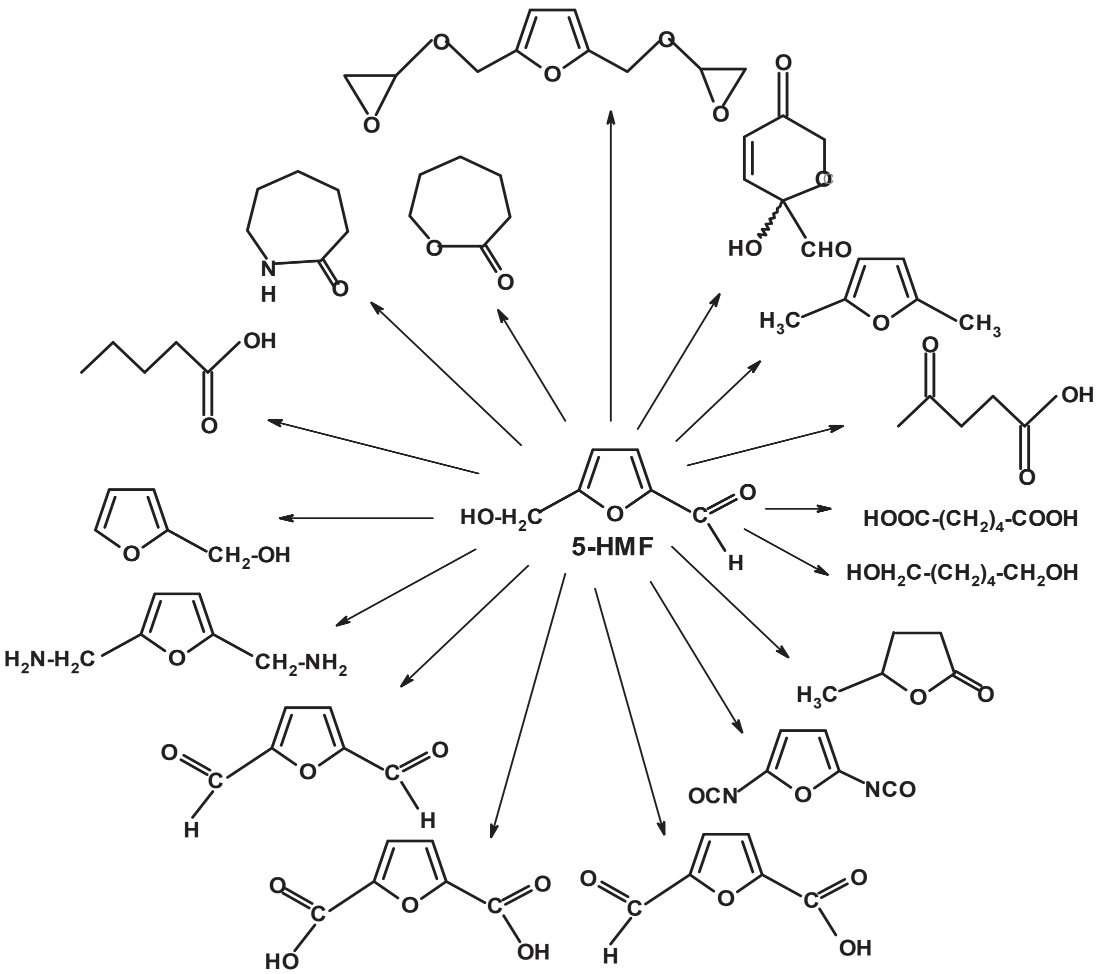

Fig. 3. Selection of simple derivatives of 5-hydroxymethylfurfural designed for further development as fine and specialty chemicals

One of the most promising derivatives of HMF, allegedly close to commercialization, is its oxidation product: 2,5-furandicarboxylic acid (FDCA). It can be considered as a bifunctional symmetric carboxylic acid, prospective monomer for polyester, polyamide, polyurethane biodegradable plastics, and a good replacement for such industrial chemicals as maleic, succinic, and terephtalic acids. As can be expected, several variants of chemical synthetic routes for FDCA, from FUR or HMF already exist [106–110], but translation from demonstration facilities to commercial manufacture is withheld because TEA and LCA assessments are not convincing [111]. Meanwhile, new opportunities based on biocatalytic transformations are maturating to enter the race for future monomer markets [112–114]. Thus, FPCs are essential for sorting out crucial issues of future chemical industry sustainability: origin of commodities and their respective life cycles specification [115], and notorious environmental pollution with polymers resistant to biodegradation [116]. The first issue can be addressed based on analytical methods suitable for LCA [117, 118], in particular Accelator Mass Spectrometry (AMS), designed for carbon dating through precise measurements of the carbon isotope ratio [119]. The environmental plastic pollution problem, on the other hand, has grown to catastrophic proportion. It has been estimated that since the mass production of synthetic polymers started 1950, ca. 6.3 Bln t of plastic waste was generated to 2015. In 2019 annual production of plastics reached 370 M t and it is still growing. Plastic recycling is low and majority of plastic wastes end up in landfills and oceans. While we have proper tools to diagnose the situation, there is still no clear answer how it could be remediated and what should be the role of biobased plastics in the process [120–122].

Conclusions

A decade ago an important exchange of opinions concerning the future of chemical synthesis as a provider of commodities and materials supporting technical development, took place between distinguished scientists representing different methodological inclinations [123]. While J.D. Keasling of UC Berkeley enthusiastically presented a growing potential of engineered microorganisms for biotechnological synthesis of chemicals, A. Mendoza and P.S. Baran from The Scripps Research Institute distinguished between synthetic biology as the way to obtain some extremely complex natural products, from more traditional chemical synthesis which excelled in satisfying the needs of industrial chemistry for circa two centuries. Perhaps not surprisingly, the current view of the necessary fundamental transformation of industrial world into sustainable bioeconomy, carries two important messages concerning origin of energy and materials required to support technical civilization:

- the rational management of the anthropogenic input of GHGs into natural carbon cycles is a critical condition of survival; and
- all bioresources, including synthetic biology and metabolic engineering have to be mobilized for the purpose, in harmony with support from chemical synthesis, both traditional and advanced through the most recent research on design of new materials (and nanoconstructs) as molecular catalysts, and support for metal catalysts.

In particular, the progress in coupling photochemically induced charge separation in a water molecule to the electrochemical (or biocatalytical) processing of the energy and basic feedstock (hydrogen), which can be casually described as artificial (or technical) photosynthesis, will practically determine the pace of the transition to bio-economy, which critically needs clean renewable energy and renewable carbon materials from biomass. Apparently, there is still no natural economic incentive for a new platform chemistries based on catalytic biomass (LCB) conversion, in the real world of coal, gas and oil markets. There is a substantial measure of good will, however, included in international agreements and treaties on climate and CE. It makes possible implementation of the most promising processes in experimental development, demonstrational, and commercialization phases, which have passed technical feasibility assessments.

The idea of sustainable economy has to be moved forward by social understanding and consent, as well as by international cooperation and ample support from intergovernmental programs. From the technical point of view, there is no doubt that with the help of innovation amassed in the first two decades of 21st century, considerable advances in synthetic biology, nanotechnology, IT, chemo- and bio-catalysis and vast renewable resources of biomass can be rationally managed. It is necessary for supporting the transition to bio-economy, and halting the scenario of irreversible global warming. We are aware of an extremely complicated environment of political antagonisms, economic inequality, environmental crisis, pandemic health problems, etc., according to already signed international agreements and treaties. Nevertheless, the transition from fossil to renewable resources is unavoidable. It has to be stressed that it is a multidimensional mega-project of unprecedented dimensions, in which local and national initiatives should be united under the SDG and CE banners. That would require, apart from massive economic support, large amount of scientific and technical innovation, generated in considerable proportion in international cooperation projects, organized within the system of grant competitions. Obviously, such system will require harmonized and precise criteria of innovation, to evaluate and select prospective projects from plethora of similar proposals. Such a goal concerning biorefineries and bioeconomy seems even harder than in the case of evaluating R&D proposals within petrochemical realm, which developed already adequate evaluation standards fitting generally adopted Oslo Manual [124]. In the case of biorefineries, where TEA and LCA are based on sets of local parameters, the innovation assessment would refer to a process functioning under specific conditions, which may defy objectivity criteria. Naturally, all above mentioned elements of change need also solid support from sound scientific education free from any political bias. Therefore, it may be concluded that the present, rather limited participation level of bioeconomy in the global industry may hamper acceleration of much needed bioeconomic innovation, for lack of sufficient tools and instruments supporting the harmonized and efficient R&D effort [125].

