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Progress and Challenges in C&D Waste Management in Greece

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Abstract

The waste produced during the life cycle of the construction industry projects (construction, renovation, demolition) has been identified as a priority waste stream by the European Union, accounting for approximately 25% - 30% of all waste generated and a large portion of waste in landfills. C&D waste consists of materials which have a high resource value and a strong potential for recycling and re-use. Still, only 5% is recycled all over the world. The level of recycling and material recovery varies greatly across EU. In order to encourage an integrated management of C&D waste with regard to circular economy theory, a strong legislative framework has been established in European Union. All member states, including Greece, must take the necessary measures to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste shall be prepared for re-use, recycled or undergo other material recovery. This paper presents the Greek legislative framework as well as current practices with regard to C&D waste management in Greece. Existing obstacles and recommended measures are discussed, in order to achieve effective C&D waste management on a larger scale and maximise its environmental and social benefits.

Keywords

Construction and Demolition Waste, C&D Waste, Circular Economy, Recycling, Greece

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1. Introduction

The sector of buildings and public construction works is very important for the economic development of a country, but it has an important contribution to the environmental degradation, due to natural resources consumption as well as its contribution to global pollution (Table 1).

Table 1. Contribution of construction industry to environmental degradation [1].

GLOBAL RESOURCES		GLOBAL POLLUTION	
Resource	**Building use**	**Type of pollution**	**Building related**
Energy	50%	Air quality (cities)	24%
Water	42%	Global warming gases	50%
Materials	50%	Drinking water pollution	40%
Agricultural land loss	48%	Landfill	20%

Construction and Demolition waste (CDW) is one of the largest waste streams in the world. Based on volume it is the largest waste stream in the EU, accounting for about one third of all waste generated in the EU [2]. It is produced from constructions, renovations, and demolitions of technical works like buildings, road constructions etc. The CD Waste

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consists of a number of materials more or less natural such as stones, wood concrete etc or synthetic like plastics, insulation. Excavated soil is also included in the legislative framework of some European countries such as Greece (ECDW). With regard to the type of the project as well as the phase of the life cycle, the materials found in the stream of ECDW can be sorted as follows (Table 2):

Table 2. ECDW deriving from constructions industry projects.

Type of project	Materials
Construction of buildings/ urban public works	Concrete, cement, bricks, tiles, stones, metals, wood
Demolition/ renovation/ maintenance of buildings/ urban public works	Concrete, paper, ceramics, stones, wood, plastics, asbestos, glass
Road construction/ maintenance	Soil, asphalt, concrete, metals, wood, plastics
Excavations	Wood, soil

The quantitative composition of ECDW varies and depends on the type of construction, the phase of the project and, of course, the country. According to the European Environment Observation Network (EIONET) [3] an average composition for the European countries includes: 75% concrete, bricks, tiles etc, 11% wood, 5% metals, 5% glass, plastics, insulation material, 5% other mixed wastes.

Their uncontrolled dumping or disposal in landfills is environmentally and economically harmful. An alternative management leading to components/ materials reuse and recycling helps to minimize ECDW quantities as well as to decrease the demand for raw materials.

The ECDW produced in worksites consists mainly of remaining quantities of materials like bricks, tiles, aggregates, steel, aluminum (some of them already destroyed) as well as packages materials like plastics, wood, metals. Most of them are clean and can be accumulated separately, so their management in terms of reuse in the same or another project or recycling seems to be easy and economically beneficial. During restoration and demolition of buildings, components like doors and windows are first recovered. They are usually sold at a lower price in the market of second hand materials and can be reused. The rest of demolition waste is mixed and in some cases may be contaminated by toxic substances or undesirable components. The use of special techniques as well equipment, in order to achieve good recycling results is necessary, but it leads to higher costs. A sustainable approach, taking into account both the need for economic profit by all the stakeholders, along with the environmental and social benefits deriving from the alternative management of ECDW should be implemented.

2. Legislative Framework

One of the objectives of the Waste Framework Directive (2008/98/EC) is to provide a framework for moving towards a European recycling society with a high level of resource efficiency, stipulating that Member States shall draw up waste management plans and waste prevention programmes and take the necessary measures designed to achieve specific goals for re-use, recycling and material recovery. In 2015, European Commission further adopted a Circular Economy package indicating the need for a "transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized" [4].

