Legislation, design and management of the electrical and electronic waste (e-waste) procedures

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Abstract-- **In the frame of the sustainable development the legislating, design and management of the electrical and electronic waste, are dominated from the applications of the precautionary principle. Every e-waste procedure needs a general reviewing, due to the many revisions and exceptions added. The introduction of the environmental principles justification, limitation and optimization, well used in the radiation protection, if appropriate modified, may be a useful complimentary tool in all the e-waste procedures.**

Index Terms—**E-waste, e-waste recycling, e-waste management, e-waste environmental pollution.**

I. Introduction

In the last years, the rate of waste electrical and electronic equipment (WEEE) is growing at an alarming rate, especially in organisation for economic cooperation and development countries where markets are saturated with huge quantities of new electronic goods [1]. The collection and proper treatment of WEEE requires a substantial management system that includes multiple operators, as well as substantial logistical and technical resources. Since environmental concerns about WEEE first emerged, many researchers have investigated consumer attitudes toward recycling [2]-[4], local government perspectives [5], and manufacturers' positions toward legislative requirements [6], [7].

There is a complicated chain of events in the e-waste problem parameters, which very early begin from the invention, followed by the production process and then by the purchase of a new product, and later on, after the finally ending of the product utilization by the end user. The expected global outcome is the consistently of the existence of electrical and electronic waste in vast quantities. The waste general categories are referred in the Article 1a of the EU Council Directive 75/442/EEC [1]. According to this as electrical and electronic wastes are classified all the related equipments or items or parts or batteries after the end of the appropriate working life, either are destroyed or are no longer needed for working or for use. Although e-waste is a general term, specified under the current version of the EU Directive 2002/96/EC [9] on waste electrical and electronic equipment (WEEE), which is studied and from the United Nations (UN) University [10]. According to this e-waste definition must be included also and all the extracted parts from the above items, which no longer perform satisfactorily. In conclusion as e-wastes must be characterized: either the true wastes, which are objects or parts that do not functioned anymore, either the objects or parts, that are false worked and do not repaired, either the worked objects or parts, which are replaced by other parts with newer technologies.

The mentioned study of the UN University estimates that there were be between 8.3 and 9.1 million tonnes of e-waste in Europe alone during 2005, with rising tendency estimated at 10.3 million tonnes per year, by the expansion from the EU15 member States to the EU27. The e-waste reusing solution is a preferable environmental action. The disassembly and recycling may be contaminate, risky and costly business to the environment and health, as well as is the throw out of the electrical and electronic wastes at the general rubbish dump, which already proved hazardous. The electrical and electronic products recovering and recycling is a very socially responsible action and the best way of the sustainable development contribution. Therefore the correct legislating, design and management of the electrical and electronic waste, is one of the most urgent environmental problems, which must be solved in national and international level. The hazardous substances from the corrosion and decomposition of the e-waste components, may release some values of pollution or toxic substances in the air, in the solid and in the water (surface & underground), which trigger's deterministic and stochastic effects on humans, animals and plants, as proved in many other waste impact (i.e. polluted water, radiation etc). The appropriate scientific limit values between the deterministic and the stochastic effects, indicates the difference of the provable effects and of the possibly and under investigation effects in the environment and health. Therefore it is clear that every hazard limit value is a percent of the above limit of the deterministic and stochastic effects, derived from the specific hazardous substance and must be reviewed frequently, according to the new scientific evidences. The many disposal natures and the collection efficiencies of e-waste, raise some obvious scientific, social and political concerns about the dangers to humans and to the environment.

The e-waste legislating, design and management involves various principles, theories and practices, verified continuously according the science progress, in order to protect the health and the environment from any hazardous waste. The not so early (1998) involved general environmental precautionary principle [11] indicates *"When an activity raises threats of harm to the environment or to the human health, precautionary measures should be taken, even if some cause and effect relationships are not fully established scientifically".* This

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simple philosophy, which adopted scientifically and politically [12] worldwide and expressed in laws and regulations, has many non obvious implications, when used in the appropriate subjects. Therefore the taking precautionary measures, in every scientific uncertainty, receives many interpretations, clarifications and specialisations, by exploring and drive alternatives to possibly harmful actions from the electrical and electronic wastes, in order of apply a protection value to the environment and to the general public, as well as for the working personnel in all the e-waste phases, mainly in the related recycling etc. The number of directives of the European Union, are an indication of the clarifications and specialisations needs of the related legislation in the frame of the precautionary principle application, for a sufficient international and national management of the electrical and electronic waste, which worsen the many details and exceptions derived from various public policies or from privet interests and/or from environmental initiatives.

