

Sustainable Waste Management in Europe

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Abstract

A sustainable integrated waste management system should be environmentally efficient, economically affordable and socially acceptable to lead to a more valuable products recovery from waste, with less energy consumption and less emissions. Integrated waste management involves the use of waste control and disposal methods for minimizing the environmental impact of municipal, trade, and industrial waste. It is defined by the United Nations Environmental Programme as "a frame of reference for designing and implementing new waste management systems and for analysing and optimising existing systems". The integrated waste management means the use in the system of energy and raw materials from the 'environment', while less emissions, including solid waste, leave the system and enter the environment.

Keywords: waste, waste definition/classification, sustainable development, integrated waste management, zero waste strategies, pollution prevention hierarchy, waste prevention/recycling policies

1. Introduction

1.1. Sustainable Development

One important challenge of the 21st century economy is the improvement and maintenance of the environment. The paradox is that whilst the technological developments have increased the human capacity to extract resources from nature, to process them, and to use them, a parallel insight into how these resources can be returned to their environmental origin, or how they could be entered into a new cycle (extraction-processing-use) has not been offered.

Sustainable development promotes economic growth without compromising the management of the environmental resources.

The Brundtland Report, *Our Common Future* (1987)¹² defines sustainable development as "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable development became a fundamental objective of the EU in 1997, when it was included in the Treaty of Amsterdam as an overarching objective of EU policies. At the Gothenburg Summit (2001), EU launched a specific sustainable development strategy that "adds a third,

environmental dimension to the Lisbon strategy" of economic and social renewal, and is complementary to it. The Lisbon strategy focuses on growth and jobs, while the sustainable development strategy is overarching and qualifies which kind of growth we want to pursue. The Gothenburg Declaration forms the core of what is known as the EU's sustainable development strategy (EU SDS).

Sustainable development uses tools and methodologies such as cleaner production (CP), various environment care programs, principle "the polluter pays", environmental management system (EMS), environmental impact assessment (EIA), environmental information technologies (EIT), eco-efficiency concept, Life Cycle Analysis method, waste management strategies.

2. Results and Discussions

2.1. Waste definitions, classification, and concerns

Even though the concept of waste is at first sight easily understood by everybody, a precise legal definition of what waste really is, is difficult to be done.

Something becomes waste when it loses its primary function for the user. On the other hand, what is considered waste by someone, could become a raw material for someone else, the Nature cycles being best examples. The relative nature of waste explains why certain wastes keep a significant economic value.

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The legal definitions of waste^{4, 5} are shown in table 1.

Table 1. International Waste definition⁴

Organisation	Legislation	Definition
European Union	Waste Framework Directive (European Directive (WFD) 2006/12/EC), as amended by the new WFD (Directive 2008/98/EC, coming into force in December 2010).	"Any substance or object the holder discards, intends to discard or is required to discard " Once a substance or object has become waste, it will remain waste until it has been fully recovered and no longer poses a potential threat to the environment or to human health.
	EU Council Directive 75/442/EEC, ammended by Council Directive 91/156/EEC, art. 1(a).	"Waste" shall mean any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard . 16 waste categories are defined.
United Nations Environmental Preogram	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, article 2	"Wastes" are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law;
OECD	OECD/Eurostat Joint Questionnaire on waste	Waste refer here to materials that are not prime products (i.e. products produced for the market) for which the generator has no further use for own purpose of production, transformation or consumption , and which he discards, or intends or is required to discard . [The following] are excluded : Residuals directly recycled or reused at the place of generation ; Waste materials that are directly discharged into ambient water or air .

A classification of wastes is possible after their origin, physical state, physical properties, safety level, original use, or material type. A wastes classification attempt is presented in table 2.

Table 2. Classification of wastes

Criterion	Criterion		
	Physical state	Physical Properties	Effect on Human Health
Residential	Solid	Non-biodegradable	Non-Hazardous
Industrial	Liquid	Bio-degradable	Hazardous
Commercial			
Institutional			
Construction and demolition			
Municipal services			
Agriculture			

2.2. Waste Management Evolution

The rate of waste generated is increasing with population rate and social standards, i.e. the more advanced and wealthy societies (individuals) produce more waste. Waste management consists of waste prevention, reuse, material recycling, composting, energy recovery, and final disposal. It covers nowadays a wide variety of materials, activities, industrial sectors and actors. For an efficient waste management, it is essential to develop and maintain a sense of responsibility and a good common understanding of the materials and operations involved over the whole range of actors concerned.

