DOI: http://doi.org/10.21698/simi.2018.fp25

END OF WASTE CRITERIA FOR OIL WASTES

Georgeta Madalina Arama, Lidia Kim, Adriana Cuciureanu, Agnes Serbanescu, Ileana Nicolescu, Mona Barbu, Bogdan Stanescu, Gina Traistaru

National Research and Development Institute for Industrial Ecology-ECOIND, 71-73 Drumul Podul Dambovitei, district 6, 060652, Bucharest, madalina.arama@incdeconind.ro, Romania

Abstract
In the context of sustainable development, harmonized good management practices should ensure the recovery of valuable components from wastes applying the principle of waste hierarchy in order to comply with Waste Frame Directive requirements. The article presents a scheme of a circular economic model applied to the oil waste. Those oil wastes are of the particular interest because they can positively respond to the End of Waste Criteria. Those criteria are referring to the compliance of the waste derived products with the legal and regulatory applicable specifications for their intended use, the existence of a market demand for this type of products and with the fact that their production and use is safe for the environmental and human health. After fulfilling those conditions the waste producer can declare the end of waste status of the generated waste and proceed to the recovery of valuables entities including the energy recovery. The article presents the economic, ecologic and social implications of applying End of Waste Criteria to the oil waste within such a circular economic model in order to respond to European and Romanian strategy of increasing the recyclable degree of those types of wastes.

Keywords: *circular economy, end of waste, oil waste*

Introduction
In the context of sustainable development, harmonized good management practices (Arama et al 2017) should ensure the recovery of valuable components from wastes applying the principle of waste hierarchy in order to comply with Waste Frame Directive requirements (EU Directive 2008). "The established EU guidance for recovering resources from waste mandates – via the "waste hierarchy" of the Waste Framework Directive (EU Directive 2008) – that in principle reuse is better for the environment than materials recycling, recycling is better than energy recovery, and energy recovery is better than disposal" (Iacovidou et al 2017) . In this paper, a scheme of managing oil wastes within a circular economic model type is presented. Those oil wastes are of the particular interest because they can positively respond to the End of Waste Criteria. Those criteria are referring to the compliance of the wastes derived products with the legal and regulatory applicable specifications for their intended use, the existence of a market demand for them and with the fact that their production and use is safe for the environmental and human health. After

fulfilling those conditions the waste producer can declare the end of waste status of the generated waste and proceeds to the recovery of valuables entities including the energy recovery. The article *presents the economic, ecologic and social implications of applying* End of Waste Criteria to the oil waste within a circular economic type of model in order to respond to the European and Romanian strategy of increasing the recyclable degree of those types of wastes. In a circular economy idealistic model, each human activity along "the life cycle of product/service" should either a) not to generate negative environmental impacts or b) to transform them into positive inputs for other activities to which the same rules should be applied trying to be as close as possible to the zero wastes target. In this context, the producers of goods and services, started to become aware about concepts like *eco-design – referring to products conceived from the very beginning as eco-friendly products* - and *eco-efficiency* – referring *to sustainable re-thinking of the operational production flows of goods and services so that the overall generated wastes to be minimum or even zero* - decoupling this way the economic growth from the consumption of natural resources. In this idea, a new field of research evolved, namely the industrial ecology that has a holistic approach recognizing that solving the current new ecological issues involves actually understanding the connections existing *between societal, technical, economical, and environmental systems* because small changes in a part of the system can induce sometimes important changes in another part of it. For example, changing the price of virgin raw materials on the market can determine either the reduction of their availability or their abundance which can determine a change in the market demand for the reprocessed materials from the virgin ones. Accepting that global industrial economy can be modelled as a network of industrial processes that use resources to transform them in merchandises that can be bought and sold in the market, industrial ecology as a new emerging field of research tries to quantify the material fluxes and to document them. It has in its field of activity the assessment of the environmental impacts that the industrial activities have or can have on the environment, the way in which natural resources are supplied and used and the way in which the resulted wastes are eliminated. In the context of global industrial economy, the industrial ecology is concerned specifically with the dynamic of industrial processes, namely with the study of how present linear economic systems based on a sequence of steps like: extraction, production, consumption and eliminate waste, can make a transition to circular economic systems in which wastes can become entries for new processes. In this respect the eco-innovation is the basis for such an endeavour. The new European vision consider eco-innovation as any innovation that can reduce the use of natural resources especially the non-renewable or hard renewable ones and decrease the pollutants discharge into the environment along the life cycle of the products and services (EU Report 2011).