II. MATERIALS AND METHODS

The precautionary principle must be applied with three preliminary conditions only: 1)-Identification of potentially adverse effects. 2)-Evaluation of the scientific data available. 3)-The extent of scientific uncertainty. Therefore the environmental waste policies and regulations are aimed at controlling the amount of pollution released into the environment and the related national and international laws must serve this without exceptions. When a governmental or privet program for the electronic waste is to be applying, the planners must calculate all the possible environmental and health impacts, in a study of "environmental impacts" by follow the appropriate laws. In some cases this is possible and easy, in some others it is not, due to the insufficient regulations that need the precautionary principle, which concentrates on prevention rather than cure. Therefore more and more arguments, clarifications and exceptions raised and must be expected, with the appropriate confusion.

An option to solve the above confusion referred in the Article 191 of the "Consolidated version of the treaty on the functioning of the EU" [13]. The referred "*It shall be based on the precautionary principle and on the principles that preventive action should be taken"* may be the adopt of a general clarification and specification, by the complimentary implementation of the three dominant environmental principles, the justification, the limitation and the optimization, well known in physical and medical sciences due to manage every radiation impact to the health and to the environment. The principles in details [14], are adopted by the EU. The justification, the limitation and the optimization principles, as well as applied for many decades in every radiation issue, may including some reference that the application is the e-waste also, by the addition of some special terms. Therefore the complimentary implementation of the justification, the limitation and the optimization to the precautionary principle application in the electrical and electronic waste procedures, may be the adding of the followed words (*in italics*): 1)-Justification: No (*e-waste)* practice shall be carried out unless its introduction produces a positive net benefit (*to health and to the environment)*. 2)-Limitation: The dose equivalent (*or the substance value)* to individuals, (*to public health and to the environment)* shall not exceed the (*e-waste)* limits recommended. 3)-Optimization (referred and as ALARA principle, from the acronym As Low As Reasonably Achievable): All (*e-waste)* exposures (*to health and to the environment)* shall be kept as low as reasonably achievable, economic and social factors being taken into account.

According these three principles as the dominant clarification and specification, in every legislation with the precautionary principle, all the electrical and electronic waste actions, which may release hazard substances (the radiation included), can be controlled and will enforce the minimizing of exceptions down to zero, as are all the implanted and infected medical devices, and/or the military electrical and electronics waste, referred specifically in the EU 2002/96/EC.

III. THE JUSTIFICATION IN THE E-WASTE

"No e-waste practice shall be carried out unless its introduction produces a positive net benefit to health and to the environment". Therefore the local regulation of e-waste must accept the environmental international legislation, with of specialized rules and specifications witch includes all the appropriate details. The meaning of the net benefit of the justification principle must be proved practically in every e-waste procedure: *In the rejected electrical and electronics* means that the related the rejection decision must produces more good than harm to the health and to the environment by the appropriate preliminary instructions. Therefore every rejected electrical and electronic item (equipment or circuit or component) must be classified, either as reused or as recycled or as e-waste rubbish. *In the dismantling and recycling* means that the recycling procedures must produces more good than harm to the health and to the environment by the appropriate measures. Therefore the dismantled and recycled components must be important or useful to the industry and the related rubbish produced do not increases the toxicity if remain in the e-waste landfill. *In the rubbish dump* means that the selection and organization of an the electrical and electronics rubbish area, must produces more good than harm to the health and to the environment by the appropriate measures. And also must do the same the related selecting and transporting procedures.