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CONSTRUCTIONAL AND TECHNICAL INFRASTRUCTURE OF BIOGAS PRODUCTION

INFRASTRUKTURA BUDOWLANA I TECHNICZNA W PRODUKCJI BIOGAZU

***Summary**: The aim of the present solution – according to inventories no 224455 and 218837 is the description of biogas production technology in family and producer farms, running the litter system of animal management, especially of cattle and pigs. The submitted technology of biogas production consists in accumulation of manure with 20% content of dry matter on the plate which – after filling – is covered with the hermetic shield, constituting the preliminary chamber I. It serves for washing out the liquid and organic mass and its transportation to the main fermentation chamber II where the process of gas obtaining at temperature of 30–40°C is carried out (mesophilic fermentation). To ensure the appropriate temperature of mesophilic fermentation, the solar collector was employed. The main fermentation chamber is equipped in agitator for unification of substrates subjected to methane fermentation, and in screw feeder, enabling supplementation of substrates with energetic additives.*

***Keywords**: substrates, methane fermentation, biogas, solar collector, biogas desulphurization device, tank for biogas storager*

***Streszczenie**: Celem niniejszego rozwiązania – według inwentarzy nr 224455 i 218837 jest opis technologii produkcji biogazu w gospodarstwach rodzinnych i produkcyjnych, prowadzących system ściółkowy chowu zwierząt, zwłaszcza bydła i trzody chlewnej. Przedstawiona technologia produkcji biogazu polega na gromadzeniu na płycie obornika z 20% zawartością suchej masy, który po napełnieniu przykryty jest hermetyczną osłoną, stanowiącą komorę wstępną I. Służy do wypłukiwania masy płynnej i organicznej oraz jego transport do głównej komory fermentacyjnej II, gdzie odbywa się proces pozyskiwania gazu w temperaturze 30–40°C (fermentacja mezofilna). Aby zapewnić odpowiednią temperaturę fermentacji mezofilnej, zastosowano kolektor słoneczny. Główna komora fermentacyjna wyposażona jest w mieszadło do unifikacji substratów poddawanych fermentacji metanowej oraz w podajnik ślimakowy, umożliwiający uzupełnienie substratów dodatkami energetycznymi.*

***Słowa kluczowe**: substraty, fermentacja metanowa, biogaz, kolektor słoneczny, urządzenie do odsiarczania biogazu, zbiornik do magazynowania biogazu*

Introduction

Production of agricultural-origin energy from agricultural farms, especially of those specialised in animal production gives a chance to diversification and increase of agricultural incomes and energetic safety of rural areas, and also to the improvement of environmental protection.

The development and implementation of biogas installations and the possibilities of their adaptation to the structure of agricultural farms in Poland brings the universal possibilities and chances for the improvement of agricultural production effectiveness and of environmental conditions. The submitted solutions give also a chance to meet the requirements of criteria in respect of sustainable production and fulfilling the economic and environmental requirements as well as animal welfare and social needs.

The described solutions satisfy the above mentioned criteria and give the possibility of developing the small and medium-size agricultural farms [1, 6].

Biogas – producing plant for solid and liquid substrates

Within the frames of the studies, the idea of biogas installation, enabling the independent or coherent methane fermentation of two types of substrates [4] was developed. Fig. 1 illustrates the biogas installation, satisfying the mentioned assumptions. Chamber I is adapted to fermentation of solid substrates, including manure, and hydraulic installation ensures the possibility of washing out the organic matter to chamber II. In chamber II, the second degree fermentation of liquid manure and of organic mass, washed out from chamber I, is carried out. Additionally, the solid substrate with dry matter content above 20% may be added to chamber II.

According to the described above biogas installation, fermentation of methane and independent biogas production may be carried out in two versions, and namely:

— simultaneously, in the chambers for solid and liquid substrates;
— irrespectively of the delivery of solid and liquid substance.

The main part of the installation for biogas production from manure with the addition of energetic plants of organic waste is

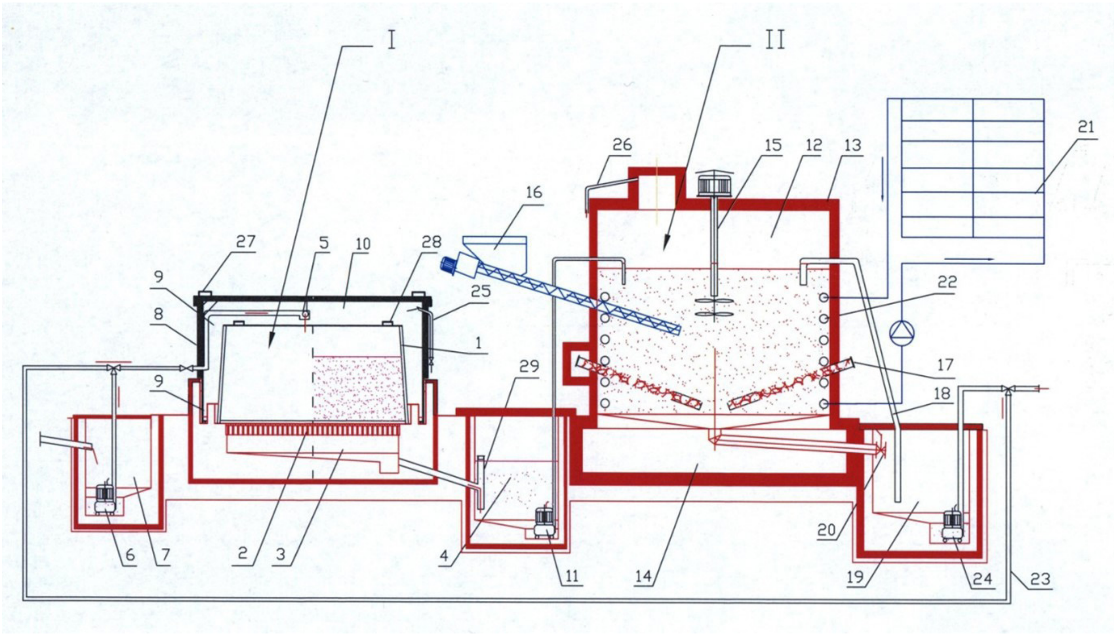

Fig. 1. Biogas installation for substrates with dry matter content above 20% (device for production of biogas from manure)

I – chamber I, II – chamber II; 1- internal container in a form of truncated pyramid; 2 – grid; 3- channel for effluent of organic matter; 4- tank for effluent from chamber I and for fresh liquid manure; 5 – sprinkler; 6 – pressure pump; 7- tank to which slurry is delivered; 8 – external container in a rectangular shape, with thermal insulation; 9 – liquid ring; 10 – hermetical chamber; 11 – pump; 12 – fermentation chamber; 13 – thermal jacket; 14 – thermally insulated strip foundation; 15 – propeller agitator; 16 – screw transporter - feeder; 17 – pipe perforated containers with expanded clay aggregate (granules); 18 – overflow siphon of post-fermentation mass; 19 – tank; 20 – sediment drain valve; 21 – solar collector (panel); 22 – tubular heat exchanger; 23 – thermally insulated pipeline; 24 – pump; 25 – gas pipeline; 25 – holder; 28 – holder; 29 – inflow of liquid manure [4]

hermetic chamber I, constituting the subject of patent no 218837. The essence of the mentioned inventory is the equipment for production of biogas from solid agricultural waste, especially of manure, having a thermal fermentation chamber of a heater, equipped in sprinkler, outflow of the excess of liquid manure and outflow of gas, wherein the fermentation chamber is made from thermal ring with the fixed upper cover whereas the bottom part of thermal ring is hermetically embedded in liquid ring, shaped in the bottom cover, on which there is embedded the container which is found in the interior of the fermentation chamber, and the said contained has a shape of truncated pyramid, being open at the bottom and at the top and having the openwork side walls. The mentioned walls are created from the inclined carrying pillars, connected with the plates. The holders are fixed to the upper part of the container and to the upper cover of the chamber. The equipment ensures the efficient loading of the fermentation charge, the run of fermentation process and unloading of the utilized material. The construction of the fermentation chamber, furnished with the holders, being embodied in hermetical channel ensures the tightness and the possibility of its lifting and lowering according to the needs of loading and unloading of the fermentation material to the container. The container with the openwork walls, as situated inside the fermentation chamber facilitates the effective utilization of the placed charge, with the utilization of sprinkler and heater, depending on the needs of fermentation as well as it enables, owing to the holders, lifting the container and unloading of the used charge from the bottom of the fermentation chamber. The effective emptying of the container from the charge, consisting of solid particles, is ensured owing to its inclined openwork walls.

The object of the inventory concerning the solution of hermetic chamber of biogas installation for solid substrates is illustrated in Fig. 2 where the equipment is presented in longitudinal cross-section and upper projection.