Greek Statutory Law 2939/2001, as amended and in force by the laws 3854/2010, 4042/2012 and 4496/2017, sets the frame for the alternative management (recovery, recycling) of waste in Greece, including excavation and demolition waste, which fall under the definition of "other waste". Transposing the provisions of Waste Framework Directive, Article 4 sets the following principles to guide the alternative management of waste: (a) in compliance with the European Waste Hierarchy: the principle of waste prevention by reducing total waste volume and contained hazardous ingredients, the principle of reuse, material recovery and recycling of waste, as a priority, followed by energy recovery, without polluting the environment, in order to reduce the final disposal of waste, (b) the "polluter pays" principle, (c) the principle of the responsibility of all public and private economic operators involved, and (d) the principle of publicity to users regarding the measures taken to enforce the law, in order to highlight their role as factors contributing to the reuse or recovery (alternative management of waste).

Law 4496/2017 amended article 4, by adding the principle of "Extended Producer Responsibility" (EPR). EPR can be defined as “an environmental policy approach in which a producer’s responsibility for a product is extended to the post-consumer stage of a product’s life cycle” [5]. EPR seeks to achieve a reduction in the environmental impact of products, throughout their lifespan, by rendering producers responsible for the cost of product management at the end of their life cycle. EPR is to be considered as a major instrument in support of the implementation of the European Waste Hierarchy, and therefore for the increase of, by priority: prevention, reuse and recycling [6].

Law 2939/2001 also outlined the foundation of the “National Organisation for the Alternative Management of Packaging and Other Waste”, which was subsequently renamed “Hellenic Recycling Agency” (HRA), by law 4042/2014. HRA is

supervised by the Ministry of Environment and Energy and its main objective is the design and implementation of policy for the alternative waste management. Law 4496/2017 further stipulates that H.R.A. may perform audits with the assistance of the Environmental Inspectors' Service, the country's economic prosecutors, the audit services of the Ministry of Economy and Development, the country's regional authorities, as well as any other public authority.

The regulatory framework aiming specifically at the management of CD waste is provided by Joint Ministerial Decision 36259/1757/E103 of 2010 setting out "measures, conditions and program for the alternative management of excavation, construction and demolition waste (ECDW)", applying to all waste from excavation, construction and demolition. Hazardous ECDW, which are produced from industrial and other areas and are polluted with hazardous substances, constitute mining and ore processing waste or excavated soil and natural materials to be used unprocessed for backfilling in the excavated area are excluded.

Article 11.2 of the Waste Framework Directive stipulates that Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste shall be prepared for re-use, recycled or undergo other material recovery (including backfilling operations using waste to substitute other materials). JMD 36259/1757/E103 sets the following goals for the alternative management of ECDW:

1) The reuse, recycling and recovery of materials should amount to at least 30% by weight of the total ECDW produced in the country, until January 1, 2012,
2) at least 50% by weight of the total ECDW, until January 1, 2015,
3) at least 70% by weight of the total ECDW, until January 1, 2020.

In order to achieve those goals, JMD 36259/2010 states the necessity of organizing and developing a network of Alternative Management Systems for the collection, sorting, treatment and recovery of waste from construction, demolition and excavation. The creation of Alternative Management Systems is based on the principle of "Extended Producer Responsibility". Despite EPR being an individual obligation, in practice stakeholders can exert this responsibility in collective schemes. H.R.A. is responsible for approving, monitoring and controlling those systems based on specific requirements. The contractors of public and private engineering projects are obliged by law to organize or participate in individual or collective alternative management systems for waste generated by their activity pursuant to Law 2939/2001 and JMD 36259/2010.

Article 181 of Law 4001/2011 stipulates that alternative management systems may be permitted to operate for the purpose of ECD waste disposal, treatment and recovery in mines and quarries that are inactive, or whose operation has been extended for environmental rehabilitation, clarifying that those facilities are of a temporary nature and are eliminated upon completion of the rehabilitation project.