Materials and methods

"The circular economy (CE) concept is gaining momentum among industry, politics and academia, putting forward a number of claims about environmental and climate-related benefits. Recently, the European Union has enacted a policy package calling for a transition from linear - towards circular production cycles across its Member States by 2050. The majority of research so far has focused on the micro- and meso-level, investigating circular economy implications on the product and firm level. On the national level however, a circular economy monitoring framework has yet to be developed" (Jacobi et al 2018). In the British Standard 8001: 2017 Framework for implementing the principles of the circular economy in organizations – Guide (Standard UK 2017). that is a voluntary guidance standard to support organization in implementing sustainable circular practices in their businesses is defining circular economy as "an economy that is restorative and regenerative by design and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (Niero & Schmidt Rivera 2018).Technical cycles is referring to the endeavour to keep as much as possible the produced products and services as functional in the economy for their initial designed utility or for another one preserving the natural resource to be transformed into wastes to be discarded in the environment and to pollute it. Biological cycle is referring to the possibility of the affected environment to restore to its initial functionality that it had before the impact of the anthropogenic activities. So circular economy is not about making a sort of "perpetum mobile" but trying to keep the consumption of natural non-renewable or hard renewable resources as it is for example a forest as low as possible, continuing the economic development but with much more care and good innovative management practices to allow decupling the economic progress from the expense of environmental degradation. In this respect, concerted efforts also should be made by each organization in order to find innovative solutions so that: everything that can be used in common such as buildings, equipments etc., everything that can be used for a longer period of time to increase the life cycle of an item such as different types of lubricating oils, and also everything that can be reused through reprocessing/regeneration such as waste oils, should to be used. Having waste oils as materials of choice to implement such a circular economic model and to sustain its performance it is necessary to use some methodological instruments in order to reach this goal First instrument is referring to the existing of a harmonized legislation for waste management at the European Community level. That has been realized in the last three decades so that, at the level of 2015, that legislation was already in place and functional also at the national levels where had been transposed. However, for reaching the goal of transition to a circular economic model some combined financial common institutional instruments and organizational management instruments should be made functional in order to reach the high degree of industrial symbiosis required for its implementation and performance. This industrial symbiosis should be reached between all those who are using oils and produce waste oils on a well defined horizon of time within European common market space. Common efforts should be directed towards investments in infrastructures for recycling or energetic recovery as well as towards eco-innovation so that the products to be eco-friendly and the oil waste necessitating the disposal to be kept at minimum. In the same time, the individual and businesses consumer's attitude towards the use of reprocessed oils should be changed. This change can be done by having enough products' information and economic incentives directed towards good organizational management practices that use those types of re-processed oils instead of similar grade oils from virgin materials. This is necessary in order participants to be able to find about each other needs/necessities so the overall recovery process of the valuable entities from the produced oil wastes to show the expected benefits."Thus, it is increasingly recognized that in the endeavour to craft a meaningful monitoring framework to inform CE policies and provide links to resource and climate policies, resource inflow and outflow data, as well as waste and emissions data, need to be integrated and conceptualized together (Elia et al cited in Jacobi et al 2018).

