Federal Ministry
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ΥΠΟΥΡΓΕΙΟ
ΠΕΡΙΒΑΛΛΟΝΤΟΣ
& ΕΝΕΡΓΕΙΑΣ

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

IMPROVED MANAGEMENT OF CONSTRUCTION & DEMOLITION WASTE IN GREECE

FINAL REPORT

24/07/2020

Athens, Greece

ENVITERRA

EXECUTIVE SUMMARY

Background

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in cooperation with the European Commission's Directorate-General for Structural Reform Support (DG REFORM) is providing technical assistance to the Hellenic Ministry of Environment & Energy (YPEN) in the framework of the project "Support to the implementation of the NWMP of Greece" for a two-year period until September 2020. The project is jointly funded by the European Commission (EC), via the Structural Reform Support Programme (SRS) and the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) for improving the framework conditions for the implementation of the NWMP and the achievement of the corresponding national targets for 2020 and facilitating the capacity development of YPEN, as well as of other involved stakeholders (Local/Regional Authorities, NGOs etc.). The hereby outlined consulting shall contribute to the improvement of Construction and Demolition Waste (CDW) management in Greece.

GIZ commissioned ENVITERRA P.C. to provide specific technical expertise to GIZ and YPEN from February to June 2020. The Consultant will provide proposals for the improvement of the institutional framework for CDW in Greece, in line with circular economy principles, and good practices for constructors of public/private works. It will also allow a cost-benefit analysis and proposals for specifications of secondary materials coming from the treatment of CDW.

Objectives

The current study aims to provide essential know-how and experience in several aspects of CDW management, in the Greek and international context, and support, in a technical level, the efforts of GIZ team. For data collection, input and suggestions, except from existing studies/reports, key Stakeholders such as **Hellenic Recycling Agency** (**HRA), Hellenic Ministry of Environment & Energy (YPEN), Producers Responsible Organizations (PROs) and Hellenic Ministry of Infrastructure and Transport (MoIT)** were consulted**.**

The Study was initiated at February 2020, led by ENVITTERA P.C. and in close co-operation with GIZ, YPEN, HRA, DWR, PROs and MoIT. The main Objective was to investigate the current situation of CDW generation, treatment and disposal methods, focusing on legal, institutional and technical aspects. That included:

- CDW management data gathering, their evaluation and assessment of their credibility.
- Development of a methodology for the calculation of CDW derived from Private (mostly) and Public Works based on statistical data from C&D activity in Greece
- Thorough codification of both national and EU legislative framework concerning CDW management and identification of gaps, overlaps and misconceptions
- Concrete proposals for amelioration of both the Legislative and the Institutional Framework focusing on providing practical solutions, in full accordance with Circular economy principles and Greek reality

- Perform a Cost-Benefit Analysis (CBA) for all stages of CDW management Processes (production, separation, collection/transport, recycling)
- Development of good practices for on-site work, focusing on creating conditions for increasing CDW recycling and for improving the quality of recycling and recovery
- Development of Quality Assurance Plan (QAP) for all stages of secondary (recycled) materials production focusing on improving their quality so as to meet specifications set for different uses (aggregates)
- Success stories and Good Practices of efficient CDW management were showcased (presented in the Annex), illustrating key elements for success, as well as any necessary preconditions.

For an effective fulfilment of the abovementioned objectives, the work carried out was broken down into four (4) Activities, according to the TORs:

1. Data collection and assessment of the status quo of construction & demolition waste management sector in Greece. Development of a methodology for the calculation of CDW from private and public works, using both data from the Digital Waste Registry and other sources such as the CDW Management Plans (developed for each work), data collected by the PROs etc.
2. Proposals for the improvement of the institutional framework for construction & demolition waste in Greece, in line with circular economy principles.
3. Cost-benefit analysis using data for on-site separation of materials, collection, transport, processing, disposal costs etc., market prices of secondary materials etc. Good practices guide for constructors of public/private works for improved construction & demolition in the work site.
4. Proposals for specifications for secondary materials coming from the treatment of C&D waste, in order to be further used in the construction of public works by replacing raw materials – JMD 2221/2012 (cooperation with Hellenic Organization for Standardization - ELOT, Ministry of Infrastructure & Transport)

A modification for the above tasks is mainly refer to Activity 4: Bearing in mind Market's skepticism about the use of secondary materials derived from recycled CDW, the latter (mainly aggregates), should comply with the same technical and environmental criteria as the natural products, as defined in JMD 2221/2012 and relevant European Standards, rather than proposing new specifications. For that reason, it is considered, bearing in mind the European Practice and the relevant literature, more practical and effective, to propose a uniform Quality Assurance Plan/Protocol (QAP) for secondary materials, including all stages of the recycling process, rather than developing new specifications for them.