Article 40 of Law 4030/2011 "New way of issuing building permits, construction inspection and other provisions" further states that excavation waste from public construction works, including concession contracts, may be disposed of in inactive quarries for partial or total rehabilitation, upon completion of the rehabilitation study and Decision on Approval of Environmental Terms. The restoration of inactive public quarries is carried out at the expense and care of certified EDCW management systems, following a tendering procedure by the Decentralized Administration.

3. ECD Waste Generation in Greece

Data on ECDW generation are provided by the Greek Statistical Authority (ELSTAT), also presented in Eurostat's Waste database [7]. Eurostat reports waste generation statistics for each country by waste category, hazardousness and economic activity (NACE Rev. 2 code).

Total waste originating from the construction sector (code F in NACE Rev.2 classification) along with "mineral waste from construction and demolition" works (W121 waste category, according to the European Waste Classification for statistical purposes) originating from all economic sectors are taken into account to estimate the total amount of ECDW generated in Greece in the years 2010, 2012 and 2014 (Table 3).

A total amount of 690,000 tonnes of non- hazardous construction and demolition waste is estimated to be generated annually by year 2020 in Greece, according to the Greek National Waste Management Plan [8].

Table 3. ECD waste generation in Greece (Eurostat).

Year	2014	2012	2010
Non hazardous ECDW (tn)	491,693	815,325	2,085,300
Hazardous ECDW (tn)	153	471	1,685

4. Current Practices in Greece

The Law required the development of a sufficient network of treatment facilities that can manage the entire amount of ECDW produced in Greece and the gradual establishment and operation of adequate ECDW managements systems to cover all areas of the Greek territory up to January 1st, 2014. Currently in Greece

there are 9 operating Systems for alternative management of excavation, construction and demolition waste. The first system for recycling ECD waste was approved by H.R.A. in 2011, followed by four more collective systems in 2012, two ECDW systems within 2013, and finally two more systems in 2014. Some of them have expanded their geographical coverage over the last years, still the whole network covers just about half the Greek territory (Figure 1).

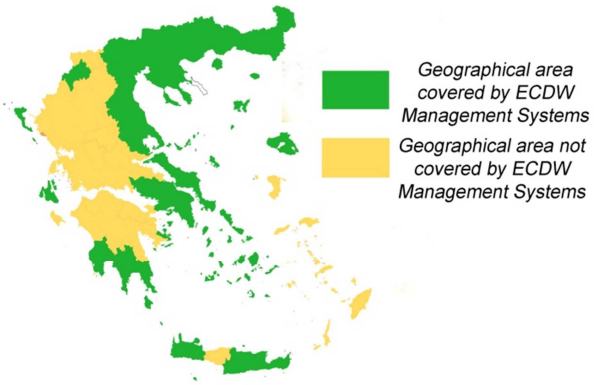

Figure 1. Map showing the geographical coverage of ECDW management systems in Greece.

According to the Greek National Waste Management Plan, the treatment facilities' registered capacity was more than 3 million tonnes per annum in May, 2013. There is also a large network of licensed collectors - carriers, capable of meeting the country's needs. The report states the absence of licensed landfills for the disposal of ECDW treatment residues. There is also no official listing of inactive/ abandoned quarries that could be backfilled with ECD waste for restoration purposes.

Tables 4 and 5 present national performance data for the years 2013-2016, based on the annual reports submitted by the ECDW Management Systems to H.R.A [9, 10]. Retrieved materials were mainly used as aggregates for rural roads surfacing. The lack of reliable data on ECDW generation and the absence of monitoring mechanisms make it difficult to make a full evaluation of national performance. However it is safe to say that, at least until 2014, the national target was not achieved. Out of the estimated total amount of 491,693 tn of ECDW generated in Greece, 176,112 tn (36%) were managed through the Systems and finally 59,315 tn of materials (12%) were retrieved from the treatment facilities in 2014.

Table 4. Quantities (tn) of ECDW that were treated over the period 2013-2016 (H.R.A.).

Year	Excavation waste	Construction and demolition waste	Total ECDW
2013		Approximately 53,000	
2014	142,722	33,390	176,112
2015	96,615	80,168	176,783
2016	370,930	154,346	525,276

Table 5. Quantities (tn) of inert materials that were retrieved from treatment facilities (H.R.A.).

