Physics- and technology-based approaches for human sustainability

[1]Marwan S. Mousa, [2,3,4]Ildiko Tulbure

[1] Mu'tah University, Department of Physics, Al-Karak, Jordan; [2] University "1 Decembrie 1918", Alba Iulia, Romania; [3] Technical University of Cluj-Napoca, Romania; [4] Clausthal University of Technology, Clausthal-Zellerfeld, Germany. Corresponding author: I. Tulbure, ildiko.tulbure@gmail.com

Abstract. Industrial activities have the direct goal to support increasing humanity quality of life. Made experiences emphasized that beside positive direct effects of industrial activities these often have also negative, undesired and sometimes unthinkable effects on environment and society. Nowadays humanity is confronting with a series of global problems, in this context the concept of sustainable development being defined in 1987 in the Brundtland-Report. With regard to sustainability, chances and risks of technological applications have to be carefully analyzed and evaluated. In the last time the pretty new discipline called Technology Assessment grew up in order to evaluate technological, environmental and social impacts of industrial activities, where physical and technological targets are to be foremost considered. Debates about applying sustainability have recently brought on scientific field the issue concerning physics of sustainability especially connected to making new technologies available which address current challenges facing humanity. It is about putting focus on using physics to meet the growing demand on natural resources, especially connected to the energy supply in order to cover the steadily growing energy demand. Fundamental physics research is needed in areas such as renewable energy resources, having in the future impacts on sustainability agenda and humanity quality of life.
Key Words: sustainability, operationalisation, technology assessment, physics-based approach, technology-based approach, life cycle assessment, interdisciplinarity.

Introduction. After the Conference for Environment in Stockholm in 1972 and the first report to the Club of Rome „Limits of the Growth", published also in 1972, it was finally understood that besides wanted effects of technological progress, undesired and negative effects can appear (Club of Rome, Meadows et al 1972). Currently humanity is confronting itself with a series of global problems, which can be mainly divided into three classes: growth of world population, increase of energy and resources consumption as well as environmental pollution, as presented in Figure 1 (Jischa 2005). Usually they are called as "old" problems, because in the meantime other issues have arisen, being called "new" global problems. For instance issues related to new technologies, to using and applying Biotechnologies or most debated Information and Communication Technologies can be mentioned in this category (Lengsfeld et al 2003; Prunariu & Tulbure 2017).

For the first time the concept of *sustainable development* has been defined in the Brundtland Report and pretty fast accepted as a potential answer for the global complex environmental, technological, economic and social challenges (Hauff 1987). This concept was deeply debated during the Conference for Environment and Development in Rio de Janeiro 1992 as well as approached in the closing document „Agenda 21" (Agenda21 1992).

The new pretty keen projection regarding human sustainability was again deeply approached during the Johannesburg Conference, well known as "Rio + 10" Conference in 2002 (Jischa 2005). Many actions after this time have emphasized that the evolution of physical, technical, social and environmental systems has to be analysed in synergetic relation. The general Brundtland definition was worldwide accepted, but made experiences since then have emphasized that alone this definition did not succeed in delivering a concept, that can be successfully used and applied to different real concrete situations. This issue has been recognized not only on regional or national level, but on global level too, following interesting debates during the "Rio + 20" Conference, which has taken place in 2012 again in Rio de Janeiro ("Rio+20" – Conference; Tulbure 2013).

Following these developments, the aim of this paper is to emphasize the role that physics and technology based approaches can have in order to support assuring human sustainability on different levels.