Modern waste management focuses on treatment and disposal of the waste that cannot be recycled in a safe environment,

and should be sustainable. In the last 20 years, a number of techniques of waste treatment have been developed, all consisting primarily of: waste incineration with or without the use of burning heat; composting; biogas production to produce heat, landfills with or without the use of biogas. The trend of waste management is the implementation of an multi-resource integrated system, based on source separation/segregation, followed by reprocessing, recycling, energy use, or treatment with different technologies. The Sustainable Waste Management needs to be environmentally effective, economically affordable, and socially acceptable.

New trends in the industry lead to the need of evolving of the 3Rs of waste management "Reuse, Reduce, and Recycle" into 5Rs: "Reduce, Reuse, Recycle, Recover resources, and Residual management". The Pollution Prevention Hierarchy is shown in figure 1.

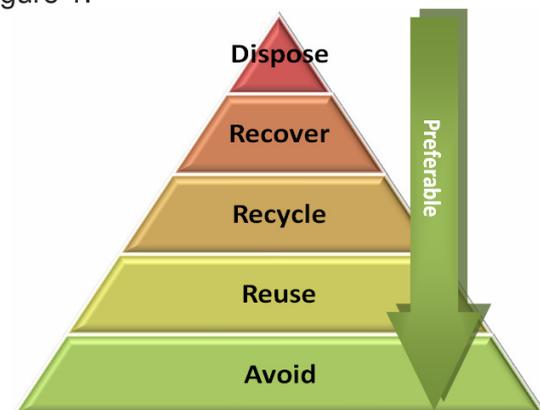


Figure 1. Pollution Prevention Hierarchy

A new hierarchy for waste management to approach full utilization of waste is a must, because of the high cost of waste treatment. It starts from reduction at source, reuse, recycle and sustainable treatment for possible material recovery for conservation of natural resources (4R Rule), and develops to the 6R Golden rule that aims at Reducing, Reusing, Recycling, Recovering of raw materials from waste through sustainable treatment, Rethinking, and Renovation. Adding Regulation, the 7R Golden Rule was established. The 7Rs rule provides a methodology to manipulate current activities to approach zero pollution and avoid landfill, incineration and/or traditional treatment, based on the concept of adapting the best environmental practice option for individual waste streams and of dealing with waste as a by-product. This 7Rs Golden Rule for zero pollution can be considered the Sustainable Waste Management Hierarchy for Zero

Pollution and the Industrial Ecology Hierarchy for Zero Pollution (figure 2)

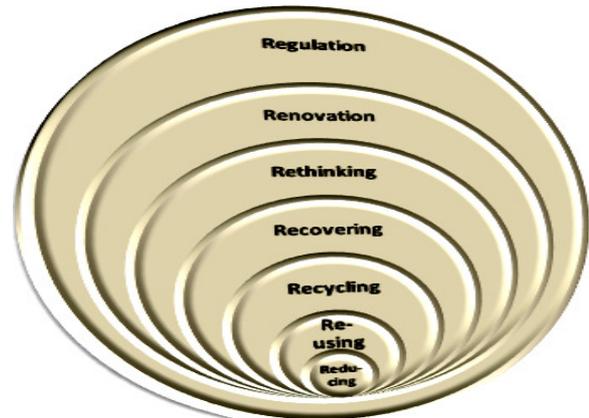


Figure 2. Sustainable Waste Management Hierarchy for Zero Pollution

The visionary goal of Zero Waste² expresses the need for a closed-loop industrial/societal system as suggested in Figure 3.