"The market penetration of recycled materials is highly dependent on their physical and chemical characteristics, which will determine their price. However, not all the existing recycling technologies enable a fair competition between virgin and secondary materials, because their quality might differ"(Cobo et al 2018).The consumers' attitude can be changed by recognizing that the oils that are managed in an inappropriate manner will represent a loss for the organization. So organization that produce the oils should understand that any oil wastes not well managed represent a loss for them and the consumers of the oils should understand that paying taxes for the differences between the amount of used virgin oils and the amount of waste recovered either by recycling or by incineration is also a loss and the more they recover the less will be the loss. As the literature mentions (GEIR cited in Zimmerman & Jepsen 2018) "waste oil is the largest liquid hazardous waste stream in Europe (...) and the end-of-life treatment of waste oils is regulated by the Waste Framework Directive 2008/98/EC (EU Directive 2008). That directive states that waste oils should be collected separately where this is technically feasible, should be treated in accordance with article 4 - i.e. applying waste hierarchy principle - and article 13 - i.e. allowing protection of the environment and human health. Because oil is a valuable resource, waste oil should be managed so that waste oils of different characteristics and waste oils and other kinds of waste or substances should not be mixed, if such mixed impedes their treatment for recovery, fulfilling the EU targets (GEIR cited in Zimmerman & Jepsen 2018) which are by 2020: *a collection rate of 95 % of collectable waste oil* and *a recycling rate of 60 % of collectable waste oil*, and by 2025 *a collection rate of 100 % of collectable waste oil* and *a recycling rate of 85 % of collectable waste oil*. The literature (Zimmerman & Jepsen 2018) recognizes also that until now" there is no consistent method for the evaluation of the efficacy of the legal framework on waste oil treatment which can be adapted by the single states", each EU country has its own algorithm of computing the figures in order to document this efficacy with data having different national or European sources. One European source is for example the Union of

European Lubricants Industry that can assist in such cases by providing country specific approximations using proprietary algorithms. When it comes to the implementation of a circular economic model for oil industry the necessity of good reliable data is a very important prerequisite because it represents the starting point for building infrastructure for treatment waste oil in order to recycle them or for energy recovery. Although this is a very important issue, it is generally recognized by the professionals working in the field that it is time consuming and involving waste oil flows analysis and complex national specificities. "The European waste oil recycling industry is constituted of about 28 plants. Between 1,000 and 1,200 people are employed in re-fining and 2,000 to 2,500 in collection of waste oil (excluding waste oil from the food industry)" (EU Report 2009). There are significant differences between EU countries regarding the topic of circularity of materials in the oil extraction and processing industry field. If for example Germany, France, Spain and Italy are well ahead documenting those oil wastes fluxes, because based on those data and calculation they have already built re-refineries capacities, for other countries like Austria, Czech Republic, Hungary, Romania and the Baltic States there is not such infrastructure built. Motivations for such differences should be found in the fact that recycling industry is facing adaptation issues that are not easy to be solved. As Reh mentions (Reh 2013) when it comes to the big plants such are the processing capacities, they need usually longer planning and also implementation periods of time. For those big plants, and re-processing capacities that are in this category being built with the intention to serve a significant geographical region, having "high capital investments during the development, planning and construction stages, by economical reasons have to be operated for long periods, up to 10 fold of a political election period or two life generations. During the first 2-5 years, depending on type and capacity of the plant under planning, only costs accumulate. During about the same length of period of operation then al revenues of the successfully started and operating plant are recovering the costs of the construction period. Having reached returned on investment (ROI) point of time, undisturbed marketing of its products and stability of operational costs provided, the plant earns steadily money above the coverage of its investment and operational costs. Toward the end of lifetime, repair and other operational burdens as well as market competition or emission legislation make operation unprofitable. With extra costs, the plant has to be dismantled in an ecologically friendly way, with itself becoming an object of recycling or modified reuse. (...) In normal operation, typical life times of plant and building projects extend to more than 40 years. If plant life were shortened by unexpected or force majeure events, huge losses of capital for future projects would occur. This capital will be lacking for the urgently needed future investments. So even risk – taking entrepreneurs take their time in preparing new plant projects properly. Legislative and political stability will ease their actions and decisions! " In an oil extraction market were fluctuations of price and productions are high enough a market demand for recycled oils although it is tempting enough when regarding circular economies in different geographical regions should be carefully analyzed when it comes to the global market in order to have a relative stable coverage of the investment costs of the re-processing plants . In the scanned literature in the field we found an example of an attempt to conceive a method to show the economic synchronicity for the behaviour of a set of different oil and gas exploitations as a prerequisite of implementation of a circular economic model in this field by relevant monitoring and evaluation through a set of relevant and specific chosen indexes. Those indexes have been designed to indicate different possible status-quo that considered pilot projects in the example are going through their current operations within a defined period of time in a certain region using an early warning method with fuzzy ISODATA cluster analysis. Signalling no changes or relevant changes in the operations status-quo should be an important help reference for the optimal functioning of a circular economy. The authors (Jian & Kun 2011) show that to determine warning references for a functional circular economic model is not about only considering the convenience of data calculation, but also "the patterns of economic exploitation complied with the principle of circular economy when choosing criterion-referenced indexes" Analyzing the industrial waste is also a matter of harmonizing the used analytical methods in order to have good reliable results to be analysed (Kim et al 2017).