After delivering the Draft Final Report, there was a consultation period during which several comments and aspects were expressed by the Stakeholders (YPEN, HRA, DWR, MoIT, YMEPERAA and GIZ). All those comments are incorporated and are presented in the context of the current Study.

CDW Management Performance – CDW Statistics

The main objective was to collect detailed information concerning CDW management in Greece, focusing also on recycling and recovery performances. This objective has been fulfilled through a

thorough screening phase. Data collection was also aimed at giving a preliminary insight on performance and practices (practical and legal) and at identifying potential barriers and drivers, especially towards the 2020 recovery target (70%).

At first, mathematical models developed by the Environmental Science and Technology Unit of the School of Chemical Engineering of the NTUA were used to calculate on a theoretical basis the generated CDW derived from private works for the period 2015 – 2019 for the totality of Greek Territory (all regional Units) based on construction activity input provided by ELSTAT. The current models were selected among others because they are based mainly on technical parameters (volume, density of waste) and it is well adjusted to the Greek reality.

For Public Works CDW calculation, theoretical estimation was based on several assumptions given the fact that due to the great differentiation between those projects, no specific methodology or model can be adopted.

From ELSTAT data it is obvious that there is an increasing trend in the construction activity for the years 2016 - 2019. That trend is mainly due to the gradual come-back of the construction sector as a result of the exit from the economic crisis and the restart of the national economy. Thus, an increasing trend for CDW generation is also expected. In fact, the amount of CDW produced in 2019 was estimated more than 4,5 million tons.

Within a framework of the new NWMP (2020), there is a common approach for ECDW calculation but there are differentiations on the assumptions and the values of some parameters such as the Demolition Surface (SD). ENVITERRA justifies its opinion about those values based on the experience from construction/demolition industry in Greece. On the other hand, PROs BPLs, also use ENVITERRA values for performing CDW production predictions.

The second step was to collect, manage and evaluate real CDW production data coming from PROs, HRA and DWR. A set of criteria was established in order to have a solid, even and comprehensive basis for analysis and comparison for all data sources. Based on the analysis criteria, screening Tables/Sheets were prepared, including a structured presentation of relevant information and data. The process of data management included in-depth literature analysis and close cooperation with all relevant Stakeholders. The comparison between different data sources along with theoretical approach of CDW calculation revealed significant contradictions. Concrete proposals for overcoming those problems in the future were developed by ENVITERRA P.C.

Comparing data from HRA annual reports (submitted by PROs) and those provided individually from each PRO to the Consultant, a small, rather expected, difference is observed (1,5 – 6%).

In general, there is a great difference between quantities calculated by the ELSTAT data and those provided by the PROs for the 2016, but that difference decreases for 2017 and 2018, while, for 2019, there is a remarkable balance between CDW reported by the PROs (4.627.590tn) and those calculated by the selected mathematical model (4.644.283tn). Nevertheless, this convergence is rather plasmatic. Looking at the data from individual Regional Units, there are significant differences between real and theoretical data, especially for the Regional Units with the higher CDW production. In many cases, the CDW quantity that managed through PROs was found 2 or 3 times greater than the one calculated based on construction activity data. The above differences may be attributed to errors such as, misreporting from the PROs and non -reporting of EW derived from large scale Private.

An alternative source for obtaining data per 6-digit EWC code was the Digital Environmental Registry (DWR). In fact, the Registry could provide data on the total amount of CDW collected/transported, per 6-digit EWC code, as those quantities are submitted to the annual reports of the registered CDW transporters. Unfortunately, data from DWR were available only for years 2017 and 2018. DWR data may be compared with PROs data only on the basis of total quantities and not per geographical unit. In that context, total quantities of CDW derived from DWR for year 2017 appear significantly increased compared to those declared by PROs. That may be attributed to (a) Incorrect recording of data by the stakeholders, (b) waste data of previous years were recorded (c) Since PROs do not cover the totality of the Greek territory in several regional units, CDW were transported by registered stakeholders, but they didn't manage through PROs (d) illegal dumping or landfilling.

A totally different picture was presented for 2018, with respect to the comparison of DWR and PROs data. The latter are presented almost 15% increased with respect to DWR registrations. That change of picture may be attributed to (a) DWR users were getting more familiar and accurate with respect to the use of DWR platform (b) The increasing effectiveness of PROs functioning and the expansion of their geographical coverage, along with increasing Public awareness.