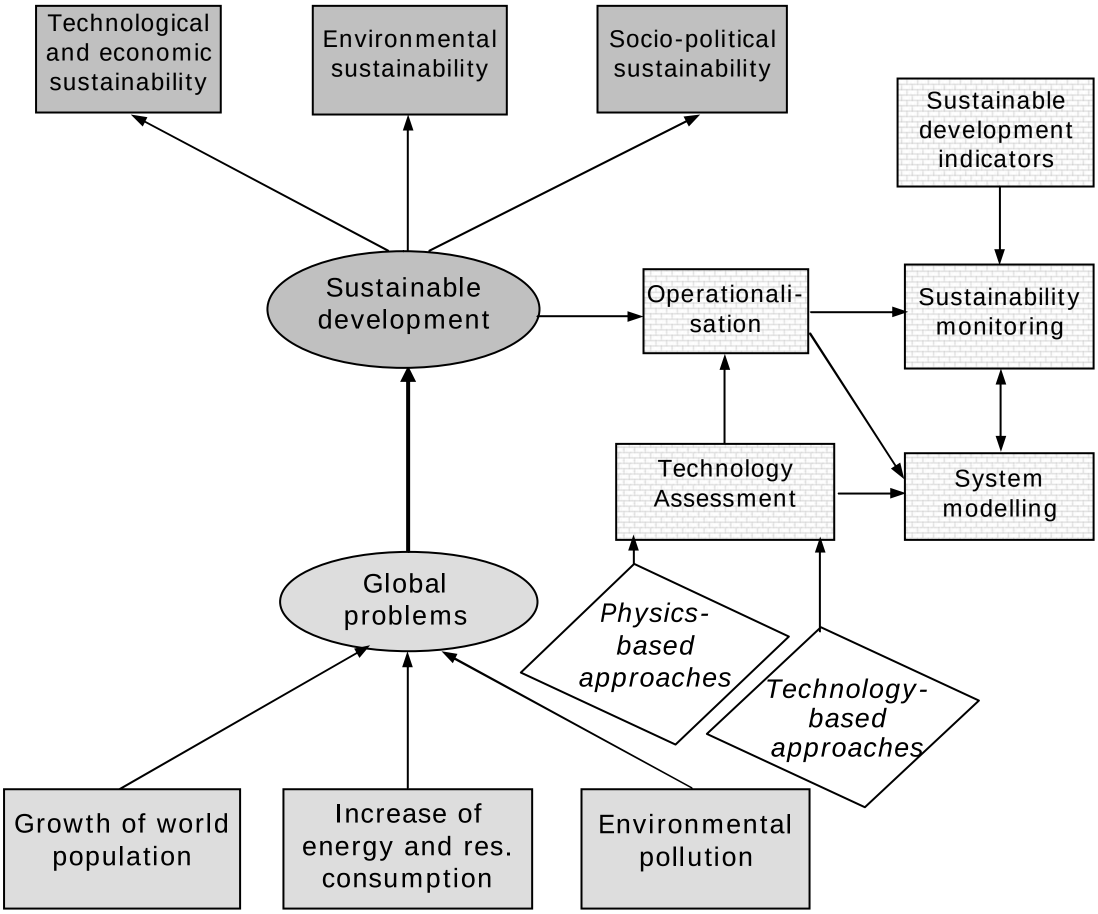

Figure 1. Global problems and sustainable development.

Material and Method. Operationalizing sustainable development actually means transforming or translating its goals into technical, socio-political, environmental and educational measures as well as into monitoring and controlling instruments with regard to succeed in shaping most relevant sustainability targets (Tulbure 2003). In this context sustainability operationalization means applying physics- and technology-based approaches on different levels and for different given situations in the attempt of improving humanity quality of life with minimum undesired impacts on environment and society (Tulbure 2013).

Physics-based approaches attempt to derive specific models based on known physical models in order to allow basic understanding of various phenomena and by this to foster scientific and technology advance in the hope of increasing humanity quality of life. Complementary technology-based approaches are represented by approaches that aim at applying technology-specific interventions to address demands of providing healthy living and working conditionds in the context of improving humanity living conditions (Jischa 2005).

A general methodology for operationalizing sustainability can be materialized on different levels by respecting following steps (Tulbure 2003):

- specifying sustainability task for the considered region;
- establishing specific space and time scales;
- systemically approaching considered region by modeling existing interactions;
- setting up concrete aims for the studied case;
- elaborating concepts and measures by establishing priorities;
- developing monitoring, assessing and controlling instruments in form of indicators;

- verifying potential results, which could be obtained after introducing proposed measures by making simulations and by comparing different potential developing scenarios;
- applying into practical situation most suitable developed concept for the considered case.

Made experiences in this field have emphasized that for successful sustainability operationalization there is a need of establishing concrete aims for an individual problem-case and from these aims concepts to achieve them are to be developed. In this context sustainability is to be newly defined for each different case as well as space and time scales are to be established for each case (Tulbure 2003). In such a complex analysis several physical, technological, economic, environmental and social criteria are playing an important role (Grunwald 2002).

Sustainability evaluation and control instruments are represented by sustainable development indicator (Jischa 2005). These indicators allow to quantitatively formulate proposed objectives and goals for getting sustainable development. After introducing proposed measures, the implementation degree can be controlled and verified by calculating these indicators and by comparing them to reference values (Tulbure 2003). The possibility to make improvements is assured in this way. On the other hand indicators serve as an instrument, which supports a better understanding of potential impacts of certain measures and correctly informing interested public.

In the last time there is consent among political economists and engineers that the Gross National Product does not represent a measure for the life quality of a nation. Gross National Product can deliver information about different economies, but it does not consider many other parameters influencing the quality of life. Some of these parameters are concentrated on physical conditions, expressed by natural living conditions, environmental pollution, irreversible use of fossil fuels, social aspects etc. That is why new indicators have to be developed on each level, where physical considerations regarding natural living conditions, availability of energy resources, climate conditions are relevant to be approached in each considered single case (Monteith & Unsworth 2013).