IV. THE LIMITATION IN E-WASTE

"The dose equivalent or the substance value to individuals, to public health and to the environment shall not exceed the e-waste limits recommended". The limits are politically decided by the up to date scientific knowledge and must be not necessary and safety limits also. Therefore must be authorized scientists, trained in e-waste, for monitoring the possible exceeding of the recommended limits in every e-waste procedure and guiding to keeping the appropriate measures for the personal and environmental safety. In accordance the substance value meaning drives the local e-waste legislation that must includes all the scientifically existed appropriate substance limits, which must be applied in practice: *In the rejected electrical and electronics* means that every rejected electrical and electronic item (equipment or circuit or component) must be classified, either as reused or as recycled or as e-waste rubbish, according to the recommended appropriate hazard limits. Therefore the related procedure will excludes every possible hazard to the health and to the

environment by the appropriate preliminary guides and measures. *In the dismantling and recycling* means that all the dismantling and recycling procedures are covered by the appropriate recommended limits as well as the related rubbish produced. *In the rubbish dump* means that every rubbish area for the rejected electrical and electronics, must be follow the recommended limits. Also must do the same and the related selecting and transporting procedures of the e-waste.

THE OPTIMIZATION IN E-WASTE

"All e-waste exposures to health and to the environment shall be kept as low as reasonably achievable, economic and social factors being taken into account". Therefore must be authorized scientists, with the appropriate training in as low as reasonably achievable, for monitoring and compare the e-waste procedures, in order to help the public and guide the involved personnel to the optimization principle applications and avoiding any possible exceeding of the minimum impact to the health and the environment in every e-waste procedure. In accordance the meaning of the kept as low as reasonably achievable, of the optimization principle, drives the local e-waste procedures to adding the international accepted scientific recommendations that must be applied in practice: *In the rejected electrical and electronics* means the existence of the installation of an organized collection management of the rejected electrical and electronic (equipment or circuit or component), which, in comparison with others, must produces the minimum impact to the health and to the environment. *In the dismantling and recycling* means that all the dismantling and recycling procedures, in comparison with others, demonstrated that must produces the minimum impact to the health and to the environment. *In the rubbish dump* means that every rubbish area, for the rejected electrical and electronics, must be proved that will produce the minimum impact to the health and to the environment by the appropriate measures. And also do the same and in the related selecting and transporting procedures.

V. RESULTS

The positive net benefit criterion of the Justification is enforcing the legislated precautionary applications with a very useful obstacle in every "try and error" practice of electrical and electronic waste, which is the most common in the modern world. Because many results, of the try and error procedure, may be proved not healthy and/or not environmentally correct. Typical examples are the expected blocking of many incorrect actions during the dismantling and recycling, during the rejected electrical and electronics management and in the rubbish areas for the e-waste. The not exceed of the recommended limits of the Limitation enforces the legislated precautionary with all the scientifically accepted limit values of the hazardous substances, included in every electrical and electronic waste and can block the non environmentally safe procedures, which probably release some hazardous substances over the appropriate limits, mostly referred as "collateral damages" impact. The criterion to keep as low as reasonably achievable of the Optimization drives to electrical and electronic waste actions with minimum impact, which enforces the legislated precautionary, in order to minimizing the environmental impact of electronic waste management, with account of the economic and social factors. This can scientifically block every arbitrary decision or policy, which very often supposedly is justified and/or covered by the local economical and social purposes, as well as, on the other side, will permit the correctly respond to the expected arguments from the politically acted ecologists, which denied many new initiatives and use the precautionary principle as a religion type.

VI. DISCUSION

Electrical and electronic waste contains potentially hazardous and/or valuable substances, which must be correctly treated and/or recovered. The e-waste legislation, design and management must be based on the precautionary principle and on the principles that preventive action should be taken. This may involve legal acts, related research programmes, public information measures, etc. The applications of the precautionary principle are based on preliminary conditions and other principles. First is the fullest possible scientific evaluation, by the determination, as far as possible, of the degree of scientific uncertainty, second is the risk evaluation and an evaluation of the potential consequences of inaction and third is the participation of all interested parties in the study of precautionary measures, after the availability of the scientific evaluation results and/or of the risk evaluation. The main targets are the justification of the act or not act decisions from the responsible authorities, which depend on the level of risk. This is a difficult and compromised decision, when the precautionary principle is invoked, which must be helped from the general principles of risk management: 1)-The proportionality between the measures and the protection level. 2)-The non-discrimination in the measures application. 3)-The measures consistency with the measures in similar situations or approaches. 4)-The benefits and costs examination from the action or from the action lack. 5)-The measures review according to the scientific developments. 6)-The burden of proof.