In Greece, there is no data available concerning the exports and imports of CDW. However, data on notified shipments of hazardous waste exist. CDW hazardous waste data refer mainly to asbestos-containing CDW. Nevertheless, there is no way to estimate what portion of e.g. asbestos has derived from CDW and in the CDW treatment quantities the amount of hazardous waste exported for landfilling is not included. DWR could be the key for effective and accurate reporting of hazardous CDW.

It is not possible to calculate the amount of excavation waste derived from Public Works and record it for the same period (2016 – 2019). In general practice, ECDW treatment on site is not reported as ECDW management, but it is integral part of the construction project activities. As long as the EW from Public Works do not managed through PROs, there is no other official record. On the other hand, the variety of Public Works that can lead to the creation of EW (e.g. road construction, ports, railways, etc.) is so great that it is almost impossible to propose a type of calculation or mathematical model that covers all cases.

In any case, based on the current national public work and environmental legislation, since there is an obligation for submitting templates with the volume or quantity of excavations that will occur and the corresponding amount of backfilling operations to an independent Authority and the Public Body that auctions the project, critical details about EW management in Public Works, may be available and should be notified to the Authorities responsible for CDW management, creating a channel for the accurate reporting of EW derived from Public Projects.

Based on ELSTAT data for calculating the "total quantity of CDW produced and PROs/HRA data for RRR and backfilling, the %RRR (Target) is estimated for years 2016-2019. The % RRR is reaching a maximum of 50% for 2019, including backfilling as low quality recovery option. For the years 2016, recovery rates are much lower, and in fact there is a decline in recovery rate in 2017 with respect 2016.

Based on the data from the HRA and the PROs, there is a significant increase in the availability of secondary (recycled) materials over the years. In fact, in 2018 more than 1,5 million tons of recycled materials were produced. CDW has been used in the previous years for the covering and

rehabilitation of existing landfills and dumping sites. The amounts of CDW used for that purpose are not reported as being recovered or backfilled and therefore are not included in the official statistics.

The existing CDW treatment facilities in Greece treat mainly the mineral fraction of CDW. The main secondary materials produced are aggregates (sand, gravel etc.). All CDW treatment facilities in Greece are affiliated with the certified PROs. From the data collected by PROs, no clear overall picture is given for the type and market of secondary materials. The data provided include various types of secondary materials that arise depending on the input (CDW) entering the Recycling Units and which are categorized in a different way. It should be mentioned that part of the materials that are recovered concern soil and stones as well as vegetable soil. In addition, some of the PROs claim that all the materials entering the RUs are used entirely for backfilling activities, including restoration of quarries. Especially the latter procedure raises questions, as neither the process by which the secondary materials end up in a quarry nor which quarries are used is clarified.

From the processing of the data provided to the Consultant, it is assumed that 60% of the recycled materials refer to aggregates. Considering sales and prices of secondary materials, very few PROs provided data on this matter, while some PROs claimed that almost all secondary materials have been sold, but they are not giving details on prices. Secondary materials prices, depended on the input, varying between 0 – 4 euro/tone, according to some PROs information and the experience of the Consultant.

There is an impressive increase in the number of contracts for all types of CDW holders, since there is a 294% increase between 2016 and 2019 in the collectors/transporters affiliated with the PROs, while the respective increase for producers is 621% and 389% for RUs. According to DWR data, up today, there are 1650 Collectors/Transporters registered and 216 RUs. In the following years, it is expected that the number of affiliated holders will further increase, since both the activation of the PROs and the Public awareness are intensified too.

In all MS, including Greece, recycling of several other materials has proven to be more difficult since those materials constitute smaller fractions of CDW and recycling of these fractions usually requires more input. A good practice from EU MS on this matter is presented at the Annex.

National and EU legislative framework for CDW Management

In general, the legislative framework for waste management in Greece is defined by **Law 4042/2012** which transposes the EU Waste Framework Directive - WFD (2008/98/EC) into Greek law. YPEN is responsible for setting the scope of national policy concerning the management of waste, drawing the draft legal framework for waste management and delivering the NWMP.

The fundamental EU legal framework constitutes of at least 5 legislative acts dealing with waste management and MS obligations. On the other hand, there are more than 22 relevant national legislative instruments, dealing with Waste Management Framework, Alternative Management, Town Planning Legislation, Waste Management Plans, Environmental Legislation/Environmental Permits, Quarries/Forest Legislation and Public Works provisions.