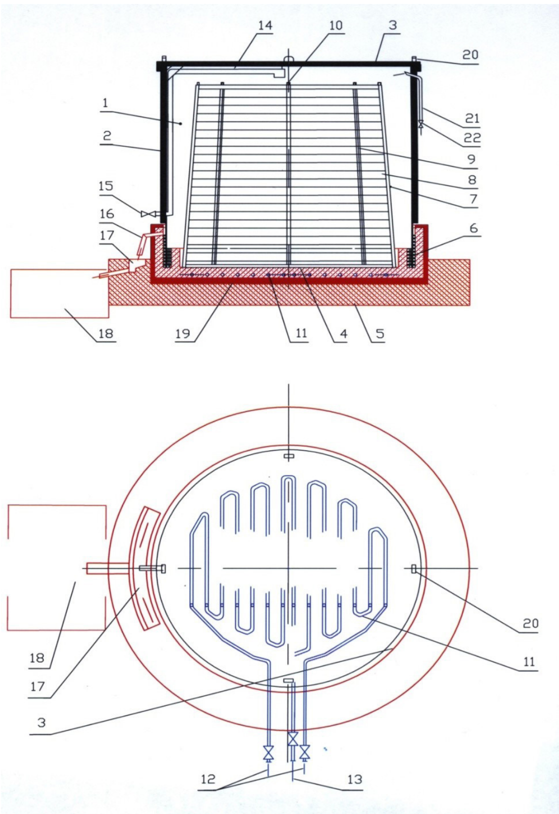

Fig. 2. The scheme of hermetic chamber of biogas installation for solid substrates
1 – fermentation chamber; 2 – thermal wall ring; 3 – upper cover; 4 – bottom cover; 5 – strip foundation; 6 – liquid ring; 7 – container; 8 – inclined carrying pillars; 9 – plates; 10 – carrying holders; 11- tubular heater; 12 – feeding valves; 13 – outflow valve; 14 – sprinkler; 15 – valve; 16 – outflow opening; 17 – outflow gutter; 18 – tank; 19 – thermal insulation; 20 – carrying holders; 21 – biogas outflow pipeline; 22 – valve [4]

The equipment consists of fermentation chamber 1, created from thermal wall ring 2 assembled with the upper cover 3. At the bottom, the fermentation chamber has a cover 4, embodied on strip foundation 5. In the bottom cover 4 there is a liquid ring shaped 6 in which the liquid hermetically tightens the lower walls of thermal wall ring 2 of the fermentation chamber 1. The container 7 is constructed in a form of truncated pyramid open at the bottom and at the top, having the openwork side walls, made of inclined carrying pillars 8 combined with the plates 9. At the upper part, the container 7 has the assembled holders 10 serving for positioning of the container on the bottom cover 4. In the wall of the bottom cover 4 there is installed a tubular heater 11, supplied with the heating agent of the pipeline, having the feed valves 12 and outflow valve 13. In the fermentation chamber 1, there installed the sprinkler 14 with the valve 15, supplying the liquid manure. In the lower part of the wall ring 2 of the fermentation chamber 1 there is a outflow opening 16 of the liquid manure which ensures obtaining the level of the liquid up to the height of the position of the said opening. The outflow opening 16 is assembled with the outflow gutter 17, combined with the tank 18. Between the bottom cover 4 of the fermentation chamber 1 and the strip foundation 5, the thermal insulation 19 is fixed. To the top cover 3, the assembling holders 20 are affixed. In the upper part of the thermal ring 2 of the fermentation chamber 1, there is fixed the biogas outflow pipeline 21 with valve 22

Functioning of installation for biogas production

After lifting of the upper cover 3 with thermal ring 2 using the holders 20, the container 7 is filled with the charge e.g. manure. Then, the upper cover 3 with the wall thermal ring 2 is put on the container 7 and the bottom part of the said ring 2 is situated in the liquid ring 6 of the bottom cover 4 what causes hermetical tightening of the fermentation chamber 1. As a result of the fermentation of the charge with the utilization, depending on the needs, of the heater 11 and sprinkler 14, the obtained biogas is evacuated by pipeline 21 for utilization according to the needs. The excess of the liquid from the fermentation chamber 1 is discharged by outflow gutter 17 to the tank 18. After ending the process of fermentation and cessation of biogas evolution, a mobile part of the fermentation chamber 1 is risen up by the holders 20 and then, the container 7 is lifted by the holders 10. The utilized charge is removed from the bottom cover 4 of the strip foundation 5. The described above installation of the fermentation chambers for biogas obtaining is supplemented with the following parts of installation: set for treatment of biogas from hydrogen sulphide and water and biogas tank for its storage.

Biogas produced in the installations, being found in the agricultural farms is transferred to the reservoirs where it is stored under a constant pressure and delivered to current-generating aggregate or to the household facilities. There are known the so-called wet gas reservoirs, constructed from cylindrical container with two walls between which the liquid is found. In the reservoir, between its walls, there is a mobile bell. The tightness of the reservoir is ensured by the liquid, present between the walls of the reservoir. Other known reservoirs are built from the elastic fabric in a shape of roller or rectangular form and are situated in the casing with rectangular walls and a gable roof. There are also the reservoirs in shape of sphere or roller with flexible walls pressured with the charging plate in order to ensure the constant pressure.

Installation for production of biogas from natural fertilizers (manure), together with the appropriate instrumentation

The constructed installations need the reservoirs which are simple in construction and effective in operation. The essence of utility model includes construction of reservoir for biogas storage under the constant pressure, delivered from the agricultural farm and destined especially for the supply of household facilities. The mentioned construction has a flexible container, pressurized with the plate form the top, being equipped in inflow, outflow and safety gas valves. The installation for production of biogas from manure is presented in Fig. 3.

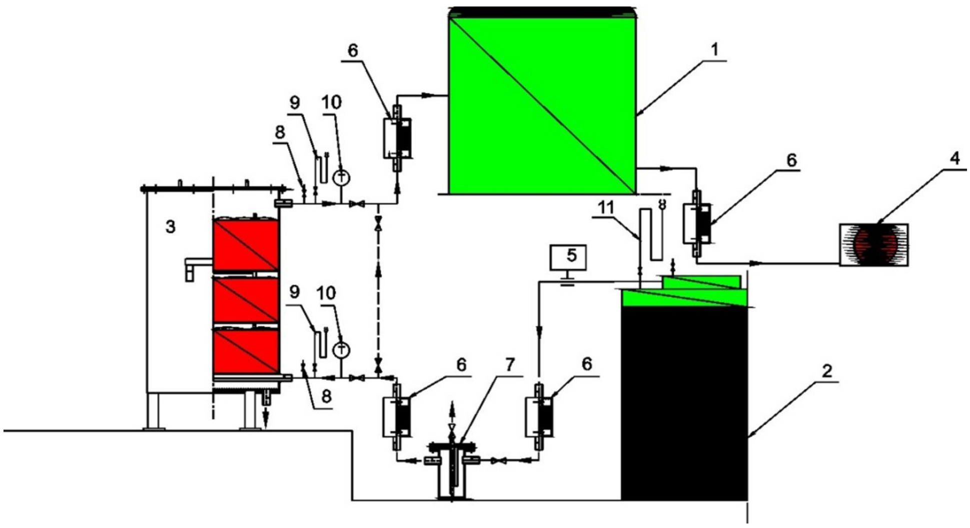

Fig. 3. Installation for production of biogas from natural fertilizers, especially from manure, with the employed system for biogas treatment – removal of H2S:

1 – biogas reservoir; 2 – fermentation chamber; 3 – desulphurisation facility; 4 – cogeneration aggregate; 5 – gas counter; 6 – flame interrupter; 7 – dewatering device; 8 – gas sampler; 9 – manometer; 10 – thermometer; 11 – safety valve [2, 5]

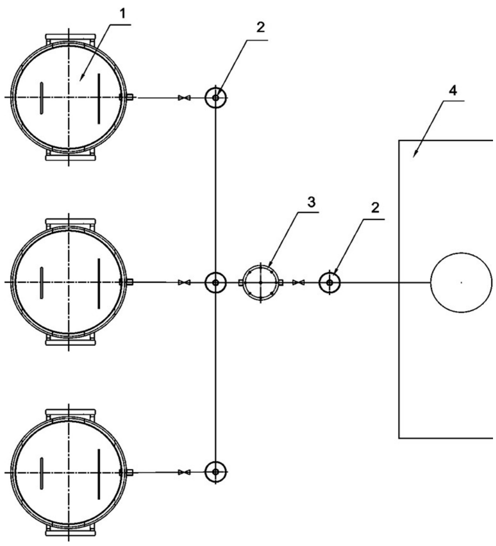

Fig. 4. Scheme of biogas producing plant with the system of three desulphurization devices: 1 – desulphurisation device; 2 – dewatering devices; 3 – flame interrupter; 4 – biogas producing plant with the chambers for solid and liquid substrates [3]