Year	Total ECDW	Retrieved materials from treatment facilities	Percentage of retrieved recyclable materials
2014	176,112	59,315	34%
2015	176,783	126,218	71%
2016	525,276	247,802	47%

The following information is retrieved from yearly reports published by ECDW management systems and personal communication with ECDW Management Systems representatives. The latter were required to participate in a survey, providing quantitative data on excavation, construction and demolition waste management and answering questions regarding the obstacles they faced, the barriers that need to be overcome and the measures they recommend in order to improve waste management performance.

In total, seven out of the nine certified, operating Systems (78%) were included in the following analysis, since the other two did not participate in the survey, nor did they provide any performance data. As a result, numerical data (e.g. total amount of ECDW treated, number of projects contracted to ECDW Management Systems) would be slightly higher in reality; however the trends revealed by the available information are not expected to vary considerably, especially since those two Systems are operating within a geographical area, in Northern Greece, already covered by the other Systems included in the survey. Most Systems provided data starting from the year following their certification and ending in 2015 (seven Systems), 2016 (seven Systems) and 2017 (five Systems).

There is some heterogeneity in the way Systems report incoming waste streams, but classification in three distinct categories (excavation, construction and demolition and other) was attempted based on their description. In cases of available data, construction and demolition wastes were also reported separately. “Construction waste” also includes waste produced by new infrastructure or new infrastructure improvements (including significant structural repairs). "Other" usually refers to additional (often partially sorted) CD waste streams. It may include waste streams such as asphalt mixtures, metals, concrete, glass, plastic, cables etc produced by road, water, sewage and other major technical projects, involving the demolition of older technical infrastructure.

The evolution of ECD waste managed by the certified Systems over time (Figure 2) shows that there is a significant improvement in the alternative management of waste in Greece, especially since 2017 quantities are retrieved from five Systems only. ECD waste managed in Greece constitutes mainly excavation waste along with separate waste streams produced from public infrastructure projects. Construction and demolition waste has a lower contribution, which is consistent with the economic recession and the decline in private construction activity (Figure 5).

The number of projects contracted with the Systems is also rising, especially since 2016. However, it seems that actors of the private sector demonstrate better compliance with the legal framework of ECDW alternative management, since there are a higher number of private contracted projects (Figure 3), having a significant contribution to the total amount of ECD waste tonnage managed by the Systems over the years (Figure 4). In fact, a System's representative stated that they haven't undertaken any ECD waste quantities from public projects to present, although the specific System holds exclusivity in some prefectures.

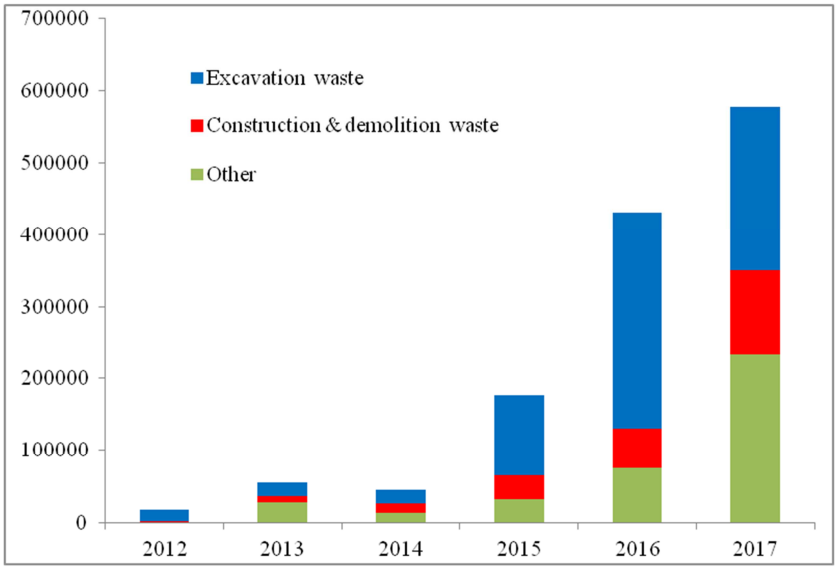

Figure 2. Quantities (tn) of ECD waste managed in Greece over time.