The new Greek Waste Management Plan (WMP) has been delivered in 2015 along with National Strategic Waste Prevention Plan (WPP). In the current WMP all waste streams are analyzed and specific measures are proposed for the environmentally sound management of each waste

stream and there are dedicated chapters for CDW and the management of asbestos waste. The Waste Prevention Plan contains a section for CDW where a few measures for waste prevention are presented as well. Waste prevention measures for CDW are mostly limited to promoting information and education about waste prevention and engaging business. WMP and WPP are currently under amendment and the new Plans are about to be delivered by the end of June 2020. Apart from the NWMP, the administrative regions of Greece have adopted their own regional WMPs but there is a need for the regional WMPs to be updated taking into account the provisions found in the substantial new body of legislation and the national planning of waste management as presented in the new National WMP.

The management of CDW in Greece involves a wide range of actors from the public and private sectors. The creation of Alternative Management Systems for CDW management is based on the principle of Extended Producer Responsibility (EPR), which uses financial incentives to encourage producers to design more environmentally friendly products and renders them responsible for the cost of product management at the end of their life cycle. JMD 36259/1757/E103/2010 has been issued, containing terms and conditions for the alternative waste management for ECDW. In this context, all producers/holders (manufacturers, traders, importers) are obliged to either organize or participate in Alternative Management Systems.

For the implementation of the legislation for the alternative waste management in Greece, the HRA has been established (under the control of YPEN) to supervise all operations regarding the re-use, recycling and recovery of all waste streams. Individual or collective Systems are approved, monitored, and controlled by the HRA. The Systems constitute private entities, non-profit, known as Producer Responsible Organizations (PROs) which are set by law for the alternative management of the waste generated by their operations. The approval of the PROs by HRA is valid for six years and may be renewed by amending or revising of the PROs Business Plans. The development of PROs is satisfactory, covering almost 81% of the Greek territory and 91% of the Greek population.

Generally, the roles of all actors involved in CDW management are sufficiently articulated in national legislation. The structure of actors and their responsibilities within the system of CDW management is theoretically sufficient to divert significant quantities of CDW from landfills or illegal dumping to recovery. However, persistent inadequacies in implementation has not allowed increased recycling over the last few years in Greece to take place.

Targets for the recovery of CDW in Greece is found in JMD 36259/1757/E103/2010. The quantitative target for the recovery of waste from excavation, construction and demolition activities, excluding codes 17 05 04 and 17 05 06 of the European Waste Catalogue (EWC), according to Decision 2001/118/EC is by January 1st, 2020, reuse, recycling and recovery of CDW should reach at least 70% relative to the total weight of the produced CDW. Note that the method of target calculation does not contain the term “Excavation Waste”, while “backfilling” also creates several misconceptions.

There is a wrong translation of Code 17 05 06 of the ECW code book in Greek. The particular code is not included in the target setting for CDW proposed by the Waste Framework Directive (2008/98/EC) in Article 11(2). Nevertheless, Law 4030/2011 abolishes the exemption of waste code 17 05 06 for the calculation of the above national targets. Conclusively, there is high risk of questionable data influencing the achievement of the national and WFD targets by 2020.

Backfilling concept, creates 2 major issues in all MS: (a) Whether backfilling can be incorporated to the National RRR targets and (b) Whether the reported quantities of ECDW backfilled are estimated correctly. Backfilling is used in Greece in different applications, mostly for rehabilitation of spent mines and quarries or landscaping as well as for landfill cover. Backfilling operations are carried out utilizing mainly EW (17 05 04) and less CDW. Based on the exemption of Public Works for reporting to PROs for their EW management those quantities used for backfilling in Public Projects are not reported.

The Consultant has spotted several drawbacks in current legislation concerning Public Works, Town Planning Authorities involvement, Landfill Tax, Quarries as CDW Treatment Sites/Quarries Restoration and Law Enforcement:

- Although there is an obligation, prior to construction permitting, for setting up a WMP concerning the construction project, by the contractor, alternative management of CDW provisions consistently missing from the Tendering procedures of public works
- Although it is clear that CDW coming from Public Works are obliged to be managed through PROs, there is a contradicting legislation about excavation waste (EW) in public works, which allows excess excavated material to be exempted from management through the PROs and estimated quantities of EW generated missing accuracy.
- There is an absence of any initiative for Green Public Procurement (GPP)
- Although TPAs play an important role in CDW management in Greece, they lack specific knowledge and expertise on CDW management issues, while, there is no legal obligation for detailed Waste Audit prior to any construction/demolition activity
- Landfill tax has not been implemented since (a) there was the concern that the tax would worsen the bad financial situation of local authorities and (b) there are no inert waste landfills licensed in Greek Territory
- Even if a pending legislation on quarries restoration through PROs has been recently adopted more details must be provided on this matter. On the other hand, a spent or inert quarry, is declared as a re-forestated area and almost all activities are forbidden including recycling activities
- Law enforcement is not sufficient