Part of what engineers are doing is not only to develop, but also to evaluate developments in technology (Grunwald 2002). Their evaluation has been focused up to now almost without exception on technical and physical considerations as well as on economic aspects following legal and financial boundary conditions. With respect to sustainability more criteria have to be considered, especially environmental quality, social and human values, quality of life (Jischa 2005). Assessing technologies in a comprehensive manner, by considering technical and physical criteria as well as environmental and social ones, can be sustained by the pretty new discipline called Technology Assessment (Grunwald 2002; Tulbure 2013).

Interdisciplinarity for operationalizing sustainability. Interdisciplinary approaches are of foremost importance with regard to operationalizing sustainability and are always successfully debated among scientists having different backgrounds in the context of multi- and transdisciplinary events (Jischa 2005; Tulbure 2013). In this regard the so-called "Humboldt-Kollegs" can be mentioned, that are supported by the Alexander von Humboldt-Foundation, located in Bonn, Germany (Alexander von Humboldt Foundation 2020). Such events, worldwide known as *Humboldt-Kollegs*, allow more or less periodically meetings among scientists being once assessed by this world-famous German institution, the Humboldt-Foundation (Humboldt-Kollegs – Programminformation 2019). Such scientists have already had carried out in Germany at a German research institution a high-level scientific research project. These scientists, actually working all over the world, and having once had carried out a research project in Germany are called *Humboldt-ians* and are usually keeping successful cooperations in their efforts of trying to push forward scientific various approaches on a global level. To allow very professional view into various conference topics often world-renowned guest scientists are invited to such events in order to tackle arisen recognised global challenges (Humboldt-Kollegs – Programminformation 2019). As manifold made experiences with such scientific events are undoubtedly showing, this is in fact the best platform which allows deep scientific debates among high-level scientists. Interdisciplinarity and diversity are common approaches, as scientists are coming from various fields and from different countries all over the world and by this are having different backgrounds (Alexander von Humboldt Foundation 2020). This fact permits providing deep innovative insights into debated scientific conference topics, these ones being usually very stringent ones to be approached, debated and solved on a global level. As an example in this regard the Humboldt-Kolleg ”*Jordanian Life Sciences Conference for Sustainable Development*” is to be mentioned, which has been organised in the time of April, 27-29, 2017 at Al al Bayt University in Mafraq, Jordan (Humboldt-Kolleg & Jordan 2017). In the context of this Humboldt-Kolleg, wherein participated both authors of the present article, the first author being actually the main organizer of this Humboldt event, relevant interdisciplinary work could be successfully delivered. At this point there can be stated especially interdisciplinary approaches concerning possibilities to connect physics-based tasks to engineering-based tasks in the context of operationalising sustainability (Tulbure 2017). This Humboldt-Kolleg has been attended by top world scientists from 27 countries, including Nobel Prize winner Prof. Erwin Neher, who delivered the opening main lecture. Mentioned Humboldt-Kolleg organized in Jordan had three intensive days of talks and events, materialized in different interdisciplinary workshops, debates and networking (Humboldt-Kolleg & Jordan 2017). Such a Kolleg is normally followed up by several visits, concretely in this case visits to Jordanian public universities for building different scientific cooperations and for networking. Some famous and highly appreciated historical sites of thousands of years old in Jordan were also visited in the context of the Jordanian Humboldt-Kolleg. Such visitations respectively investigations have been very interesting and well appreciated from the side of all participants in the Humboldt-Kolleg, but especially from the side of the archaeologist scientists participating in this Jordanian Humboldt-Kolleg in 2017 (Humboldt-Kolleg & Jordan 2017). Scientific contributions to this International Conference organised in Jordan has been successfully published after full referring in two issues of the Jordan Journal of Physics, Volume 11, No. 1, April 2018, ISSN 1994-7607 and in Applied Microscopy Journal of the Korean Society of Microscopy, Vol 47, No. 3, September 2017, pISSN 228-5123, eISSN 2287-4445.

***a**. **Physics-based approaches for operationalizing sustainability**.* Sustainability operationalisation is only possible, when for an individual problem-case concrete goals are set up and from these goals concepts to achieve them are developed. Sustainability is to be newly defined for each different case, where space and time scales are to be established for each case (Grunwald 2002). There are several levels for applying sustainability, starting with the global one, meaning to define general goals for the whole world, things which happened more or less with the Rio-Conference in 1992 (Jischa 2005). On a national level the operationalization means to define goals by paying attention to specific conditions of the certain country. On regional or local level concrete measures represent the content of the Local Agendas 21 (Agenda 21 1992; Tulbure 2013). But what about applying sustainable development on the level of companies, of industrial processes or of products? In this field sustainability operationalization means to use instruments or tools of the pretty new discipline called Technology Assessment (Grunwald 2002; Tulbure 2013), where physics notions are foremost relevant (Monteith & Unsworth 2013).