Results and discussion

In this paper a general scheme for wastes management based on product lifecycle assessment within a circular economic type of model is presented in Figure 1.

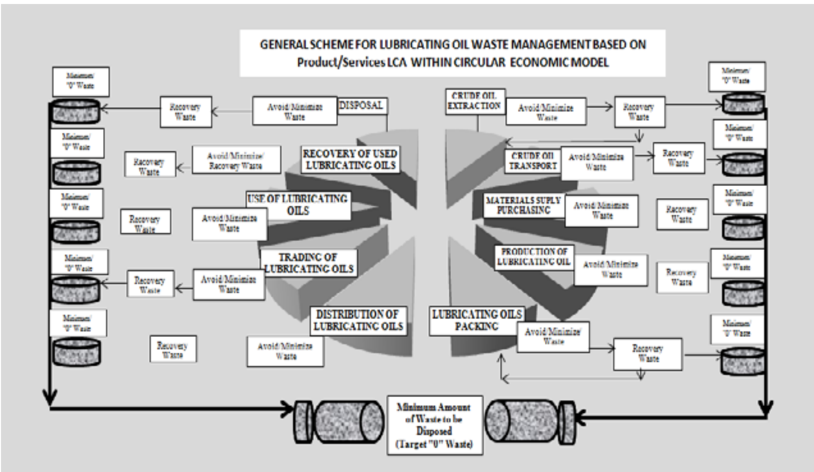

Figure 1. General scheme for lubrication oil waste management based on Product/Services LCA within circular economic model

In the scheme from Figure 1, an example for a lubricating oil type is taken. This product is considered along its life cycle namely from the extraction, transportation of raw materials needed for the manufacturing of the base oil and purchasing /supply of additive necessary for its formulation and continuing through, production of base oil necessary for lubricating oil product type and its bench formulation, lubricating oil packaging, distribution, trading, use, recovery and disposal In each of those steps corresponding to the phases through which this product is followed, in an ideal circular economy at the level of each organization there is the need to have in place good waste management practices in order to avoid or to minimize waste generation. Whenever based on technological applied process involving those mentioned phases, it is possible to apply local treatment for generated waste to end the status of waste and to apply recovery techniques including the incineration for energy recovery as a suboptimal option of recovery, all those techniques should be applied. The resulted recovered waste oil can become input for other economic activity within the local organization or within other ones within national/regional economy. Regarding the presented scheme it looks on the paper simply enough. In reality as presented in the former section such an endeavour requires a high degree of synchronicity with reference to the two types of raw materials namely the virgin raw material which is crude oil in the case of lubricating oil and recycled materials which may form the raw materials for recycled products. The products involving a high degree of circularity should have a quality similar to that from virgin raw materials when it comes for examples for lubricating oils obtained from re-refined used oils and be as we have mentioned earlier competitive as price i.e. the process of re-refining should be adjusted all the time in certain limits to the price of the crude oil on the market. This is a complicated endeavour on the unregulated, free market which trading products (stocks) should be in good agreement and synchronicity with the collection, transport and processing activity of the waste oils at least at the national and regional levels ensuring in the same time the high protection of environment and human health through evaluation of the hazards associated with waste and products that use waste as secondary materials (Guta et al 2017). Very good accounts about input-outputs levels with reference to the national production of such a product in correlation with to the import-export of such goods where it is the case should be kept to assure the industrial symbiosis. However, economic and social implication of such a circular economy means actually a good deal of control and national/regional intervention in order to have a functional economy. Consequently, strict monitoring in order to signal alert level for supply of virgin and secondary materials is necessary for assuring the level of planned outputs. From all these steps certain amounts of waste derived and linked to the lubrication oil product type result for the final disposal that also should be minimize in order to reach sustainability.