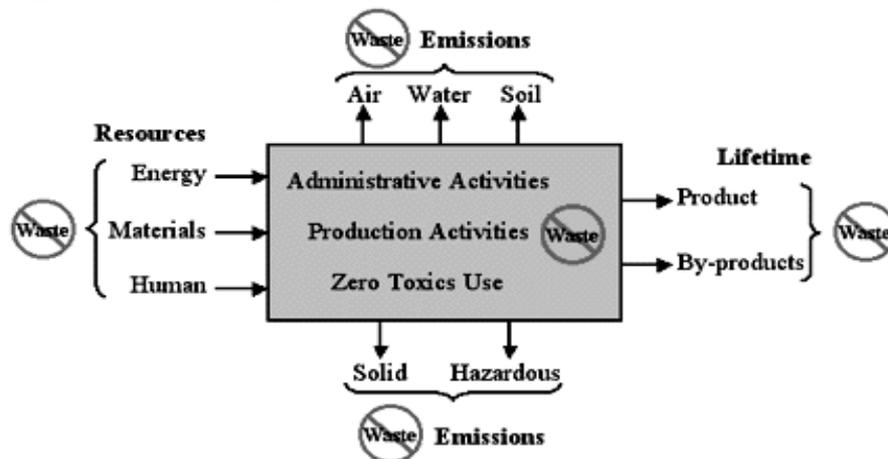


Figure 3. Application of Zero Waste Strategy

The term Zero Waste includes "Zero Solid Waste", "Zero Hazardous Waste", "Zero Toxics", and "Zero Emissions".

Zero waste suggests that the entire concept of waste should be eliminated. Instead, waste should be thought of as a "residual product" or simply a "potential resource". Opportunities such as reduced costs, increased profits, and reduced environmental impacts are found when returning these "residual products" or "resources" as food to either natural and industrial systems.

Zero Waste strategies consider the entire life-cycle of products, processes and systems, in the context of a comprehensive systems understanding of their interactions with nature, and search for inefficiencies at

all stages. In this light, wastes can be prevented through designs based on full life-cycle thinking. A Zero Waste strategy leads to look for inefficiencies in the use of materials, energy and human resources. To achieve a sustainable future, extreme efficiency in the use of all resources is required, which is supported by this strategy.

Sustainable solid waste management systems can be engineered by accepting the concept of an integrated approach to solid waste management, and using as a tool for optimising the integrated waste management system a Life Cycle Assessment.

2.3 European Legislation

The European Legislation^{3, 5, 6, 7} concerning wastes is presented in figure 5

and includes framework legislation, operations, and the waste streams. legislation concerning the waste treatment