Assessing developments in technological field has been focused up to now almost without exception on technical and physical aspects, as presented in Figure 1. Such assessments have usually been correlated with economic aspects, following legal and financial boundary conditions (Jischa 2005). With respect to sustainability more criteria have to be considered like: environmental quality, social and human values, quality of life. This means, the activities of engineers when evaluating technologies can be sustained by Technology Assessment (Grunwald 2002; Tulbure 2013). Although in last 20 years main advance has been registered in the field of Technology Assessment especially due to several studies carried out in USA, Japan, Germany and other European countries, there is still impetuous need in developing integrative methods for Technology

Assessment, considering physical, technical, environmental and social aspects (Jischa 2005; Tulbure 2013).

Innovative programs, focusing on using physics to meet the growing demand on our natural resources and on technical appplications, should allow using new energy resources and new technologies in this regard. Physics of sustainability shall concentrate on making new technologies available which to address complex challenges facing society (Monteith & Unsworth 2013). Strong emphasis will be put on fundamental physics research into such areas as transportation systems or renewable energy resources, including photovoltaic ones, water and wind energy resources, bio-energy, that will surely have important implications in elaborating humanity sustainability agenda in the long-term.

Exploring Sustainability by using Physics means actually using concepts of Energy and Work, concepts of Thermodynamics related to heat, entropy, and energy use, concepts of Electricity and Magnetism as well as Nuclear Physics for commercial power generation and Electronics for novel energy transport systems as main notions for assuring Sustainability on a global level. Sustainability by Physics is representing a great way to link standard physics concepts to topics applicable to the real world and being currently in deep debates (Monteith & Unsworth 2013).

***b*. *Technology-based approaches for operationalizing sustainability*.** From the made presentation became clear that sustainability operationalisation is to be made when for an individual problem-case concrete goals are set up and from these aims concepts to achieve them are developed (Grunwald 2002). Regarding companies developing technologies and technological applications by considering sustainability on companies level means actually to assess potential impacts of production processes (Grunwald 2002; Jischa 2005). Evaluating developments in technological field is carried out by using Technology Assessment (Grunwald 2002; Tulbure 2013). Following mentioned goal several instruments or tools of the pretty new discipline Technology Assessment can be used, where several notions from mathematics, physics and engineering are foremost relevant (Jischa 2005; Monteith & Unsworth 2013).

Technology Assessment means after German Engineers Guidelines, VDI-Richtlinie, 3780/2000 (VDI-Richtlinie 3780, 2000) the methodical, systematic, organized process of:

- analyzing a technology and its developmental possibilities,
- assessing direct and indirect technical, economic, health, ecological, human, social and other impacts of this technology and possible alternatives,
- judging these impacts according to defined goals and values, or also demanding further desirable developments,
- deriving possibilities for action and design from this and elaborating these,

so that well-founded decisions are possible and can be made and implemented by suitable institutions if need be (VDI-Richtlinie 3780, 2000).

When going through the given methodology for operationalising sustainable development, mentioned before, one can recognize that many steps can be identified also in the phases distinguished in Technology Assessment (Tulbure 2013). Often a certain sustainability task especially related to a technological issue is to be solved by carrying out a Technology Assessment study. Or a Technology Assessment study has as a goal to research potential undesired effects of a technology on various domains, this means to actually analyse if potential impacts of a technology application do or do not conflict with the goals of sustainable development (UNDP 2015).

Operationalisation of sustainable development with Technology Assessment means analysing complex dynamic technical, economic, environmental, as well as social systems in order to try discovering developments which lead to instabilities (Jischa 2005). The concept of Technology Assessment, equally how it is named, if Technology Evaluation, Innovation Research, System Analysis or others, brings together almost all scientific disciplines with the question of how sustainability can be operationalized (Grunwald 2002). Technology Assessment tries to give an answer to the question: Which are technologies that we need, how are these technologies to be developed and how do they integrate into environment and society? These questions are in the present worldwide conditions from dominant importance, in the process of modernization of old technologies and of implementation of new ones. Technology Assessment is the discipline, which tries to answer exactly such questions. From this reason Technology Assessment should play a central role in the future technological, economic, environmental and social development of countries being concerned with respecting sustainability criteria (Grunwald 2002; Jischa 2005).