The extent of scientific uncertainty, as indicates the precautionary principle, will be easiest solved by the applications of the justification, the limitation and the optimization principles, added as the complimentary modification to the precautionary principle. These modifications will enforce the correct environmental e-waste legislation for the managing of the local e-waste procedures, by minimizing of the misjudging from the government officials and the misunderstandings from the involved personnel and/or from the policymakers. The identification of the potentially adverse effects in the precautionary principle will be easiest by the applications of the justification and the optimization, because all the scientific results for the stochastic effects will guide the e-waste correct decisions, through the positive net benefit and the minimizing of the environmental impact also. The evaluation of the scientific data available in the precautionary principle will be easiest by the applications of the limitation, because all the scientific results for the deterministic and the stochastic effects will guide the e-waste correct decisions, through the comparisons of the appropriate limit value, for every hazardous substance in the e-waste. Furthermore every e-waste limit application must comply with the positive net benefit of the justification and also with the minimizing of the environmental impact of the optimization.

Therefore this complimentary modification to the precautionary principle will enforces the correct e-waste applications from the local enterprises in the recovering and/or recycling of the potentially hazardous and of the valuable materials in the electrical and electronic waste. Under the proposed additional principles, every producer must inform the consumer if the product includes hazardous components, with instructions of how must handled the product during and after its use as e-waste, in order to prevent the dropping in garbage bins and the possible health effects from this e-waste mismanaging. The main modification benefit is that the trained professionals and/or the environmentalists and the related opinion-makers will find some important issues for the easiest decisions of the do and do-not in the details of the e-waste subject.

VII. CONCLUSION

E-waste has become a dominant problem in the municipal waste, which must be locally treated by the appropriate rules. The legislation with the precautionary principle, when in detail examined, has several non obvious implications and every regulation based on it, for the electronic waste, has being revising some times over the last 15 years. It appears that the principles group of the justification, of the limitation and of the optimization, which works well, over a half century, in radiation protection, is a useful tool in clarification and specialisation of the electrical and electronic waste legislating, design and management. These principles may be an important addition to the precautionary, with purpose the well been in health and environment by the cleaner air, water and land. This addition may help the regulatory bodies, mainly at the national level, to safely control the e-waste problem, instead of the spreading argument that everything is dangerous and also, in opposed, may pose obstacles to the occupational safety standards deviations and to the convenient but risky opinion that humans and ecosystems can absorb an amount of contamination, without being harmed. In either case the expected results are a contamination value of air, soil and water systems.

The introduction of the justification, of the limitation and of the optimization in the precautionary principle for regulated dismantling and recycling, as well as for the rejected electrical and/or electronics and for the rubbish dumps, will block the very risky dismantling items from non professional poor people without the occupational safety standards, the improper e-waste characterization, the politically accepted try and error risky procedures etc and finally will permit environmentally correct and healthy regulations, without some detailed marks and exceptions. A well managed today e-waste rubbish dumb will be the future source of the usable substance recovery and must be viewed as an unusable mine, which expect the technology development. Therefore the legislation, design and management of the e-waste procedures with the introduction of the justification, of the limitation and of the optimization, as principles added to the precautionary principle, will permit to the future technology to enhance the substance recovery from a well treated e-waste rubbish dumb.

The justification-limitation-optimization may be the legal and practical obstacles to the very inefficient and already utilized incorrect recycling, having deviations from the appropriate limits. Therefore the expected result will be the introduction of the new recovering technology driving. Finally the justification-limitation-optimization as already applied to the medicine and military radiation subjects, will make easiest the appropriate e-waste handling and non realistic every legal exception of the medicine and military issues, which is inserted in the e-waste legislation, regulation etc.

VIII. REFERENCES

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