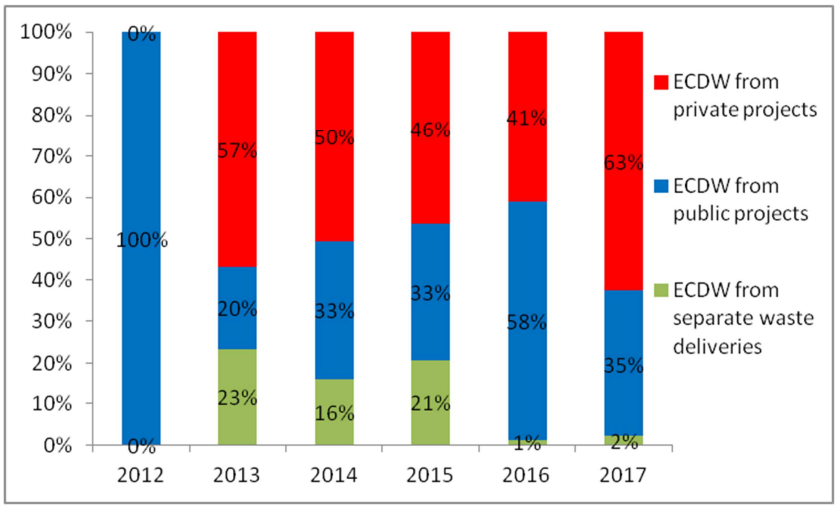

Figure 3. Percentage contribution of private and public projects to the total amount of ECD waste tonnage managed over time.

Although there seems to be a significant increase in the number of contracted projects, some of the Systems noted that the relative ratio compared to the estimated undergoing projects in their geographical range remains low, along with the reported and treated quantities of ECD waste for the specific contracts. Indeed the ratio of contracted projects in Greece (both public and private, since some Systems don't report them separately) to the number of private building permits was less than 10% until 2016, showing though a rising trend and reaching at 17% in 2017, with regard to the available, so far, data (Figure 5).

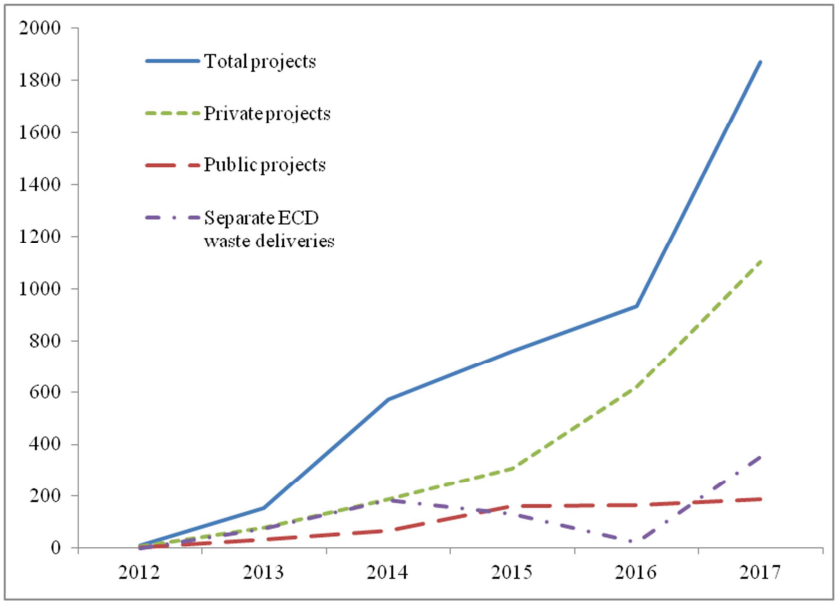

Figure 4. Chronological evolution of number of projects contracted with ECDW Management Systems.