In order to assess potential environmental impacts of human activities, especially industrial processes, several tools, so-called Instruments of Technology Assessment can be applied, as presented in Figure 2. As it can be observed in before mentioned figure the most used Instruments of Technology Assessment are the following (Grunwald 2002; Tulbure 2013):

- Environmental Management Systems;
- Life Cycle Assessment;
- Eco-audit;
- Ecobalance.

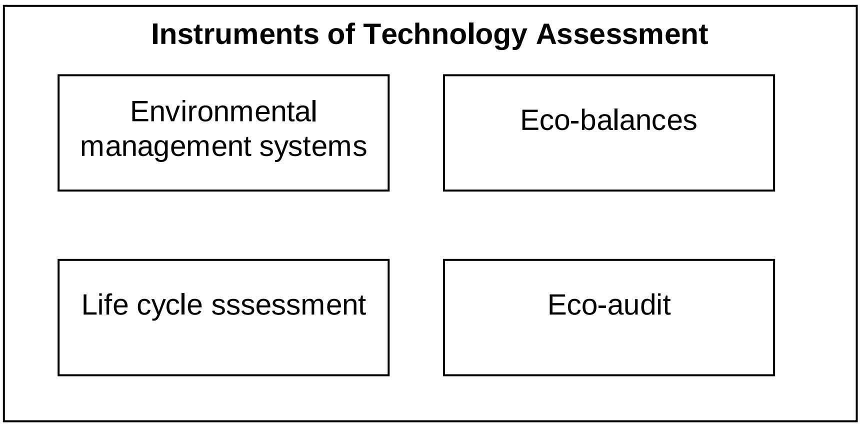

Figure 2. Instruments of Technology Assessment.

The most meaningful instrument used for carrying out a study of technology assessment is presented by the life cycle assessment (LCA) (Tulbure 2013). Other tools, as presented in Figure 2, are also often used, depending on the concrete situation on regional, local or company level. The legislative framework for environmental impact assessment exists from 1985 in countries of the European Community. In Germany the law concerning the examination of different public or private projects was promulgated 1990. In Romania there is a legislative regulation from 1996 about examination of potential environmental impacts of economic and social activities (Tulbure 2003). The analysis of potential environmental impacts has the goal to assure developing and applying such activities, that have at the end minimal environmental impacts. Going into details following aspects have to be taken into account (Jischa 2005):

- possible impacts of a project have to be searched, described and assessed;
- results of made analysis have to be delivered to authorities for supporting them in taking most proper decisions.

The LCA is an analysis which registers environmental effects of a product during its life "from the cradle to the grave", from its production to consumption and recycling (Tulbure 2013). The general life cycle of a product is presented in Figure 3, where beside production and consumption processes also transport processes are taken into consideration. As it can be remarked in Figure 3, transport processes are indicated with *T* within the life cycle of a product.

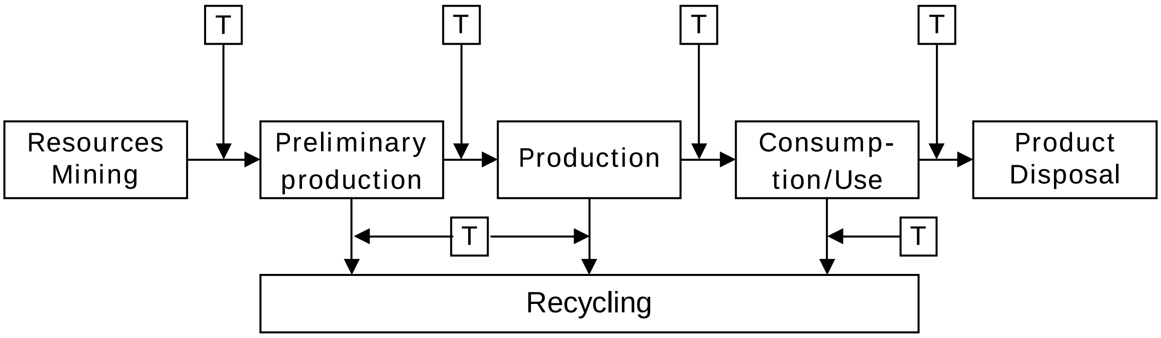

Figure 3. General life cycle of products.

Experimental*.* As mentioned before instruments of Technology Assessment are started to be applied in various situations, especially when assessing potential environmnetal impacts of technological applications. In this regard in order to emphasise the usage potential of LCA an example is presented, where two life cycle stations of a generic passenger car are compared with regard to their environmental impacts, considering pollutants emissions for this attempt (Tulbure 2018). These two life cycle stations are preliminary production and usage of a car. Basic materials needed in the preliminary production of the car are produced by using first of all different mining activities for gaining needed raw materials.