The drivers proposed, include:

- Financial incentives through taxes and charges, landfill bans for several CDW fractions, reduction on VAT for recycled materials, taxation and/or levy of the natural materials.
- GPP (Green Public Procurement) through the introduction of mandatory percentages of recycled aggregates, at least in large civil engineering projects.
- The quality of the CDW collected and transferred to the Recycling Units should be improved through modification of the legal framework, including provisions for compulsory sorting, pre-demolition audits and selective demolition, surveillance and protective measures for the containers and assurance of waste traceability
- Clarification for the inclusion of quarries' areas declared re-forestated, to the provisions of Law referred to the installation of Recycling Units and quarries restoration.

- A national target for expansion of PROs jurisdiction to the 100% of Greek Territory
- Common categorization of CDW in streams, categories and subcategories for all PROs
- Rationalization of PROs BPLs for increasing RUs motivation for recycling
- Ensure a cross-check of the CDW data from different national organizations
- Upgrade the role of DWR for appropriate data gathering and reporting
- Improve the effectiveness of Law Enforcement focusing on inspections, fines and close co-ordination of DWR with HRA

Best Practices for C&D in work site

Best Practices were divided in 2 distinct phases for all type of works (a) Design Phase and (b) Execution Phase.As a general Best Practice, regardless the type of work, a detailed and comprehensive Waste Audit (WA) should be conducted. A complete WA should constitute of the following parts (1) Desk study (2) Field Survey (3) Inventory of Materials (4) Waste Management Recommendations and (5) Report.

The Design phase of a Demolition Project should be described in detail within the context of the WA. During the Design Phase of a demolition/renovation project, BPs include, among others, collection of historical information and design documents, performing chemical and mechanical tests on materials (especially for hazardous waste) and locate the appropriate space for proper collection of generated CDW.

During the Execution Phase of a Demolition Project, the most important BP is the implementation of selective demolition. Other BPs include good planning of number and size of containers, proper recording of CDW produced and leaving the site, periodic controls for assuring correct use of containers, performing on-site segregation of each waste category, distributing small containers in the working areas to facilitate the segregation, following the manufacturer's instructions in the collection of materials, organizing talks and training for the operators in the subject of waste management, training and informing all personnel, hiring authorized and properly licensed companies for the management of waste and use of machinery for the management of CDW if that process can be licensed within the specific work site. For hazardous waste, the implementation of the Austrian Standard ÖNORM B3151 (2014) backed-up with the extensive national legislation on asbestos management are considered the ideal BP.

The Design phase for a Construction Process should include a Life Cycle Assessment Study (LCA). This approach can be useful to support the waste hierarchy of WFD, to make a decision about the best way to reuse, recycle or dispose waste materials. The concept of "Designing Out Waste" is an essential BP for minimizing waste at every stage of the life cycle of a building construction during its design. Finally, "Design for deconstruction" considers the implementation of key design features for the easy disassembly of construction elements and the planning for possible reuse.

The BPs for the execution phase of a construction project are focusing on waste prevention and management and material use efficiency and include, among others, proper management of the purchased materials, correct storage and handling of construction materials, assigning individual responsibility to sub-contractors for the purchase of raw materials and for the management of wastes arising, use prefabricated systems, provide space for collecting and storing CDW, hire authorized companies for the management of waste, make maximum use of materials and

products, observe the manufacturer's instructions regarding the transportation, collection, and commissioning of materials, establish a container for each type of CDW, train and informing all personnel of the correct labelling of containers and their responsibilities, record the date of withdrawal, quantities and characteristics of the waste and create documents that collect instructions regarding the different processes that generate waste.

The BPs for EW from Public Works are also described in the document. Those BPs include a detail audit to be performed for the calculation of the quantities that are about to be produced, following the plans of the project and the recommendation made in WA, determining total quantity and characteristics of excavated material and assign possible re-use (according to their characteristics). Obviously, many of the BPs described for Construction/Demolition may also be implemented for EW from Public Works.