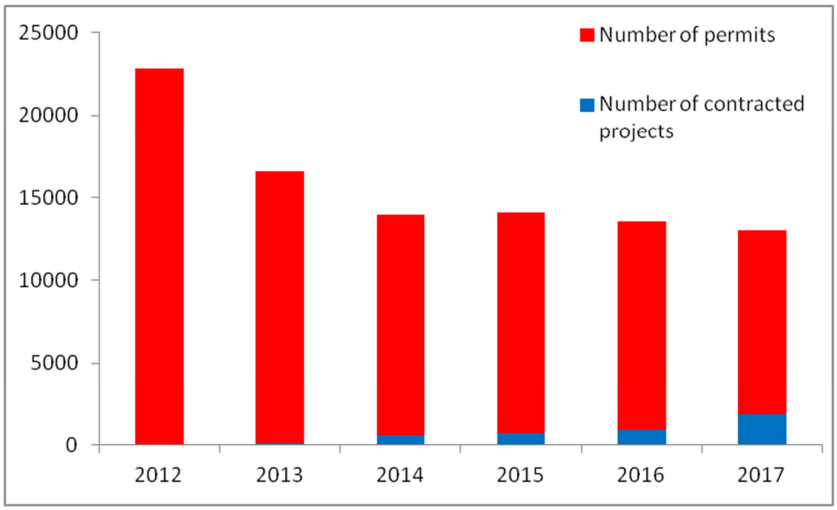

Figure 5. Evolution of private building permits compared to (public and private) contracted projects over time.

As far as the management of ECDW by the Systems is concerned, in most cases, the largest amount of incoming waste is subject to treatment, achieving recycling and recovery of materials to a high degree (Figure 6). In fact, one of the Systems in Northern Greece, in collaboration with treatment facilities, equipped with high-specification infrastructure, has achieved 100% recycling of incoming waste streams, throughout its operation. The problem then lies in the market and reuse of retrieved materials, which is quite limited.

Some ECD waste streams, for example European Waste Codes 17 04 (metals, including their alloys) and 17 05 (soil, stones and dredging soil), may be used without treatment for backfilling in quarry restoration or for final covers in solid waste landfills. This approach is mainly implemented in rural areas, where there are plenty of inactive quarries (mainly in Central Greece and to a less degree in Attica).

The characterization of recycled ECDW materials and the evaluation of their re-use potential in Greece have been already performed to some degree, showing promising results. Alexandridou et al. [11] examined the influence of Recycled Concrete Aggregates in concrete performance. Results indicated that concrete mixtures containing recycled concrete aggregates have a minor deterioration of their properties compared to conventional concrete containing the same cement quantity. Papatzani & Paine [12] concluded that recycled aggregates and recycled concrete aggregates can be safely used in structural concrete applications, while recycled dust may offer further potentials, also stating that extended usage of nanomodified recycled concrete can be expected in the future. Galbenis and Tsimas [13] investigated the possibility of utilizing Recycled Concrete Aggregates and

Recycled Masonry Aggregates derived from demolished buildings in Attica as substitutes of Portland cement raw meal. Konstantopoulou and Spanou [14] performed a slope stability analysis of the CDW deposits in a quarry northwest of Kozani town, and investigated failure mechanisms in order to propose appropriate protection measures.

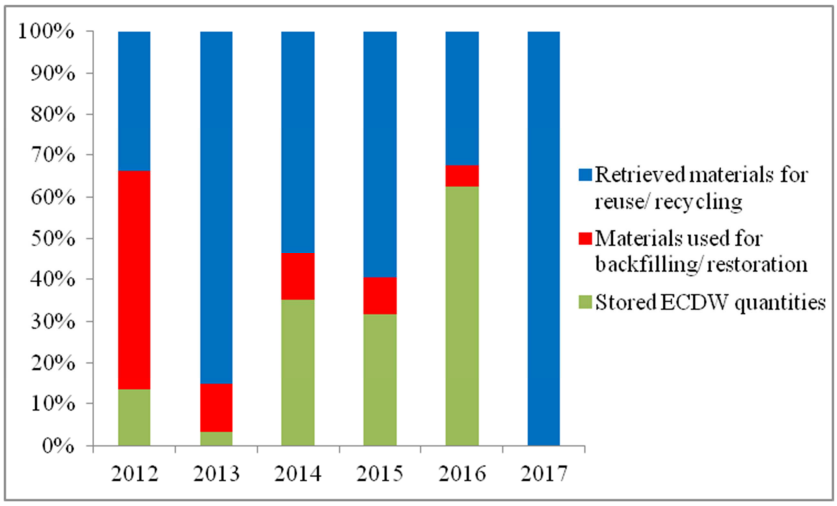

Figure 6. Ratios of alternative waste management practices- recycling performance.