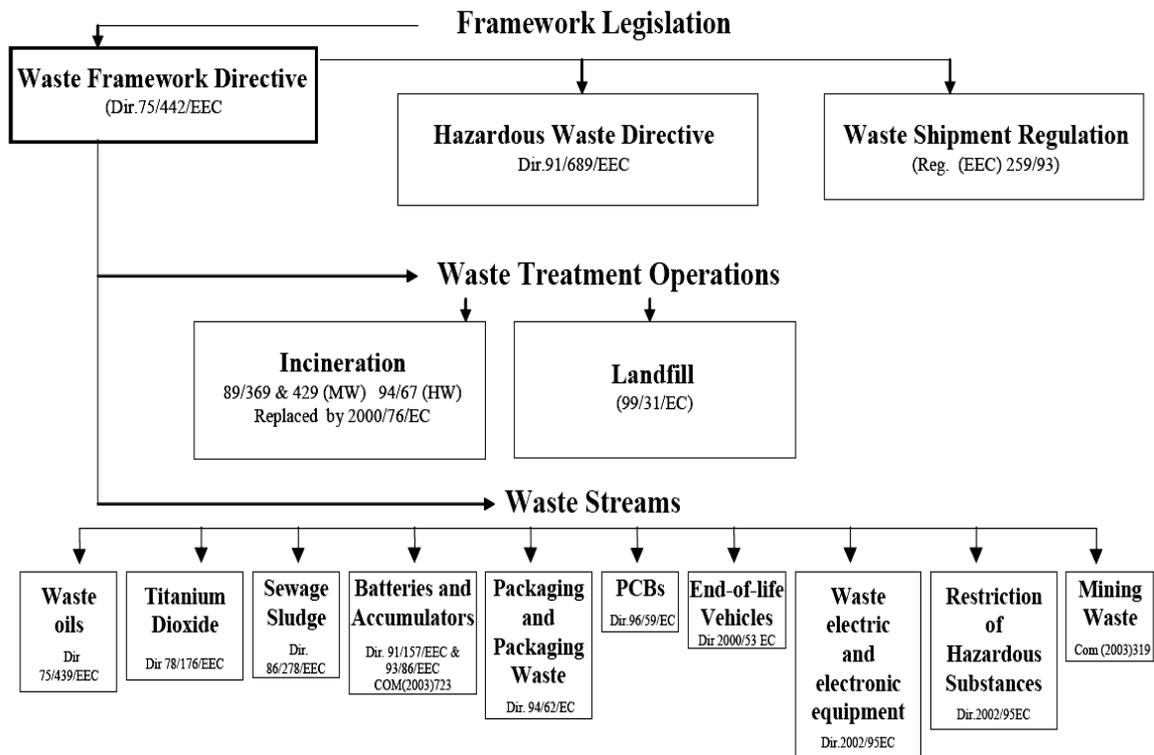


Figure 5. EU Waste legislation

2.4. European Waste Strategy

The European Commission proposed a new strategy⁹ on the prevention and recycling of waste. The “New waste strategy: Making Europe a recycling society” is a long-term strategy that aims to help Europe become a recycling society seeking to avoid waste and uses waste as a resource. The first step is the revision of the 1975 Waste Framework Directive to set recycling standards and to include an obligation for Member States to develop national waste prevention programmes. The revision will also merge streamline and clarify legislation, contributing to better regulation. The waste and resources strategies are two of the six thematic strategies required under the 6th Environment Action Programme (2002-2012) considered a modern way of decision-making.

The Thematic Strategy on the prevention and recycling of waste is based on two major premises.

1. Waste policy should focus on the environmental impact of using resources.

2. Waste policy should take a life-cycle approach.

Waste policy should also tie in with the Integrated Product Policy (IPP). IPP aims to reduce environmental impacts from products throughout their life-cycle, where possible using a market-driven approach. It seeks to integrate the many policies and instruments that affect products during their life-cycles, from eco-design measures and lifecycle assessments through public purchasing and information campaigns to producer-responsibility mechanisms, to encourage greater penetration of the market place by “greener” products.

Waste prevention and recycling policies can reduce three different environmental impacts: the impacts of extraction of primary raw materials, air pollution or energy use from the transformation of primary raw materials in production processes, and emissions from waste disposal installations, e.g. methane emissions from landfills.

Waste prevention and recycling measures need to yield net benefits and reduce the accumulated impacts throughout the life cycle of a resource. The new knowledge base developed in conformity with the

principles of the Resources Strategy will help identify the key impacts that waste prevention and recycling can reduce.

The Thematic Strategy on the prevention and recycling of waste will help the EU adopt more sustainable patterns of resource use. The aim is to move closer to a society that is not wasteful and manages waste according to the following principles:

- A good knowledge base informs waste policy
- Waste prevention policies work towards a common goal
- An overall eco-efficient recycling policy covers all waste materials
- Waste recycling operates with high environmental standards in an open market

2.5. Integrated Waste Management (IWM) Concept

2.5.1. Waste Prevention and Integrated Waste Management.

In life cycle studies^{8, 13}, a 'system' is defined (with boundaries indicated by broken lines). Energy and raw materials from the 'environment' are used in the system. Emissions, including solid waste, leave the system and enter the environment.

The waste generating process, and roles of waste prevention and of an IWM are presented respectively in figure 6.