For a generic car with an average weight of 1000 kg the emissions data calculated in the phase of material fabrication and in the phase of use of the considered car are given in Table 1 (Tulbure 2018). Mentioned generic car is actually a car with an average weight of 1000 kg, an average mileage of 150000 km, with emissions calculated as average between diesel and petrol engines (Tulbure 2013).

Table 1

Matrix of pollutants emissions in [kg] for two life cycle stations of a generic car (Tulbure 2013)

Considered life cycle stations of a generic car	*Emissions [kg] of*			
	CO_2	*NO_x*	*SO_2*	*CO*
Preliminary production (basic materials fabrication)	1692.58	2.16	5.16	0.50
Usage of the car	29308	189	6.8	804
Σ	31000.58	191.16	11.96	804.5

Results and Discussion. Physics uses observations, experiments, and mathematical analyses to find quantitative physical laws that apply at all scales. The study of environmental physics requires an understanding of classical physics but frequently also draws on knowledge of environmental physiology, that is, how living organisms function and respond to the environment. Environmental physics is often concerned with analyzing interactions in which the environment modifies an organism's response, and those responses modify the surrounding environment through feedback processes. It follows that advance in environmental physics is often registered as a result of cooperation among physicists, biologists, atmospheric and soil scientists and environmental engineers. An environmental physicist needs a sound understanding of basic physics, particularly the properties of matter, heat and thermodynamics, as well as of fluid dynamics (Monteith & Unsworth 2013).

On the other side, regarding physics targets for assuring sustainability there is to be mentioned the possibility to develop new materials with until now unknown properties, in this regard several fields are to be explored (Monteith & Unsworth 2013):

- Designer materials – using materials chemistry for molecular engineering, there is the hope to change materials properties;

- Light and matter - the primary source of energy on our planet is sunlight and a pretty recent direction is the usage of solar energy for human needs;
- Self-assembly – the future nanoscale engineering will require the invention of new manufacturing methods at the nanoscale;
- Multiscale modeling - novel sustainable materials and technologies will require an understanding of how quantum mechanical models on atomic scales can be combined with classical modeling on large scales for designing complex systems and devices.

In the last time there have been debates concerning environmental physics, which is defined as the branch of physics concerned with the measurement and analysis of interactions between organisms and their environment. From the point of view of environmental physics the field of energy consumption by assuring sustainability is actually meaning that sustainability is defined as the condition that must be globally developed for humanity to flourish until technology advances extraterrestrial travel that will allow migration to another planet once conditions here deteriorate (Prunariu & Tulbure 2017). The emphasis is on anthropogenic climate change caused primarily by changes in the chemistry of the atmosphere due to dominant use of fossil fuels. This review is focused on climate change. It is based on the understanding that anthropogenic climate change is caused primarily by changes in the chemistry of the atmosphere due to dominant use of fossil fuels (Monteith& Unsworth 2013). Climate stabilization requires energy transition from business as usual scenarios to a mixture of non-carbon based energy sources, even if by using space activities in support to climate change mitigation (Prunariu 2017). The starting point for discussing this transition is driven by population growth, increase in the standard of living, the required energy intensity, and the transition to different sources of energy (Jischa 2005).

Living organisms will have to adapt and will have to survive in a big diversity of environmental conditions, including hot and cold climates. They are thermodynamic entities characterized by energy flows both within the body, and between the body and its environment (Monteith & Unsworth 2013). For people to survive, the core body temperature has to be maintained within a narrow temperature range of 35-40ºC. The rate of energy transfers and the mechanism of thermoregulation are governed by the following laws and concepts of physics (Monteith & Unsworth 2013):

- Laws of thermodynamics;
- Principles of entropy, enthalpy, and the Gibbs free energy:
- Principles of conduction, convection, radiation and evaporation;
- Newton’s law of cooling;
- Wien’s and Stefan-Boltzmann radiation laws.

Human beings have learned to manage living in all different environments present throughout the Earth: from the wastes of the Arctic to the deserts of Mongolia, from the jungles of Africa to the coral islands of the Pacific (Monteith & Unsworth 2013). Mammals, including humans, have the remarkable ability to maintain a constant body temperature, in spite of dramatic changes in environmental conditions. They sustain their body temperatures by adjusting the rate of energy transfer and energy production (transformation).