Cost Benefit Analysis

Cost Benefit Analysis (CBA) was performed for the most complex work of demolition. Calculations were performed by considering the demolition of a 130m^2 building from which about 160t of CDWs are produced. It is considered that the calculations performed are also representative for Construction, Addition and Renovation works.

The first scenario included the implementation of a Selective demolition (Deconstruction) process in work-site. The total cost was calculated at 12,69€/t (including labor, and machinery costs). Costs for collection/transportation (on an average distance of 20Km) were calculated at 1,06€/t. Finally, the average treatment cost estimated at 4,25€/t. Consequently, for selective demolition the total cost was 18,34€/t CDW.

The second scenario included the implementation of a traditional demolition process in work-site. The total cost was calculated at 4,25€/t (including labor and machinery costs). Costs for collection/transportation (on an average distance of 20Km) were calculated at 1,06€/t. Finally, the average treatment cost, estimated at 10,50€/t. Consequently, for traditional demolition total cost was 16,15€/t CDW.

According to market data, even for the better-quality materials, the market price for recycled (secondary) materials in Greece has an upper limit of 4€/t. It is obvious, that under the current circumstances recycling is highly uneconomical in Greece. An obvious choice for rendering recycling more attractive, could be the reduction of RUs treatment cost. In-situ treatment may also significantly reduce treatment costs, if applicable due to licensing issues. Finally, financial incentives through legislative framework (e.g. GPP) are more than necessary in order to boost secondary materials market and lowering the total recycling costs. Both the State and the PROs should further support the RUs to participate in international programs that will contribute to the exchange of know-how and the application of innovative and more economical technologies at all stages of the recycling process.

Quality Management Plan (QMP)

Quality management is a crucial step towards increasing the confidence in the CDW management processes and the trust in the quality of CDW recycled materials. There is a need to promote quality assurance of the primary processes (from demolition site to waste logistics), as well as the provision of reliable and accurate information about the performance of the recycled or re-used products.

The most important barriers to be overcome, considering the acceptance and establishment of the recycled products in the market, include quality, environmental and marketing issues. In any case, harmonized European standards that apply to primary materials also apply to recycled materials. CDW recycled materials must be assessed in accordance with requirements of European product standards, when covered by them.

The Quality Management Plan (QMP) or Quality Protocol proposed is divided in 2 broad categories i.e. QMP for the Primary Process and QMP for the Products.

The QMP for the Primary Process deals with quality demands including CDW Identification & Source Separation (e.g. Pre-demolition audit & WMP, Selective demolition/Separation), identification of Materials/Waste Covered by the QMP (by producing a specific list), CDW Collection & Transport/Logistics (including provision for containers, trucks and drivers) and CDW traceability issues.

The QMP for the products mainly refers to the operation of a RU and includes clear definition of waste acceptance criteria, proper storage & handling of Input Material, implementation of Factory Production Control on CDW Processing/Treatment along with CE accreditation on equipment, proper storage and handling of products, sufficient training of the employees in a RU, proper Records & Documentation and detail Testing of Final Product.

The QAP proposed in this Assessment may significantly contribute to the development of EoW for CDW. The QAP covers, not only the quality of the “product” but also all the steps of the production chain (treatment process, logistics etc.).

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LIST OF ABBREVIATIONS

BAT	Best Available Techniques
BP	Best Practices
BPL	Business Plans
C & D	Construction & Demolition
CDW	Construction & Demolition Waste
DER	Digital Environmental Registry
DWR	Digital Waste Registry
EC	European Commission
ECDW	Excavation, Construction, Demolition Waste
ELOT	Hellenic Organization for Standardization
ELSTAT	Hellenic Statistical Authority
EPR	Extended Producer Responsibility/Alternative Management System
EU	European Union
EW	Excavation Waste
EWC	European Waste Catalogue
GPP	Green Public Procurement
HRA	Hellenic Recycling Agency
JMD	Joint Ministerial Decision
LCA	Life Cycle Assessment
MD	Ministerial Decision
MoIT	Hellenic Ministry of Infrastructure and Transport
MS	Member State
NWMP	National Waste Management Plan
QAP	Quality Assurance Plan/Protocol
PD	Presidential Decree
PRO	Producer Responsible Organization
RA	Recycled Aggregates
RM	Recycled Materials
RRR	Recycling, Reuse, Recovery
RU	Recycling Unit
RWMP	Regional Waste Management Plan
TCG	Technical Chamber of Greece
SM	Secondary Materials
TPA	Town Planning Authority
TORs	Terms of Reference
WA	Waste Audit
WMP	Waste Management Plan
WPP	Waste Prevention Plan
YMEPERAA	OPERATIONAL PROGRAM Transport Infrastructure, Environment and Sustainable Development
YPEN	Hellenic Ministry of Environment & Energy

Background and disclaimer

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Assignment	**IMPROVED MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE (CDW) IN GREECE**
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Project Name	Technical support for the implementation of the National Waste Management Plan (NWMP) of Greece (68.3045.9)
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Disclaimer:

ENVITERRA P.C. has taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the study.