5. Obstacles to the Alternative Management of ECDW in Greece

Only half, approximately, of the Greek territory is covered by the network of certified Alternative Waste Management Systems. The distance between the location of the waste source and the treatment facilities often constitutes transportation cost prohibitive for the sustainable waste management. There is a lack of appropriate sites for ECDW to be temporarily stored, until they are processed. There is also no official record of abandoned quarries to be used for backfilling.

Although there is a specific legislative framework for the management of ECDW in Greece since 2010, there is a high level of both ignorance and disregard for the law, by public and private actors. Almost all the participants in the survey described the implementation of the law in practice, regarding both private and public works, as poor. Only one System rated the implementation of the law specifically in private projects as “fair/ marginally adequate”. Due to the lack of training and guidance actions for public authorities regarding the implementation of alternative waste management, the tendering services often ask for clarification on the administrative steps to be followed regarding the submission of the necessary supporting documents. Likewise, Urban Planning authorities are not familiar with the administrative steps to be followed in each case (eg. the issuance of a building/ demolition permit, a license for small-scale works) and require a clarification circular. Some Systems noted that it wasn't until 2015 that Urban Planning Services begun to take into account the provisions of the JMD 36259/2010, regarding the alternative management of ECDW, for the issuance of building permits. H.R.A.'s latest report underlines the lack of cooperation with municipalities/ local public authorities, which can be summarized in just three contracts of alternative ECDW management.

Legal obligation concerning the alternative management of ECDW has not been integrated and is not taken into consideration in the required licenses, approvals and standards for the construction projects (such as Decision on Approval of Environmental Terms, Standard Environmental Commitments and Greek Technical Specifications).

There are no provisions for ECDW recycled material in the Standards developed by the Greek Body for Standardisation (ELOT), hindering the marketing of recycled materials. According to the Greek technical specifications, except for the use of recycled aggregates in the pavement layer, their use is not allowed in road pavements or in the production of concrete (ELOT IT 1501-05-03-03-00: 2009 and ELOT IT 1501-01-01-01-01-00: 2009), contrary to European standards EN13242 and EN12620, allowing the use of recycled aggregates in road and concrete respectively.

Tendering procedures of public works fail to include provisions for the alternative management of ECDW. The cost for the alternative management of ECD waste is not included in the budget by the tenderer of the project, resulting in the project promoters' trying to avoid the specific cost. Many of the participants in the survey underlined the inefficient certification, monitoring and control of the ECDW Management Systems by the Hellenic Recycling Authority, pointing out that the latter is strongly understaffed.

Considerable controversy is raised as to the distinction between private and public works in Joint Ministerial Decision 36259/2010 and Circular 4834/2013 and the obligation to manage excavation waste from public projects. In fact, in 2013, a Greek Member of the European Parliament addressed a question to the Commission whether the distinction between private and public works is compatible with Directive 2008/98/EC in terms of the obligation to manage excavation, construction and demolition waste [15]. The Commission replied in writing that the circular refers to a Decision from 2010 which predates the national transposition Law 4042/2012 and holds a lower legal rank. "In any case, the legal obligations laid down in the WFD do not distinguish between publicly or privately generated wastes. Soil and rocks excavated during the construction of public (and private) works constitute waste if the holder of such material discards or intends or is required to discard in line with the definition of waste provided in Article 3 (1) of the WFD. Should it be categorized as waste, it shall undergo a recovery operation in line with the waste hierarchy so as to contribute to the 70% target set out in Article 11 (2) of the WFD; or safely disposed of, as the last resort". Still, this ambiguity leaves room for public project promoters characterizing ECD waste as excavation waste, in order to avoid the cost of alternative management.

Illegal dumping is still a common practice in many cases, due to the lack of control from public authorities and insufficient inspection procedures. Some of the collection/ transport services, not affiliated to any CDW management system, play an important role in illegal dumping, by receiving and disposing of untreated waste at low prices, in private properties, difficult to locate sites such as streams, watercourses and ditches or abandoned mines and quarries.