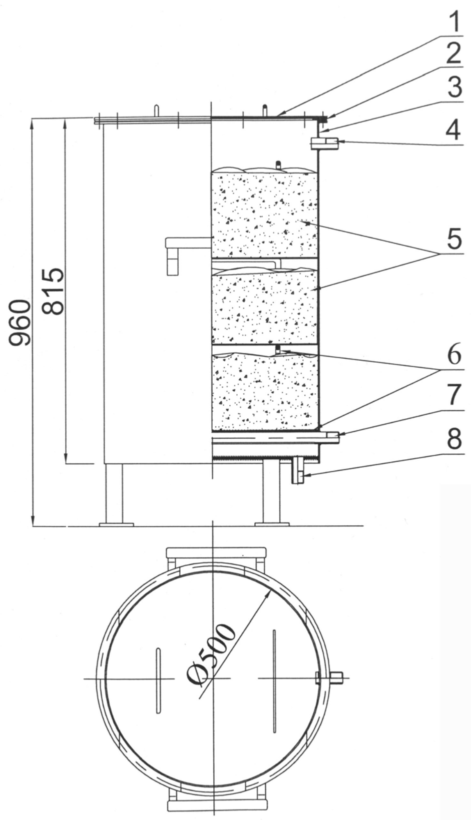

Fig. 5. Desulphurisation device adapted to removal of H2S in the biogas installation with the power below 20 kW: 1 – cover; 2 – seal; 3 – reservoir of sulphur recovery device; 4 – connection – gas entrance; 5 – bed of bog iron ore; 6 – bracket with perforated plate; 7 – connection – gas exit; 8 – connection for condensate removal [3]

Additionally, the submitted construction has also floor foundation with three vertical slideways, furnished with distance sleeves, on which two rubber (lower and upper) ring reservoirs are placed; on the mentioned ring reservoirs, the pressure plate with the fixed leading sleeves is situated. The sleeves are put on vertical slideways, the upper terminals of which are linked with the bonding element. The reservoir rings are connected with the installation by flow-through system, with the use of three tees: inflow tee, outflow tee and control-measuring tee, situated between the walls of the reservoir rings. Pressing the reservoir rings from the top with the pressure plate, lowered down on the slideways to the level of upper distance terminals of the sleeves and the simultaneous observation of manometer, linked to the pipeline with the control-measuring tee, enables obtaining of the correct, constant pressure, under which biogas is transferred to receivers of the household facilities. In the periods when the biogas is not supplied to the reservoir from the biogas plant – what may cause the drop of the pressure which can cut off the gas delivery to the receivers (by reaction of cut-off valve, attached to the pipeline with outflow valve) – the pressuring plate may be additionally charged with the charger in order to increase the insufficient pressure [3].

Fig. 4 and 5 show the desulphurization devices, and Fig. 6 illustrates flame interrupter. The both devices are the elements of the submitted installation.

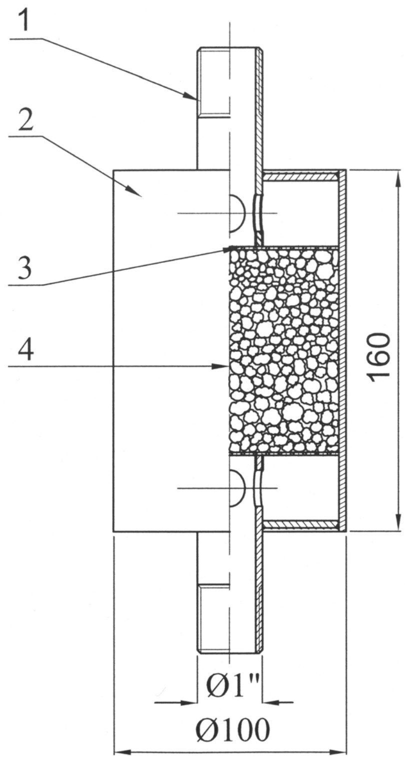

Fig. 6. Flame interrupter for biogas installation (vertical situation): 1 – connection; 2 – reservoir; 3 – perforated bottom; 4 – filling (fine gravel) [3]

Reservoir for storage of biogas, constructed from flexible cylindrical rings (utility model of 24.08.2012)

Biogas produced in the installations, being found in the agricultural farms is transferred to the reservoirs where it is stored under a constant pressure and delivered to current-generating aggregate or to the household facilities.

There are known the so-called wet gas reservoirs, constructed from cylindrical container with two walls between which the liquid is found. In the reservoir, between its walls, there is a mobile bell. The tightness of the reservoir is ensured by the liquid, present between the walls of the reservoir. Other known reservoirs are built from the elastic fabric in a shape of roller or rectangular form and are situated in the casing with rectangular walls and a gable roof. There are also the reservoirs in shape of sphere or roller with flexible walls pressured with the charging plate in order to ensure the constant pressure.

The constructed installations need the reservoirs which are simple in construction and effective in operation. The essence of utility model includes construction of reservoir for biogas storage under the constant pressure, delivered from the agricultural farm and destined especially for the supply of household facilities. The mentioned construction has a flexible container, pressurized with the plate form the top, being equipped in inflow, outflow and safety gas valves.

The discussed installation has a floor base with three vertical guide bars, furnished with distance sleeves, on which two rubber (lower and upper) ring reservoirs are placed; on the mentioned ring reservoirs, the pressure plate with the fixed leading sleeves is situated. The sleeves are put on vertical slideways, the upper terminals of which are linked with the bonding element. The reservoir rings are connected with the installation by flow-through system, with the use of three tees: inflow tee, outflow tee and control-measuring tee, situated between the walls of the reservoir rings. The reservoir has a relatively simple construction and is easy in operation. Pressing the reservoir rings from the top with the pressure plate, lowered down on the slideways to the level of upper distance terminals of the sleeves and the simultaneous observation of manometer, linked to the pipeline with the control-measuring tee, enables obtaining of the correct, constant pressure, under which biogas is transferred to receivers of the household facilities. In the periods when the biogas is not supplied to the reservoir from the biogas plant – what may cause the drop of the pressure which can cut off the gas delivery to the receivers (by reaction of cut-off valve, attached to the pipeline with outflow valve) – the pressuring plate may be additionally charged with the charger in order to increase the insufficient pressure.

Fig. 7. Prototype of the biogas reservoir, consisting of flexible rings [archive of the Institute]

The idea of the solution, constituting the utility model is presented in Fig. 7 where the prototype of the biogas reservoir has been constructed from three cylindrical rings (rubber tubes). Fig. 8 shows two rings.

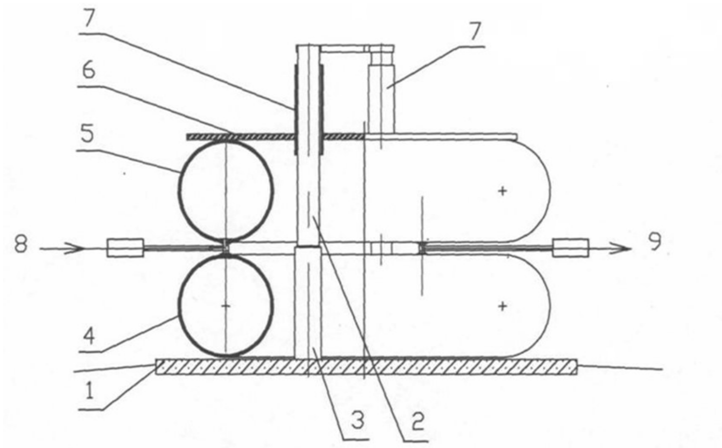

Fig. 8. Scheme of biogas reservoir made from flexible (rubber) rings, suitable for application in laboratory biogas devices or small biogas plants
1 – base; 2 – slideway; 3 – foot; 4 – cylindrical (flexible) lower ring; 5 – cylindrical (flexible) upper ring; 6 – upper pressuring plate; 7 – sleeve of slideway; 8 – inflow of biogas; 9 – outflow of biogas [own development]

Operating costs of the suggested installation

The annual maintenance cost:

$$K_{utrz} = \frac{K_i}{T_i} + K_u = \frac{450\ 000}{20} + 0{,}2 \cdot \frac{450\ 000}{20} = 27\ 000 \text{ PLN} \cdot \text{year}^{-1}$$

where:

S – coefficient – 0,2

K_{utrz} – maintenance cost

K_i – cost of investment

T_i – time of investment utilizing

K_u – insurance cost: $\frac{K_i}{T_i} \cdot S$

$K_{uż}$ – The operating costs

$K_{uż} = K_r + K_{ee} + K_n$ = 10 600 PLN • year^{-1}

K_r – labour cost;

K_{ee} – costs of electric energy;

K_n – costs of repairs 0.3 $\frac{K_i}{T_i}$

The quantity of the produced biogas – 112 thousand m^3/year^1.
The quantity of the produced electric energy – 212 MWh · year^1.
The quantity of the produced thermal energy – 246 MWh · year^1.

The operating costs:

$$K_e = K_{utrz} + K_{uż} = 27\ 000 \text{ PLN} + 15\ 450 \text{ PLN} = 42\ 450 \text{ PLN} \cdot \text{year}^{-1}$$

The cost of electric energy production:

$$K_{ce1} = \frac{27\,000 + 15\,450}{212 + 172} = 110.55 \text{ PLN·MW h}^{-1}$$

The calculations did not consider 30% of thermal energy which is used in heating of biogas plant.