This document was produced with the financial assistance of the European Union. The views expressed herein reflect the views only of the authors and can in no way be taken to reflect the official opinion of the European Union.

1. Introduction

1.1 Project Background

Construction and demolition waste (CDW) is the left-over material from activities such as the construction of buildings and civil infrastructure, total or partial demolition of buildings and civil infrastructure, road construction and maintenance. CDW consists of various material, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, hazardous substances (asbestos, PCBs, etc.) and excavated soil, many of which can be recycled. The construction and demolition industry is responsible for the production of immense quantities of waste, the increasing volume of which has become unbearable from the environmental, economic and social viewpoints. In the EU alone, it accounts for approximately 30% of the total waste generated [Eurostat, 2015]. About 374 million tons of CDW were generated in 2016 [EEA, 2020, Eurostat, 2019], making it the largest waste stream in the EU by weight. According to the findings of the current Study, the respective amount for Greece was estimated up to 4,5 million tons for 2019.

CDW are defined as a priority area in the EU according to the Circular Economy Action Plan [EC, 2015] for closing the loop, while the revised Waste Framework Directive (WFD 2008/98/EC, amended by 2018/851/EE) sets a mandatory target for its recovery of 70% by 2020. Following the requirements of EU legislation, in December 2015, Greece adopted the National Waste Management Plan (NWMP) [YPEN, 2015] prepared by the Hellenic Ministry of Environment and Energy (YPEN). Along with 13 Regional Waste Management Plans (RWMPs), it provides a number of actions and measures to be taken in order to achieve the maximum environmental, social and economic benefits and to meet the EU targets. CDW is also a priority stream of the NWMP [YPEN, 2015]. The target set is that by 2020 a minimum of 70% (by weight) of non-hazardous CDW shall be prepared for re-use, recycling or undergo other material recovery, including backfilling operations (JMD 36259/1757/E103/2010). Furthermore, circular economy activities for CDW are also included in the National Circular Economy Strategy [YPEN, 2018] which promotes measures regarding the use of recycled CDW aggregates in public and private construction projects with the creation of appropriate framework of specifications, standards and certification of secondary materials, as well as public procurement. CDW is also mentioned in the National Energy and Climate Plan – NECP [YPEN, 2019] published as the Greek government's strategic plan for climate and energy issues. CDW sound management and the full adoption of the Circular Economy principles are included as key objectives in the detailed roadmap set with the aim of achieving specific energy and climate objectives by 2030.

The potential to increase the resource efficiency of the construction sector by improving the CDW recycling rate is significant but identifying and implementing good practices is not an easy task. In fact, the practical management of CDW varies greatly across Member States (MS) due to local variations in context, legislation, enforcement, and construction practices. Moreover, monitoring and data collection of recycling performance are often not accurate, due to data traceability and availability issues. Monitoring MS performances in recycling CDW is a real challenge that MS and European authorities are facing. It is however an essential step in assessing MS progress with regards to their recovery targets. Finally, different definitions of CDW are applied throughout the EU, which makes cross-country comparisons difficult.

1.2 Objectives of the Study

The Study was initiated at February 2020, led by ENVITTERA P.C. and in close co-operation with GIZ, YPEN, HRA, DWR, PROs and MoIT. The main Objective was to investigate the current situation of CDW generation, treatment and disposal methods, focusing on legal, institutional and technical aspects. That included:

- CDW management data gathering, their evaluation and assessment of their credibility.
- Development of a methodology for the calculation of CDW derived from Private (mostly) and Public Works based on statistical data from C&D activity in Greece
- Thorough codification of both national and EU legislative framework concerning CDW management and identification of gaps, overlaps and misconceptions
- Concrete proposals for improvement of both the Legislative and the Institutional Framework focusing on providing practical solutions, in full accordance with Circular economy principles and Greek reality
- Perform a Cost-Benefit Analysis (CBA) for all stages of CDW management Processes (production, separation, collection/transport, recycling)
- Development of good practices for on-site work, focusing on creating conditions for increasing CDW recycling and for improving the quality of recycling and recovery
- Development of Quality Assurance Plan (QAP) for all stages of secondary (recycled) materials production focusing on improving their quality so as to meet specifications set for different uses (aggregates)
- Success stories and Good Practices of efficient CDW management were showcased (presented in the Annex), illustrating key elements for success, as well as any necessary preconditions.