Conclusions

Because circular economy is an emerging concept its application from the practical point of view is supporting yet improvements so that challenges related to its implementation to be solved in the most efficient way. The presented scheme helps to give a general view about this very complex endeavour and is meant to be supported in future with different specific management scheme applied for the oil and oil waste field

Acknowledgments: The concept and work presented in this paper helped to enforce the application of good waste management principles in practice considering the current updated waste environmental legislation. The work has been achieved through funding support offered by Romanian Nucleu Programme developed by the Romanian Ministry of Research and Innovation within research and development, Project PN 18 05 04 01.

References

Arama, GM, Kim, L & Guta, D 2017, 'General scheme to evaluate the dangerousness of wastes in order to manage them by producer/holder organizations', *20th International Symposium "The environment and The industry", SIMI 2017,* National Research and Development Institute for Industrial Ecology ECOIND, Buucharest, pp. 151-158.

Cobo, S, Dominguez-Ramos A & Irabien, A 2018, 'From linear to circular integrated waste management systems: A review of methodological approaches', *Resources, Conservation & Recycling*, 135, pp. 279-295.

EC Directive 2008, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, Official Journal of European Communities, L. 312 of 22.112008, Brussels.

EU Report 2009, 'Study on the selection of waste streams for End of Waste assessment', Joint Research Centre, Final Report Annex I – Waste Stream Profiles –Waste Oil, p. 304. Available from: http://susproc.jrc.ec.europa.eu/documents/SelectionofwastestreamsforEoW-FinalReport13_02_2009.pdf

EU Report 2011, 'Closing the eco-innovation gap, Eco Innovation Observatory Annual Report'. Available from: http://www.eco-innovation.eu/index.php/reports/annual-reports

Guta, D, Cuciureanu, A, Kim, L & Arama, M 2017, 'The Assessment of dangerousness of waste, case study: waste originating from drilling muds'. *20th International Symposium "The environment and The industry", SIMI 2017,* National Research and Development Institute for Industrial Ecology ECOIND, Bucharest, pp. 189-196.

Jacobi, N, Haas, W, Wiedenhofer, D & Mayer, A 2018, 'Providing an economy – wide monitoring framework for the circular economy in Austria: Status quo and challenges', *Resources, Conservation & Recycling*, 137, pp. 156-166.

Iacovidou, E, Velis, AC, Purnell, P, Zwirner, O, Brown, A, Hahladakis, J, Millward – Hopkins, J & Williams, TP 2017, 'Metrics for optimising the multi-dimensional value of resources recovered from waste in a circular economy: A critical review', *Journal of Cleaner Production*, 166, pp. 910-938.

Jian, Z & Kun, H 2011, 'Research on Early-Warning Method and its Application of Complex System of Circular Economy for Oil and Gas Exploitation', *Energy Procedia*, 5, pp. 2040-2047.

Kim, L, Muresan, AM, Cuciureanu, A, Guta, D, Arama, GM, Cristea, NI & Dediu, V 2017, 'Experimental models of characterization and analysis of industrial waste', *20th International Symposium "The environment and The industry", SIMI 2017,* National Research and Development Institute for Industrial Ecology ECOIND, Bucharest, pp.142-150.

Niero, M & Schmidt Rivera, XC 2018, 'The Role of Life Cycle Sustainability Assessment in the Implementation of Circular Economy Principles in Organizations', *Procedia CIRP*, 69, pp. 793 -798.

Reh, L 2013, 'Process engineering in circular economy', *Particuology*, 11, pp.119-133.

Standards U.K. 2017, *British Standard 8001: 2017 Framework for implementing the principles of the circular economy in organizations – Guide.* Standards U.K.

Zimmermann, T & Jepsen, D 2018, 'A framework for calculating waste oil flows in the EU and beyond - the cases of Germany and Belgium 2015', *Resources, Conservation & Recycling*, 134, pp. 315-328.