The cost of thermal energy production:

$$K_{ce2} = \frac{27\,000 + 15\,450}{212} = 200.23 \text{ PLN·MW h}^{-1}$$

The annual consumption of raw material (substrate) for biogas production:

$$2.9 \text{ t·d}^{-1}\text{·}365 \text{ d} = 1058.5 \text{ t}$$

When assuming the price of raw material (manure, droppings) in amount of 10 PLN for 1 t, the annual cost of the raw material is:

$$1058.5 \text{ t} \times 10 \text{ PLN·t}^{-1} = 10\,585 \text{ PLN}$$

The real cost of electric energy production:

$$K_{ce3} = \frac{27\,000 + 15\,450 + 10\,585}{212 + 172} = 138.11 \text{ PLN·MWh}^{-1}$$

The real cost of thermal energy production:

$$K_{ce4} = \frac{27\,000 + 15\,450 + 10\,585}{212} = 250.16 \text{ PLN·MWh}^{-1}$$

The mentioned above elements of installation were taken from own authorial developments for the needs of the project BIOSTRATEG BIOGASEE/WP1/1/ZEBW/B/D02 for biogas installation of 20 kW size, with fermentation chambers 2 x 100 m^3.

Summing up

The submitted solutions of technological installation for biogas obtaining from substrates with dry matter content above 20% as well as from liquid substrates with 5–8% dry matter content allow the universal utilization up to ca. 200 LSU (Livestock Units) in agricultural farms specialized in animal production.

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THE INFLUENCE OF CLIMATE CHANGE IN EUROPE ON THE SITUATION OF THE FUTURE AGRICULTURE

WPŁYW ZMIAN KLIMATYCZNYCH W EUROPIE NA PRZYSZŁOŚĆ ROLNICTWA

***Summary**: Climate change has a significant impact on soils, and changes in land use can either accelerate or slow down these changes. Without proper soil and sustainable land management, we will not be able to face the climate crisis, produce enough food or adapt to climate change. The answer to these questions may be to protect and restore key ecosystems and allow nature to absorb carbon from the atmosphere. After the oceans, soil is the second largest natural carbon sink and surpasses forests and other vegetation in its ability to trap carbon dioxide from the air. These facts remind us of the importance of healthy soils - not only for food production, but also for our efforts to prevent the worst possible effects of climate change. The continual decline in soil moisture can contribute to increasing the need for irrigation in agriculture and can lead to reduced yields and even desertification with potentially dramatic effects on food production. Land surface desertification is also affected by solar activity, which changes as cycles - currently there is a cycle with a fairly moderate impact on agricultural land.*

***Keywords**: climate change, soil water resources, desertification of agricultural areas, sun activity*

***Streszczenie**: Zmiana klimatu ma znaczący wpływ na gleby, a zmiany w użytkowaniu gruntów mogą przyspieszyć lub spowolnić te zmiany. Bez odpowiedniej gleby i zrównoważonego gospodarowania gruntami nie będziemy w stanie stawić czoła kryzysowi klimatycznemu, produkować wystarczającej ilości żywności ani dostosowywać się do zmian klimatu. Odpowiedzią na te pytania może być ochrona i odbudowa kluczowych ekosystemów oraz umożliwienie naturze pochłaniania węgla z atmosfery. Po oceanach, gleba jest drugim co do wielkości naturalnym pochłaniaczem dwutlenku węgla i przewyższa lasy i inną roślinność pod względem zdolności do wychwytywania dwutlenku węgla z powietrza. Te fakty przypominają nam o znaczeniu zdrowych gleb – nie tylko dla produkcji żywności, ale także dla naszych wysiłków na rzecz zapobiegania najgorszym możliwym skutkom zmian klimatycznych. Ciągły spadek wilgotności gleby może przyczynić się do zwiększenia zapotrzebowania na nawadnianie w rolnictwie i może prowadzić do zmniejszenia plonów, a nawet pustynnienia, co może mieć dramatyczny wpływ na produkcję żywności. Na pustynnienie powierzchni ziemi ma również wpływ aktywność słoneczna, która zmienia się cyklicznie – obecnie występuje cykl o dość umiarkowanym wpływie na grunty rolne.*

***Słowa kluczowe**: zmiany klimatyczne, zasoby wodne gleby, pustynnienie terenów rolniczych, aktywność słoneczna*

Introduction

Scientists are already seeing the effects of climate change around the world, including in European soils. Hence, although it would seem that the lack of water affects Poland to a limited extent, nothing could be more wrong. Climate changes, human interference in the natural course of rivers and over-exploitation of water resources make droughts our new reality and the country's steppe – a real problem. We found out about it in April 2021, when the low water level in the Vistula River, revealing a surprising landscape, brought to light the problem of drought in Poland. For example, according to the latest EU report on climate change, its effects and vulnerability in Europe, soil moisture has decreased significantly in the Mediterranean region and increased in parts of northern Europe since the 1950s.

Climate researchers predict similar effects in the coming decades as the rise in average temperatures continues and rainfall patterns fluctuate. A total of 13 EU Member States said they were affected by desertification and in a further 3 the problem is starting to become apparent. In the years 1951-1981, only 6 droughts were recorded in Poland - one on average every 5 years, while in the years 1982–2011 there were as many as 18 droughts - on average every 2 years. Starting from 2013 – drought affects us every year. In 2020, we experienced drought for the first time in spring. The Food and Agriculture Organization of the United Nations (FAO) recently released a map that shows that 30 cm of the top soil in the world contains about twice as much carbon as the entire atmosphere.

Despite these observations, a recent report by the European Court of Auditors recognizes that Europe does not have a clear picture of the situation regarding the challenges of desertification and land degradation, and that the measures taken to combat desertification are not consistent. Figure 1 shows in light color the top view of the soil moisture content in individual European countries. It is clearly visible that the greatest problems with water in the soil are experienced by the Iberian Peninsula,

Fig. 1. The structure of the land surface of European countries in terms of water abundance (light color, tendency to desertification – low water supply in the ground)
Source: https://www.dreamstime.com

southern Italy, Bulgaria, Romania, Central European countries, including Poland and northern European countries. The UN General Assembly in 1995 established June 17 as the World Day to Combat Desertification and Drought.

The influence of the sun also has impact on the condition of agricultural land on earth. Solar activity is a series of cycles in which we observe changes in the behavior of our life-giving star. Cycles lasting about 11 years are characterized by decreases and increases, among others sunspots, flares, and spectacular mass ejections from the sun. Scientists already agree that we have been in the 25th Cycle of Solar Activity for at least a few months, and it is starting to increase. The sun in its cycles sometimes "calms down" and sometimes it behaves more "restless". In the transition periods between cycles, there is no observation of, inter alia, sunspots or large flares in the sun. Such a time occurred in 2017 and 2018. Scientists around the world, including US scientists from NASA and NOAA (National Oceanic and Atmospheric Administration), have been waiting for more symptoms of the new cycle and agree that the transitional moment occurred in December 2019, and today we are certainly experiencing another, 25th solar cycle. First of all, the number of sunspots will continue to increase.

The current observations of astronomers show that in recent months the activity of the Sun has been increasing at a similar pace as it was in the case of the last cycle. On this basis, it is estimated that the peak of solar activity will fall in July 2025, when about 115 sunspots will be visible on the disk of our star. Solar activity has an impact on the Earth, and above all on the temperature of the atmosphere and the temperature of the surface of arable land. Scientists also agree that once in several million years, the Sun can produce such a powerful flare that is capable of destroying the entire ozone layer, leading to the annihilation of life on Earth. Smaller, but still large, flares that can have a noticeable devastating effect on agricultural infrastructure are "slightly" more frequent.

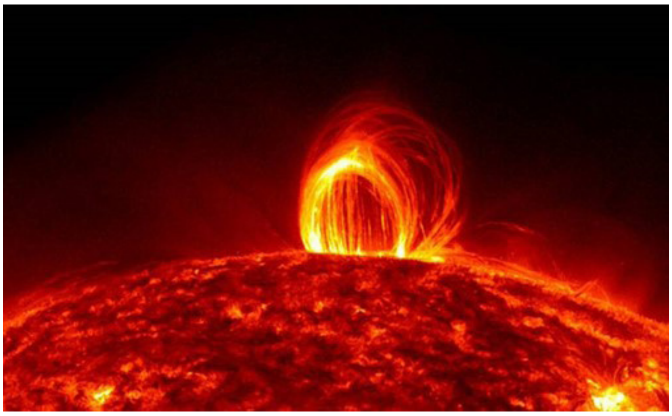

Fig. 2. Local outbreaks in the sun have a big impact on climate change around the globe
Source: [NASA - 2021] https://www.komputerswiat.pl/aktualnosci/nauka-i-technika

Changes in the seasonal temperature pattern may also shift the life cycles of plants and animals throughout the year, which may result in lower yields. For example, spring may come earlier and the trees may bloom before the pollinating insects have hatched. Given the expected population growth, what is needed is an increase, not a decrease, in world food production. This is largely dependent on the maintenance of healthy soil and the sustainable management of agricultural land. At the same time, there is a growing demand for biofuels and other plant-based

Fig. 3. Dried grass during dry season
Source: https://pixabay.com

products due to the urgent need to replace fossil fuels and prevent greenhouse gas emissions.