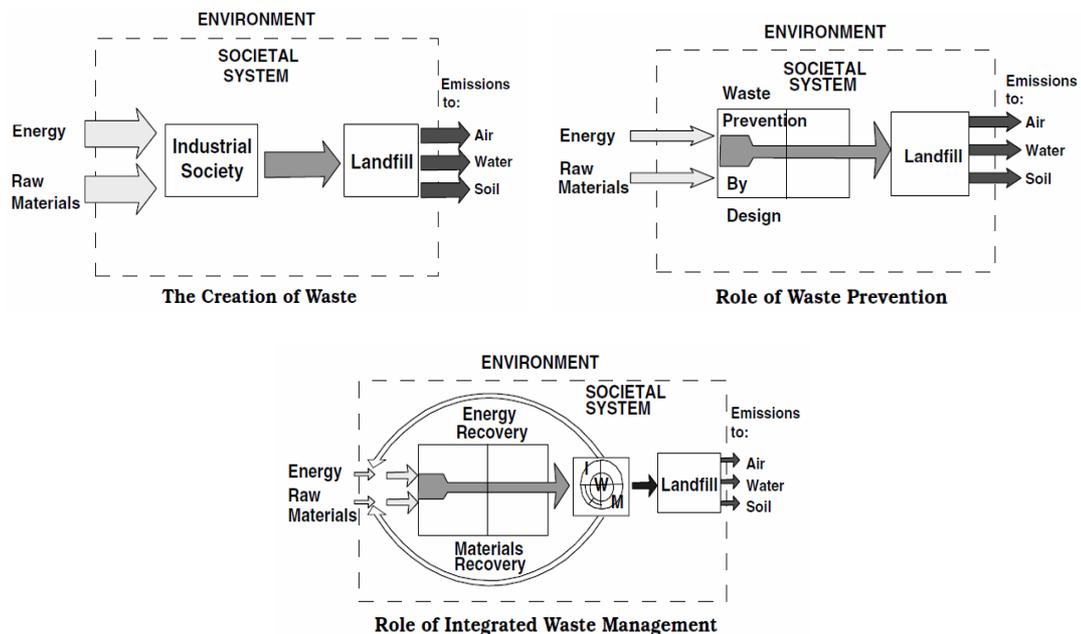


Figure 6. Role of waste prevention and of Integrated Waste management in pollution reduction

2.5.2. Integrated Waste Management Concept

Integrated Waste Management (IWM)¹⁴ is comprehensively defined as a system for waste management that has control over all types of solid waste materials and all sources of solid waste, such as domestic, commercial, industrial, institutional, construction and agricultural. Hazardous waste needs to be dealt with within the system, but in a separate stream. IWM systems combine waste streams, waste collection, treatment and disposal methods, with the objective of achieving environmental benefits, economic optimisation and societal

acceptability. This will lead to a practical waste management system for any specific region.

The Key features of IWM are an overall approach, it uses a range of collection and treatment methods, it handles all materials in the waste stream, it is environmentally effective, economically affordable, and socially acceptable.

An integrated system would include an optimised waste collection system and efficient sorting, followed by one or more of the following options: Materials recycling, Biological treatment of organic materials, Thermal treatment, Landfill (figure 7)

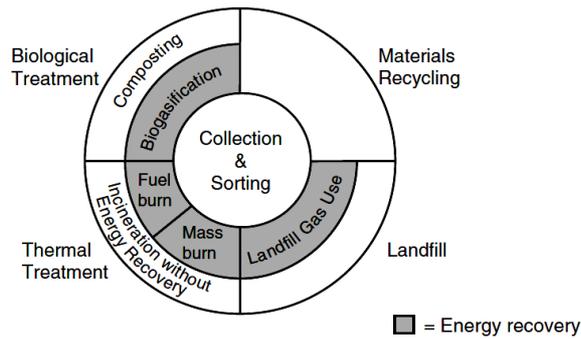


Figure 7. Elements of Integrated Waste Management

The final and most significant definition of IWM took place in 1991, when a task force from the Economic Commission for Europe published a Draft Regional Strategy for Integrated Waste Management that defined IWM as a 'process of change in which the concept of waste management is gradually broadened to eventually include the necessary control of gaseous, liquid and solid material flows in the human environment.'

The concept of IWM now included all waste types, the option of using a range of treatment technologies depending on the situation and an overall approach being taken with respect to Development of the Integrated Waste Management Concept

The United Nations Environmental Programme (UNEP, 1996) recognised the importance of Integrated Waste Management, which is defined as "a frame of reference for designing and implementing new waste management systems and for analysing and optimising existing systems" and as 'an important element of sound waste management practice'.