Assessments for technological decisions are usually important and far-reaching, yet only rarely applicable to methodical solutions. Thus, it is the aim of an assessment to determine a scaling value of an alternative that represents its advantages in only a single expression. The solution of this problem of selection will be especially difficult, if following conditions hold (Jischa 2005):

- Many objectives are to be considered;
- Different assessment scales emerge;
- Objectives are weighted differently;
- Information is uncertain and may be subject to doubt;
- Problem is time-dependent;

- Many are to participate in decision making process;
- No unique criterion exists for decision making.

Therefore, a multidimensional assessment problem can be considered as a logical measurement operation. Consequently, one usually has to deal with complex and nonlinear systems, where many non-measurable qualities occur and interactions are at least partially uncertain (Grunwald 2002; Tulbure 2013).

Related to assessing technologies a current main question is connected to energy technologies, which are making available needed energy for living for human beings, if from fossil fuels or by using water energy or in form of nuclear power. Newer energy strategy on global level are represented by using renewable energy resources, hydro power, tidal power, wind power, wave power, biomass and solar power, in form of solar collector and solar photovoltaic (Monteith & Unsworth 2013; Prunariu 2017).

With regard to energy targets for assuring sustainability another obvious approach is to reduce energy demand and energy losses. Since a large part of the energy demand in most countries is for space heating, it makes sense to consider this as basic example for energy demand. There is the basic physics of heat transfer and thermal insulation for approaching energy demand in this case. There is the trade-off that is essential between an energy-efficient building and other conditions that must be considered, heat transfer and thermal insulation as well as assessing heat losses in buildings in order to reduce them, what means that physics notions and phenomena are becoming essential for the vision of concretely materialising human sustainability.

The matrix of pollutants emissions for two life cycle stations of a generic car with specific data regarding the mentioned application example, given in Table 1, emphasize that most pollutants are emitted in the usage phase of a car. By making comparisons to other phases in the life cycle of the considered product, here a car, regarding environmental impacts, interesting conclusions can be drawn connected to optimizing potentials of the considered life cycle. In comparison to the phase of preliminary production of the car, actually to the phase of basic materials fabrication can be concluded that the phase of car usage is characterised by the most environmental impacts, as remarked in Table 1. Following same algorithm pollutants emissions can also be calculated also in other life cycle stations of the same product and also for other products. In this way dangerous points in different production lines concerning potential environmental impacts can be recognized and improving measures related to these potential environmental impacts can be found. Availability of specific data has always to be debated, because made experiences have demonstrated that the phase of collecting needed environmental data in different life cycles of products is representing a most difficult task in carrying out the LCA (Grunwald 2002; Jischa 2005; Tulbure 2013).

Conclusions. Sustainability concept has begun to find its main role from global to local levels. The heightened awareness for potential environmental impacts associated with different manufactured products has increased the interest in the development of methods, so-called instruments of Technology Assessment. Applying such tools is needed in order to better comprehend mentioned impacts with the final goal of mitigating them or even of avoiding their appearance from the very beginning. Industrial activities have the direct goal to support increasing humanity quality of life. Beside positive direct and desired effects of industrial activities, these also can have negative, undesired and sometimes unthinkable impacts on environment and society. Especially mining based activities in order to produce basic materials, like in the case of materials used for cars fabrication, have several unwanted impacts on environment, but not only on environment. As it was presented, there are several tools of Technology Assessment in order to evaluate potential impacts of human activities. LCA are presently worldwide used in order to assess environmental impacts of products and by this to try improving production lines. Presented results emphasize the working way of applied method and allow evaluating different phases in the life-cycle of various products, in this case of a car. The final goal is to reduce as much as possible the impacts on environment of each of these phases in the general life-cycle of a product. Environmental impacts related to obtaining basic materials needed in order to produce a more complex product are relevant, but as it is to be observed from the presented example, the usage phase of a car produces much more air pollutants than the car production itself. And this is related to human mentalities regarding the usage way of a car. The field of changing human mentalities regarding the usage way of cars is much more complex than obtaining a less pollutant industrial process and overrun technical competencies of physicists and of engineers. In this field an interdisciplinary cooperation with social scientists would be foremost necessary. Presented case study regarding elaborating the matrix of pollutants emissions for different life cycle stations, in this case for a generic car, is demonstrating that for tackling sustainability issues with regard to technological applications, physics- and technology-based approaches are essential to be considered and that in this regard there is a need for deep inter- and transdisciplinary cooperation.

Acknowledgement. The authors would like to thank the Alexander von Humboldt – Foundation, Bonn, Germany for steady financial support that made possible these research activities.

References

Grunwald A., 2002 Technikfolgenabschätzung - Eine Einführung (Technology assessment – an introduction). Edition Sigma, Berlin, 35 pp.

Hauff V. (ed), 1987 Our common future. The Brundtland Report of the World Commission on Environment and Development. Oxford University Press, Oxford, 25 pp.