The EU report also highlights other effects of climate change on soil quality, including erosion, which can be accelerated by extreme weather events such as heavy rainfall, droughts, heat waves and storms. In addition to the loss of land surface, rising sea levels can contribute to changing the condition of the soil in coastal areas or to introducing marine pollutants, including salt, into them. Regarding land use, climate change may render some agricultural areas – mainly in the south – unusable or less productive, while more in the north, climate change is likely to open up new opportunities.

Prevention of the climate crisis through actions for the benefit of the soil

In April 2019, an EU group of scientists called for "the protection and restoration of forests, peatlands, swamps, natural seabed and other key ecosystems" to enable nature to absorb and store carbon dioxide from the atmosphere. Restoring ecosystems will also support biodiversity conservation and contribute to the enhancement of a wide range of ecosystem services including air and water purification, providing people with pleasant spaces for recreation. Information on the relationship between soils and climate change shows that around 75 billion tonnes of organic carbon is stored in soil across the EU. About half of these soil resources are found in Sweden, Finland and the United Kingdom, as they have more forest soils than other countries, in particular moist organic soils such as peat. For comparison, according to the latest EU estimates, in 2017 total CO_2 emissions in the EU amounted to around 4.5 billion tonnes.

Organic carbon content in EU soils may increase slowly, but estimates of the pace of this change are highly uncertain. The situation becomes even more complicated as organic carbon stocks are also constantly changing, as plants capture carbon dioxide from the air before it decomposes and releases gases back into the atmosphere. An EU report confirms that greenhouse gas emissions from all sectors, including land and food, need to be reduced in order to meet the goal of keeping global warming well below 2 degrees Celsius. Despite the uncertainties, restoring ecosystems and improving soil quality can be a very cost-effective action in terms of climate action, with a triple effect.

First of all growing plants helps to absorb carbon dioxide from the atmosphere. According to the FAO, restoring currently degraded soils could remove as much as 63 million tonnes of carbon, which would offset a small but significant percentage of global greenhouse gas emissions. Second, healthy soils trap carbon underground. Third, many natural and semi-natural areas offer powerful protection against the effects of climate change. There are many examples of the benefits. For example, areas adjacent to rivers (riverside zones) and green spaces in cities can provide cost-effective protection against floods and heat waves.

Desertification in the EU – an increasing threat posed by climate change and human activities

Europe is increasingly affected by desertification. The greatest risk of desertification is in southern Portugal, parts of Spain and southern Italy, south-eastern Greece, Malta and Cyprus, and the Black Sea areas in Bulgaria and Romania. Research has shown that these regions are often affected by soil erosion, salinity, soil organic carbon loss, biodiversity loss and landslides. The long period of high temperatures and little rainfall in Europe in summer 2018 reminded us of the growing importance of this problem.

Desertification is a form of land degradation in drylands. The term is used to describe the processes related to human activity and the climate that result in specific problems in arid lands, such as less food production, decreased soil fertility, reduced natural soil resilience and poor water quality.

Desertification means "the degradation of the land in arid and semi-arid regions due to a variety of factors, including climate variability and human activity". This phenomenon can lead to poverty, serious health problems due to wind-blown dust, and

Fig. 4. Typical small Polish farms in Świętokrzyskie region
Source: https://pixabay.com

a reduction in biodiversity. It also has demographic and economic effects as it forces people to flee the affected areas. Desertification does not describe the conditions in areas traditionally described as "deserts". Rather, it relates to dry areas.

Soil degradation means a reduction or loss in biological or economic productivity. As a result, fertile land becomes less productive. Overall, human activity is the cause of soil degradation.

Dry, semi-arid or intermittently dry areas are areas where the ratio of annual rainfall to potential evaporation and transpiration – that is, the dryness index – is in the range of 0.05 to 0.655. Dry areas are prone to frequent occurrence of droughts.

Drought is a situation where rainfall levels remain well below normally recorded levels, causing severe disturbance of the hydrological balance that adversely affects the land resource production system. Drought and desertification are closely related phenomena, but drought is short to medium term in nature, in contrast to desertification which is a long term phenomenon.

If droughts last for months or years, they can affect huge areas and have serious economic, social and environmental impacts. While droughts have always occurred, their frequency and impact have increased as a result of climate change and human activities that are not adapted to local climatic conditions.

Fig. 5. Inhibition of the growth and development of maize seedlings in conditions of water scarcity

Source: https://pixabay.com

Dryness means a climatic situation characterized by a scarcity of water resources. This long-term phenomenon is measured by comparing the long-term average water supply (rainfall) to the long-term average water demand (evaporation and transpiration of plants).

Deserts mean extremely dry, barren areas with very little rainfall and where the consequent conditions are unfavorable for plant and animal life.

Soil degradation leads to emissions of greenhouse gases into the atmosphere, which risk exacerbating climate change and further loss of biodiversity. There is a risk that biomass and organic carbon stored in the soil will be released into the atmosphere as a result of the projected increase in storm intensity, as well as due to fires, soil degradation and the presence of pests.

Soil remediation allows greenhouse gases to be gradually absorbed from the atmosphere, allowing trees and vegetation to grow. These plants, in turn, can absorb greater amounts of carbon dioxide. In areas where soil has been degraded, these processes do not take place and carbon dioxide is not absorbed from the atmosphere.

Fig. 6. Grain just before harvest in central Poland, in an area affected by drought

Source: https://Shutterstock.com

Various climate change scenarios confirm the EU's increasing exposure to desertification. As climate change progresses, water resources in parts of Europe are dwindling and droughts have been found to become more frequent in parts of Europe, increasing exposure to desertification. Based on climate change models used by the European Commission, temperatures are projected to increase by more than 2°C in some regions (e.g. Spain) by the end of the century. Over the same period, summer rainfall is expected to decrease by 50% or more in southern Europe.

The 2018 report of the Intergovernmental Panel on Climate Change stated with great certainty that temperatures on particularly hot days in mid-latitudes will increase by around 3°C with global warming of 1.5 °C and around 4°C with a global warming of 2°C, and that the number of hot days will increase in most land regions.

Forecasts of climate change in Europe confirm that the threat of desertification in Europe is increasing. Hot semi-deserts already exist in southern Europe, where – as the research shows – the climate changes from temperate to dry. Already, this phenomenon is progressing further north. Scientific evidence shows that anthropogenic emissions have significantly increased the likelihood of dry years in the Mediterranean basin.

Discussion and conclusions

— Desertification and land degradation are complex phenomena influenced by many interdependent factors. To date, no scientific consenses has been reached on how to evaluate these factors. However, indirect indicators can be used to detect soil deterioration. While many such indirect indicators exist, the EU recommends the use of three sub-indicators for assessing soil degradation: land productivity, soil organic carbon, and land cover and land cover change.

- The 2013 EU Strategy on Adaptation to Climate Change recognizes the importance of combating desertification as one of the climate adaptation actions to be supported. Member States are encouraged to develop their own national strategies.
- Data related to desertification monitored by the European Commission report that 22% of Europe's land area is affected by soil erosion.
- Soil degradation has a transboundary impact: soil is not a static formation and the causes of soil degradation are often global. Soil degradation is often considered a local phenomenon, but soil particles move around. Research shows that erosion processes by water and wind, dust storms or human-related phenomena such as pesticide contamination are important in terms of the transboundary impacts of soil degradation and have economic, social and environmental impacts such as climate change, health problems and food shortages. Despite the cross-border dimension of the phenomenon, Member States and the Commission are not coordinating efforts to achieve the EU's land degradation neutrality objective.
- In order to develop a fully consistent assessment of desertification and land degradation across the EU, the European Commission needs the agreement of the Member States on a common methodology for compiling the available indicators.
- The European Commission collects relevant data for monitoring desertification, on land cover/land use, soil moisture content and vegetation/biomass indicators from satellite data (Copernicus program), and soil data from LUCAS and national programs. These data are already included in indicators at EU level (agri-environment indicators, SDG indicators, etc.). In 2018, the Commission published the Global Desertification Atlas, based on data collected at EU and global level.
- It should be recalled that, in the case of afforestation and forestry projects, Member States are required to ensure that the selection of species, varieties and origin of trees takes into account the need for resilience to climate change as well as the hydrological conditions. Forestry projects have a beneficial effect in preventing desertification and soil degradation. The forest cover protects the soil against erosion, and at the same time increases the ability to absorb carbon. Restoring the forest landscape can help to conserve biodiversity and reduce soil degradation. Also, agroforestry measures can help tackle soil degradation through the efforts of local communities in peripheral areas.
- In the absence of EU soil protection legislation and measures to prevent and restore soil degradation, Member States are responsible for implementing appropriate measures at national level.
- We found that the EU is not taking effective and efficient action to reduce the risk of desertification. While desertification and land degradation represent current and growing threats in the EU, the Commission does not have a clear view of the situation in this regard, and efforts to combat desertification are not consistent.