2.5.3. Sustainable Waste Management System concept

A sustainable solid waste management system¹³, considered in a holistic way, should be designed taking into account that it aims for

- Environmental effectiveness: reduce environmental burdens
- Economic affordability: drive costs out

The system should be *integrated*: in waste materials, in sources of waste, in collection methods, in treatment methods (anaerobic digestion, composting, energy recovery, landfill, recycling); *Market oriented*: materials and energy must, have end uses and generate income; *Flexible*: for constant improvement

Care has to be taken to define clear objectives, design a total system against those objective, operate on a large enough scale. Never stop looking for improvements in overall environmental performance and methods to lower operating costs.

The holistic approach has three main advantages: it gives the *overall picture* of the waste management process, essential for strategic planning; *environmentally*, all waste management systems are part of the same system – the global ecosystem; *economically*, each individual unit in the waste management chain should run at a profit, or at least break even.

2.5.4. Integrated Solid Waste Management Planning

A comprehensive Integrated Solid Waste Management Planning Process is presented in figure 8.



Figure 8. ISWM planning algorithm

An Integrated Waste Management system minimises risks to public health and results in a clean, healthy environment for all citizens. The recycling industry benefits from a steady supply of recyclable materials. The system must be affordable for all sections of the community, but the full cost of the waste management system must be recovered to ensure that the system is sustainable. This is another of the great challenge of waste management.

Conclusions

A sustainable integrated waste management system should be environmentally efficient, economically affordable and socially acceptable to lead to a more valuable products recovery from waste, with less energy consumption and less emissions. Integrated waste management involves the use of waste control and disposal methods for minimizing the environmental impact of municipal, trade, and industrial waste. The integrated waste management means the use in the system of energy and raw materials from the 'environment', while less emissions, including solid waste, leave the system and enter the environment.

The IWM concept and LCA tools can help to move towards affordable environmental sustainability.

Waste characterisation and understanding of total waste arising are needed, to make better decisions for every waste management system.

A variety of waste management systems are required to meet local needs especially in countries with developing economies.

Limited waste management budgets make the use of LCA tools even more important to ensure that money is not wasted on systems that deliver sub-optimal environmental results.

Bibliography

- [1] ***US EPA, Solid Waste Management: A Local Challenge With Global Impacts, <http://www.epa.gov/globalwarming/actions/waste/tools.html>
- [2] ***Zero Waste Approach, Zero Waste Alliance, <http://www.zerowaste.org>
- [3] Basel convention on the control of transboundary movements of hazardous wastes and their disposal adopted by the conference of the plenipotentiaries on 22 March 1989
- [4] Bontoux, Laurent, Leone, Fabio , The Legal Definition of Waste and its Impact on Waste Management in Europe, Luxembourg, Office for Official Publications of the European Communities, EUR 17716 EN, 1997
- [5] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Directive), OJ of EU L 312/3/ 22.11.2008
- [6] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment, Official Journal of the European Union, L 37/2, 13.2.2003
- [7] Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, Official Journal of the European Union L 37/19, 13.2.2003
- [8] Luo, Zheng, Eder, Peter, Evolution of waste generation and management in EU Accession Countries, Proceedings Integrated Waste Management & Life Cycle Assessment Workshop and Conference, Prague, 13th to 16th April, 2004
- [9] <http://ec.europa.eu/environment/waste/pdf/FinalReportfinal25Oct.pdf>
- [10] Ministry of Environment and Sustainable Development & United Nations Development Program, National Centre for Sustainable Development, Bucharest, 2008, Official Gazette No. 824 / 8 December 2008
- [11] National Sustainable Development Strategy of Romania 2013-2020-2030, Government of Romania
- [12] Report of the World Commission on Environment and Development: Our Common Future (The Brundtland Report), (1987), <http://www.un-documents.net/wced-ocf.htm>
- [13] Salah El-Haggar, Sustainable Industrial Design and Waste Management: Cradle to Cradle for Sustainable Development, Elsevier Science & Technology Books, ISBN: 0123736234, 2007
- [14] Salter, S., Resources from Waste: A Guide to Integrated Resource Recovery, British Columbia Ministry of Community Development, ISBN 978-0-7726-6116-6, http://www.cscd.gov.bc.ca/lgd/infra/library/Resources_From_Waste_IRR_Guide.pdf