Jischa M. F., 2005 Herausforderung Zukunft (Challenging the future). 2nd edition, Elsevier, Spektrum Akademischer Verlag, Heidelberg, Germany, pp. 188-193.

Lengsfeld T., Tulbure I., Vali A., 2003 Exploring a worthwhile future for all. Spanish Chapter of the Club of Rome, 111 pp.

Monteith J. L., Unsworth M. H., 2013 Principles of environmental physics. 4th edition, Elsevier Academic Press, 35 pp.

Meadows D. H., Meadows D. L., Randers J., Behrens III W. W., 1972 The limits to growth. Universe Books, New York, 205 pp.

Prunariu D., 2017 Space activities in support to climate change mitigation and climate resilience. UFS-DiMTEC Symposium on climate resilience and water. University of the Free State, Bloemfontein, South Africa, 22-23 February 2017.

Prunariu D., Tulbure I., 2017 Space activities and sustainable development. In: Proceedings of the 17th International Multidisciplinary Scientific Geoconference, SGEM2017, "Nano, Bio, Green and Space – Technologies for a Sustainable Future", Section "Space Technologies and Planetary Science", Albena, Bulgaria, 17(62):947-954.

Tulbure I., 2003 Integrative Modellierung zur Beschreibung von Transformations-prozessen (Integrative modelling for describing transformation processes). VDI-Progress Report Series, Series 16, Nr. 154, VDI Publishing House, Düsseldorf, Germany, 97 pp.

Tulbure I., 2013 Technikbewertung – Vorlesungsskript (Technology Assessment - Lecture Notes). Institute for Applied Mechanics, Clausthal University of Technology, Clausthal-Zellerfeld, Germany, pp. 47-63.

Tulbure I., 2017 The role of systems engineering in the drug development process. Contribution for the Humboldt-Kolleg "Jordanian Life Sciences Conference for Sustainable Development", April, 27-29, 2017, Al al Bayt University, Mafraq, Jordan, pp. 57-62.

Tulbure I., 2018 Analiza si evaluarea ciclului de viata al produselor – Note de curs, online (Life cycle assessment – lecture notes, online). "1 December 1918" University of Alba Iulia, Romania, pp. 31-35.

VDI-Richtlinie 3780, 2000 Technikbewertung - Begriffe und Grundlagen (Technology assessment – concepts and basic notions). New Edition, Berlin, Germany, pp 3-7.

*** Agenda 21, 1992 Available at: http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm. Accessed: March, 2020.
*** Alexander von Humboldt-Foundation. Available at: http://www.humboldt-foundation.de/web/home.html. Accessed: February, 2020.
*** Applied Microscopy, Korean Society of Microscopy. Available at: https://appmicro.springeropen.com/. Accessed: March, 2020.
*** Humboldt-Kollegs – Programminformation, 2019 Available at: https://www.humboldt-foundation.de/web/docs/F1872482547/programminformation_kolleg.pdf. Accessed: March, 2020.
*** Humboldt-Kolleg/Jordan - "Jordanian Life Sciences Conference for Sustainable Development", April, 27-29, 2017, Al al Bayt University, Mafraq, Jordan. Available at: http://www.gju.edu.jo/news/participation-gju-alexander-von-humboldt-kolleg-conference-cultural-heritage-intersection. Accessed: March, 2020.
*** Jordan Journal of Physics, JJP. Available at: http://journals.yu.edu.jo/jjp/. Accessed: March, 2020.
*** Club of Rome. Available at: www.clubofrome.org. Accessed: February, 2020.
*** "Rio+20" – Conference: United Nartions Conference on Sustainable Development, Rio de Janeiro, 2012 Available at: http://www.rio20.gov.br/about_the_rio_more_20/rio-20-como-chegamos-ate-aqui/at_download/rio-20-como-chegamos-ate-aqui.pdf. Accessed: March, 2020.
*** UNDP, 2015 Sustainable Development Goals. Available at: https://www.undp.org/content/undp/en/home/sustainable-development-goals.html. Accessed: March, 2020.

Received: 21 February 2020. Accepted: 12 March 2020. Published online: 30 March 2020.
Authors:
Marwan S. Mousa, Mu'tah University, Department of Physics, Al-Karak, Jordan, e-mail: marwansmousa@yahoo.com
Ildiko Tulbure, Faculty of Exact and Engineering Sciences, University „1 December 1918", Unirii-Str., No. 15-17, 510009 Alba Iulia, Romania, e-mail: ildiko.tulbure@gmail.com

How to cite this article:
Mousa M. S., Tulbure I., 2020 Physics- and technology-based approaches for human sustainability. Ecoterra 17(1):13-23.