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THE USE OF TECHNICAL KNOWLEDGE IN LABOUR ECONOMICS

WYKORZYSTANIE WIEDZY TECHNICZNEJ W EKONOMII PRACY

***Summary**: The results of labour intensity calculations for a specific employee with the use of normative documents are presented. The indicators of average energy consumption of labour, as calculated for all categories of workers, depending on sex, age, body weight and physical activity ratio are presented.*

***Keywords**: labour consumption, physiological energy norms, physical activity indicator, average energy consumption of labour, cost, price*

***Streszczenie**: W artykule przedstawiono wyniki obliczeń pracochłonności dla konkretnego pracownika z wykorzystaniem dokumentów normatywnych. Przedstawiono wskaźniki przeciętnej energochłonności pracy obliczone dla wszystkich kategorii pracowników w zależności od płci, wieku, masy ciała i wskaźnika aktywności fizycznej.*

***Słowa kluczowe**: pracochłonność, fizjologiczne normy energetyczne, wskaźnik aktywności fizycznej, średnia energochłonność pracy, koszt, cena*

Introduction

According to the universal Declaration of Human Rights (1948) [6] and the International Covenant on economic, social and cultural rights (1966) [4], "the ideal of free human beings enjoying freedom from fear and want can only be implemented if there is a conditions whereby everyone may enjoy his economic, social and cultural rights, as well as their civil and political rights". Their effective implementation is necessary to observe the principle of equal pay for equal labour. However, the average wage level in rural areas is much lower than in other sectors of the economy, although the quantity and quality of labor is the same. This negative fact results in discrimination on a sectoral basis. To eliminate it, the method of energy analysis was developed. The mentioned problems were partially addressed in [2] and [3].

In our opinion, the labour is a conscious energy to create goods; it is the basis of evaluating and pricing. On the basis of equality of people, the socially necessary equal work should be paid equally regardless of the industry sector worker. Therefore, the development of standards for the energy equivalent of 1 man-hour is an urgent task.

Material and methods

To determine the energy consumption (energy equivalent) of labour in various categories of workers, we used the "Norms of physiological needs for energy and nutrients for different groups of population of the Russian Federation. Guidelines" [5] and the obtained data were compared with materials GOST R 51750-2001. Method of determining energy consumption during the production of goods and rendering of services in technological energy systems [1].

Total energy expenditure (ΣE_H) per day according to intensity can be divided into three parts: during sleep (E_S) (cost of energy at this time is equal to the value of basal metabolism (E_{VBM}) [5]), during personal time (E_{PT}) (very low physical activity, I group physical activity [6]) and to labor (E_L):

$$\Sigma E_H = E_S + E_{PT} + E_L \tag{1}$$

$$E_S = E_{VBM} : 3 \tag{2}$$

$$E_{PT} = [(E_{VBM} \times 1.4) - E_S] : 2 \tag{3}$$

$$E_L = (E_{VBM} \times C_{PhA}) - E_S - E_{PT} \tag{4}$$

where:
C_{PhA} is the coefficient of physical activity, [5].

Using the above mentioned formulas, we calculated the average values of the energy intensity of labor all categories of workers, depending on physical activity, body mass, gender and age. It is worthy to notice that the entire adult population, depending on the magnitude of energy expenditure was divided into 5 groups for men and 4 groups for women, taking into account the production of physical activity and other expenditure [5].

Results and discussion

When utilizing the results of the calculations according to the above discussed procedure, we obtained the following values of energy consumption or the energy equivalent of labour between the different types of workers according to the ratio of their physical activity. The employed unit is MJ/hour.

Group I (a very low physical activity; men and women): The workers mainly performing a mental work; physical activity coefficient of **1.4** (civil servants of administrative organs and institutions, researchers, teachers of universities, colleges, secondary school teachers, students, medical professionals, psychologists, managers, operators including equipment maintenance of computers and computer software, programmers, employees of financial-economic, legal and administrative services, employees of design offices and divisions, advertising and information services, architects and engineers in industrial and civil construction, tax officers, employees of museums, archives, librarians, specialists, service, insurance, dealers, brokers, sales agents and procurement officials on social and pension funding, patent attorneys, graphic designers, Travel Desk, reference services and other related activities).

Table 1. The average values of the labour energy consumption of the adult population of Russia for group I of physical activity (MJ/h)]

Men					Women				
Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years	Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.405	0.382	0.357	0.329	40	0.302	0.293	0.285	0.268
55	0.424	0.399	0.377	0.346	45	0.321	0.313	0.301	0.287
60	0.444	0.419	0.394	0.363	50	0.343	0.332	0.324	0.307
65	0.466	0.438	0.413	0.380	55	0.363	0.352	0.341	0.324
70	0.488	0.461	0.432	0.399	60	0.385	0.374	0.363	0.343
75	0.511	0.480	0.452	0.419	65	0.405	0.394	0.382	0.360
80	0.536	0.505	0.475	0.438	70	0.427	0.416	0.402	0.380
85	0.561	0.530	0.497	0.458	75	0.447	0.433	0.422	0.399
90	0.589	0.555	0.522	0.480	80	0.469	0.455	0.441	0.419

Group II (low physical activity; men and women) – workers engaged in light labour, the physical activity coefficient is **1.6** (drivers of urban transport, workers of food processing, textile, garment, electronic industry, operators of pipelines, packers, drivers of railway transport, local doctors, surgeons, nurses, salesmen, employees of enterprises of public catering, hairdressers, workers of housing and maintenance services, restorers of art products, guides, photographers, technicians and operators of radio and television broadcasting, customs inspectors, workers of police and highway patrol officers and other related activities).

Table 2. The average values of labour energy consumption of the adult population of Russia for group II of physical activity (MJ/h)

Men					Women				
Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years	Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.556	0.526	0.491	0.453	40	0.414	0.403	0.391	0.368
55	0.583	0.549	0.518	0.476	45	0.441	0.430	0.414	0.395
60	0.610	0.576	0.541	0.499	50	0.472	0.457	0.445	0.422
65	0.641	0.602	0.568	0.522	55	0.499	0.484	0.468	0.445
70	0.672	0.633	0.595	0.549	60	0.530	0.514	0.499	0.472
75	0.702	0.660	0.622	0.576	65	0.556	0.541	0.526	0.495
80	0.737	0.695	0.652	0.603	70	0.587	0.572	0.553	0.522
85	0.771	0.729	0.683	0.629	75	0.614	0.595	0.580	0.549
90	0.810	0.764	0.718	0.660	80	0.645	0.626	0.606	0.576

Group III (medium physical activity; men and women) – workers engaged in average weight of labour; the physical activity coefficient is **1.9** (machinists, operators, machine operators, drillers, drivers of electric vehicles, excavators, bulldozers and other heavy equipment; workers of greenhouses, growers, gardeners, fisheries and other related activities).

Table 3. The average values of labour energy consumption of the adult population of Russia for group III of physical activity (MJ/h)

Men					Women				
Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years	Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.784	0.741	0.692	0.638	40	0.584	0.568	0.552	0.519
55	0.822	0.773	0.730	0.671	45	0.622	0.606	0.584	0.557
60	0.860	0.811	0.763	0.703	50	0.665	0.644	0.627	0.595
65	0.903	0.849	0.800	0.735	55	0.703	0.681	0.660	0.627
70	0.946	0.892	0.838	0.773	60	0.746	0.725	0.703	0.665
75	0.990	0.930	0.876	0.811	65	0.784	0.763	0.741	0.698
80	1.038	0.979	0.919	0.849	70	0.827	0.806	0.779	0.735
85	1.087	1.028	0.963	0.887	75	0.865	0.838	0.817	0.773
90	1.141	1.076	1.011	0.930	80	0.909	0.881	0.854	0.811

Group IV (high physical activity; men and women) – workers performing a heavy physical labour; the physical activity coefficient is **2.2** (construction workers, porters, those ones working on maintenance of railway tracks and repair of roads, forestry, hunting and agriculture; woodworkers, athletes, blast furnace steelmakers-casters and other related activities)

Table 4. The average values of labour energy consumption of the adult population of Russia for group IV of physical activity (MJ/h)