In general, ECDW is often not perceived as waste and people seem to underestimate its environmental burden due to its inert nature. There is a lack of incentives, for the society and the stakeholders to activate themselves towards the alternative management of ECD waste.

6. Recommendations

The following requirements for advances in infrastructure and management networks are already pointed out in the National Waste Management Plan:

i Development of new treatment units in Administrative Regions that are not yet served by the current facilities (with priority to mobile units for the Greek islands) and expansion of the network of ECDW management systems to cover the whole territory of Greece.

ii Creation of a public register of inactive or abandoned quarries that could be backfilled with inactive ECDW materials for restoration purposes.

iii Construction of at least one landfill for inactive ECDW management residues in each Administrative Region, especially in the Greek islands.

iv As far as hazardous waste is concerned, implementation of selective demolition of buildings in order to ensure separate collection of asbestos containing demolition waste and special treatment by certified facilities. Modification of the environmental conditions of existing or planned private hazardous waste landfills, to include the disposal of asbestos containing waste.

Based on the results of the survey the following measures should also be examined:

i There is a need for an information and awareness campaign, for all the actors in the ECDW chain and the public, in order for them to realize the importance of alternative waste management and understand their legal obligations. Information and dissemination regarding good practices in other countries could help in achieving better results.

ii Some amendments and clarification of the law, especially with regard to public projects, along with training activities for the involved parties would improve performance in the public sector.

iii An effective control mechanism is needed to supervise the licensing, progress and completion of all technical projects with regard to the alternative waste management, checking, for example, the compliance of waste quantities in the "Waste Management Plans" with the contracts affiliated with the ECDW Management Systems, comparing the number of building permits to ECDW management contracts and using GIS techniques and aerial photography to identify illegal dumping locations.

iv The role of engineers is crucial with regard to prevention policies to minimize the production of ECDW. Architectural design, the use of specific construction techniques and the selection of construction materials should take into account the waste produced by the construction or demolition works in the future.

v The use of recycled products in technical projects is expected to offer an important boost to the alternative management of ECD waste. The use of recycled aggregates, which is a prerequisite for the alternative management of ECDW in Greece, also requires the full harmonization of the Greek Technical Specifications with the European standards. The Greek Technical Specifications must be reviewed by the Greek Body for Standardisation, in order for recycled ECDW materials to return to the market.

vi The public sector has a significant contribution to the consumption of construction materials and the production of ECD waste, thus holds an important role in achieving national sustainability goals. The use of recyclates in public projects, that would improve national performance, can be accelerated through Green Public Procurement (GPP). GPP is defined as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" [16]. It is a voluntary instrument that many public authorities in Europe use to have environmental and social criteria integrated in their purchasing decisions and tendering procedures.

vii Financial incentives must be developed to promote the alternative management of ECD waste by all the stakeholders and the use of recycled materials in the market. A system of rewards such as tax reliefs, regarding good practices is expected to have better results than the issuance of penalties for any violations.

7. Conclusions

There is already a strong legislative framework for the alternative ECD waste management in Greece (improved by the new Law 4496/2017), although there are some points that leave room for malpractices and need clarifying, especially in the case of public projects. The problem lies with the non-compliance of all involved parties due to the lack of information and control. The existing network of Management Systems and treatment facilities, in most cases, possesses the necessary expertise and infrastructure and succeeds in achieving high recycling rates, but it has to be expanded to cover the entire country. Another important obstacle in achieving national goals is the failure of ECDW retrieved materials to be introduced back into the market, especially with regard to the recession of the private building activity and the abundance of natural resources at low prices. Specific measures such as the review of Technical Specifications to provide for recyclates and Green Public Procurement could drastically improve their marketing potential. Apart from penalties for violations, financial incentives such as tax-reliefs would also boost the alternative management of ECDW. Moreover, what mostly needs to change, especially in times of economic recession, is people's attitude towards the perception of waste as a useful product and the realization of the benefits arising from the alternative management of ECD waste, such as protection of the natural environment, flooding prevention, saving of natural resources, less need for quarrying and borrow pits excavation for the production of raw materials, energy conservation, extension of the life of municipal solid waste landfills, visual pollution prevention etc.

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