Men					Women				
Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years	Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	1.012	0.956	0.893	0.823	40	0.754	0.733	0.712	0.670
55	1.061	0.998	0.942	0.865	45	0.802	0.782	0.754	0.719
60	1.110	1.047	0.984	0.907	50	0.858	0.830	0.809	0.768
65	1.165	1.096	1.033	0.949	55	0.907	0.879	0.851	0.809
70	1.221	1.151	1.082	0.998	60	0.963	0.935	0.907	0.858
75	1.277	1.200	1.130	1.047	65	1.012	0.984	0.956	0.900
80	1.340	1.263	1.186	1.096	70	1.068	1.040	1.005	0.949
85	1.403	1.326	1.242	1.144	75	1.116	1.082	1.054	0.998
90	1.472	1.389	1.305	1.200	80	1.172	1.137	1.103	1.047

Group V (a very high physical activity; men) – workers particularly performing hard physical labour; the coefficient of physical activity – **2.5** (sportsmen of high qualification in the training period, machine operators and agricultural workers in the sowing and the harvest period, the miners and the people working in underground tunnels, fellers, concrete workers, bricklayers, those performing non-mechanized labour, herders and other related activities)

Table 5. The average values of labour energy consumption of the adult population (men) of Russia for group V of physical activity (MJ/h)

Men				
Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	1.239	1.171	1.094	1.009
55	1.299	1.222	1.154	1.060
60	1.359	1.282	1.205	1.111
65	1.428	1.342	1.265	1.163
70	1.496	1.410	1.325	1.222
75	1.564	1.470	1.385	1.282
80	1.641	1.547	1.453	1.342
85	1.718	1.624	1.522	1.402
90	1.804	1.701	1.598	1.470

The indicators were calculated on the basis of the state of [2] and can be used in the development of federal and municipal rules and regulations as well as in the economic activity of enterprises, organizations and institutions of all forms of ownership.

In our opinion, the application of the average values of labour energy consumption by the workers may practically reduce a social tension in labour relations, bring the wages be aligned in line with the level of labour costs in the particular sectors of the economy and individual industries. It will also optimize the structure of the economy and will allow the proportional. dynamic development of the real sector economy.

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VISIONARY IDEAS ARE AHEAD OF TIME

WIZJONERSKIE POMYSŁY WYPRZEDZAJĄ CZAS

The letter of intent on cooperation between the Warsaw New Tech University Foundation and the American company Enfoglobe provides for the implementation of joint initiatives in the field of personalized learning using digital solutions and virtual reality (VR). The combination of interdisciplinary scientific and technological potential as well as knowledge and international experience will allow both partners to prepare model systems in this area. The tools for their construction will be provided by the Enfoglobe company, specializing in the creation of innovative IT solutions, multimedia platforms, mobile applications and interactive medical simulators for learning by residents and students. The document was signed by Fr. prof. Stanisław Dziekoński, president of the WNTUF Foundation and Małgorzata Andraka, president of Enfoglobe based in Florida.

Fig. Małgorzata Andraka, president of Enfoglobe based in Florida and Fr. prof. Stanisław Dziekoński, president of the WNTUF Foundation

Jolanta Czudak: *The activities of the foundation and the American company Enfoglobe are focused on helping people, often lost in the digital world, and on solving health and social problems. Did these similarities in the business profile have brought the two partners together?*

Stanisław Dziekoński: The similarity of our intentions and priorities brought us closer together quite a long time ago. I had the opportunity to get to know the innovative products and services of Enfoglobe much earlier, when I was still the rector of the Cardinal Stefan Wyszyński University. The potential for developing information technology and virtual reality in Enfoglobe is impressive. It is used in many areas, including to optimize business operations, comprehensive investment management, legal documentation, as well as to create training programs in an augmented reality environment. Unique proprietary solutions for the medical industry combine the latest virtual reality techniques with procedures defined by doctors and world experts in this field. These achievements and the international prestige of the company, whose president and co-founder is Mrs. Małgorzata Andraka, an experienced IT expert, is very important to us in planning joint initiatives. The Foundation gains extensive technical facilities to implement its plans in the field of personalized learning with the use of digital solutions and virtual reality.

Małgorzata Andraka: Our activities with Fr. prof. Stanisław Dziekoński always shared a common goal to use digital tools to help people and modern education. As the rector of the UKSW, he did a lot in this area, transforming the humanities and social university into a broad-profile university, where he created innovative research and implementation centers in the field of digital science and technology and introduced innovative methods of education in the field of social sciences, humanities, biological and medical sciences. After completing the dual term of university management, Fr. The professor, already as the founder and president of the Warsaw New Tech University Foundation, can now act even more globally in the development of model teaching models using digital solutions and virtual reality. I am very happy that we can share our visions, ideas and experiences in planning joint initiatives. For many years I have been specializing in programming solutions created, among others for the educational, medical, legal and business sectors, therefore the combination of this potential can bring many benefits in the preparation of model solutions in socially important areas.

JC: *In the activities of the Foundation, the innovative solutions of the Enfoglobe company will complement the implementation of the visions and ideas initiated on the initiative of Fr. professor at UKSW?*

SD*:* Certain processes cannot be stopped anymore. They have to be continued with the same intensity, although not at the university, but at the Foundation, which was established to carry out many things here that are very difficult to accomplish in a university with its own life. Certain standards and restrictions often block innovative solutions. It happened that my ideas about various initiatives in the field of implementing digital science and technology at the UKSW were not understood. I had few allies to transform the UKSW into a broad-profile university, create a Collegium Medicum at the university or build a campus dedicated to digital technologies in Dziekanów Leśny. It was similar with the intention to establish the EZRA company at the UKSW, implementing a proprietary model of psychological community care for children and adolescents. The originator of this valuable initiative, Tomasz Rowiński, immediately gained my approval and, as the university rector at the time, I made the decision very quickly. Everyone, except the initiator and me, was against. Even when we have already received funding in the amount of PLN 35 million. The community psychiatry project was a great success. We started with B. other Warsaw districts. A few years ago, we initiated something that was not so obvious then, and today, in covid conditions, community psychiatry is the only lifeline for many people. Visionary ideas are ahead of time. It turned out that their introduction brought many benefits, and the university only benefited from these changes.

JC: *How did previous skeptics react to this?*

SD: Without any particular enthusiasm. Habits do their thing and not everyone feels the need to introduce groundbreaking changes at the university, even if they bring many benefits. By creating a digital technology campus, we have established cooperation with technical universities, as well as companies of key importance to the economic sector. We jointly conducted research on the use of large databases and artificial intelligence algorithms in the field of the research agenda, which we created together with KGHM Polska Miedź S.A. The works concerned various analyzes, e.g. rhenium-titanium alloy, which will be implemented into the economy, because it is an ideal material for 3D printers. It shows how the world of digital technologies can be used for innovative achievements. In today's world, it is no longer possible to imagine life without digital technologies. In the activities of the Foundation, the innovative solutions of the Enfoglobe company will be a perfect complement to the implementation of our shared visions and ideas without any restrictions. We intend to establish a group of experts who will advise us and indicate what needs to be changed in the area of science and what to do to establish contact with other entities. We want to create special purpose vehicles to carry out specific tasks, reach for EU funds, and help universities to carry out reorganization. We have a lot of plans, and thanks to good intuition, we will always choose the best solutions.

MA: Creativity, vision, hard work determine success, but intuition is always the source of the best ideas. It helps to make optimal choices. Our company brings many years of experience and a wide spectrum of technologies in the field of, inter alia, medical education, telemedicine, treatment of addictions and civilization diseases, and the Foundation will be a conceptual leader indicating strategic directions of joint action. Our medical simulators with the ability to virtually travel deep into cells and organs enable scientists, students, residents and healthcare professionals to better understand the processes taking place in the body. For example, our interactive heart simulator NeoCardioSim, which is the only such technological device in the world, was developed in cooperation with international experts in the field of neonatology and cardiology. The modeling of cardiovascular diseases allows to better illustrate the course of treatment and complications that may occur in neonatal intensive care. The Medical University of Rzeszów, with whom we have been cooperating for several years, already has this device and helps a lot in the process of diagnosing and treating diseases. We have many proprietary products, created with the participation of scientists, which, thanks to our cooperation with the Foundation, will also be much more widely used in Poland.

JC: *Will the nature of the Foundation's cooperation with Enfoglobe be flexible or focused on specific tasks?*

SD: Our priority is, above all, to help people and society, which is not always able to cope in the modern world. It would be difficult to imagine life without digital technology, but this presents us with new challenges. We need to think about the man affected by these groundbreaking changes. The very name of the Warsaw New Tech University Foundation may suggest that we focus only on new technologies, but in fact one of the Foundation's tasks is to create a think-tank that will be focused on people living in the world of new technologies. On the needs that are triggered by the digital civilization, the changes it makes in people, creating, for example, new needs. At the same time, we also focus on specific areas of life that show great potential in digital technologies and their application. Human subjectivity, however, will always dominate our activities, for which technologies are to serve as modern tools. The combination of the activities of two strong entities will certainly bring very good results.

With Fr. prof. Stanisław Dziekoński, president of WNTUF and CEO of Enfoglobe Małgorzata Andraka, interviewed by Jolanta Czudak


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