For an effective fulfilment of the abovementioned objectives, the work carried out was broken down into four (4) Activities, according to the TORs (Annex 1):

1. Data collection and assessment of the status quo of construction & demolition waste management sector in Greece. Development of a methodology for the calculation of C&D waste from private and public works, using both data from the Digital Waste Registry and other sources such as the C&D Waste Management Plans (developed for each work), data collected by the EPRs etc.
2. Proposals for the improvement of the institutional framework for construction & demolition waste in Greece, in line with circular economy principles.
3. Cost-benefit analysis using data for on-site separation of materials, collection, transport, processing, disposal costs etc., market prices of secondary materials etc. Good practices guide for constructors of public/private works for improved construction & demolition in the work site.
4. Proposals for specifications for secondary materials coming from the treatment of C&D waste, in order to be further used in the construction of public works by replacing raw materials – JMD 2221/2012 (cooperation with Hellenic Organization for Standardization - ELOT, Ministry of Infrastructure & Transport)

A modification for the above tasks is mainly refer to Activity 4: Bearing in mind Market's scepticism about the use of secondary materials derived from recycled CDW, the latter (mainly

aggregates), should comply with the same technical and environmental criteria as the natural products, as defined in JMD 2221/2012 and relevant European Standards, rather than proposing new specifications. For that reason, it is considered, bearing in mind the European Practice and the relevant literature, more practical and effective, to propose a uniform Quality Assurance Plan/Protocol (QAP) for secondary materials, including all stages of the recycling process, rather than developing new specifications for them.

1.3 Methodology for different Activities

1.3.1 Activity 1

The main objective of Activity 1 is to collect detailed information concerning CDW management in Greece, focusing also on recycling and recovery performances. This objective was fulfilled through a thorough screening phase for as many as Regional Units of Greece possible. Data collection is also aimed at giving a preliminary insight on performance and practices and at identifying potential barriers and drivers, especially towards the 2020 recovery target (70%). Thus, the specific activity constitutes a very important first step, laying the ground for further analysis on specific topics in CDW management practices in Greece.

In order to analyse the performance and management practices of CDW in Greece, a comprehensive methodology was set up, to facilitate the gathering of relevant data and information from each individual source (namely PROs, HRA, DWR, ELSTAT).

At first, mathematical models developed by the Environmental Science and Technology Unit of the School of Chemical Engineering of the NTUA [Kourmousis F., 2013, LIFE03/TCY/CY/018] was used to calculate on a theoretical basis the generated CDW derived from private works for the period 2016 – 2019 for the totality of Greek Territory (all regional Units) based on construction activity input provided by ELSTAT. The current models were selected among others [USEPA, 2012, Yunfu et al 2018] because they are based mainly on technical parameters (volume, density of waste) and it is well adjusted to the Greek reality.

For Public Works CDW calculation, theoretical estimation was based on several assumptions given the fact that due to the great differentiation between those projects, no specific methodology or model can be adopted.

The second step was to collect, manage and evaluate real CDW production data coming from PROs, HRA and DWR. A set of criteria was established in order to have a solid, even and comprehensive basis for analysis and comparison for all data sources. Based on the analysis criteria, screening Tables/Sheets were prepared, including a structured presentation of relevant information and data. The process of data management included in-depth literature analysis and close cooperation with all relevant Stakeholders. The comparison between different data sources along with theoretical approach of CDW calculation revealed significant contradictions. Concrete proposals for overcoming those problems in the future were developed by ENVITERRA P.C.

An overall assessment of CDW management performance in Greece was conducted based on the collected data and their comparison. Performance was measured in relation to the respective EU target (recycle or recover at least 70% of CDW by 2020). Other quantitative criteria were also assessed to identify any trends and to examine performance from different angles.

1.3.2Activity 2

The methodology for fulfilment of the current activity leans on the following pillars:

- Presentation of the legal framework of CDW management in Greece, based on the concept of Alternative Management and the principle of Extended Producer Responsibility (EPR).
- Systematic record and codification of the existing Greek CDW legislation, along with relative EU framework. All relevant acts (including pending ones) are presented in different categories namely: PROs functioning, licensing and environmental provisions for recycling units (including siting criteria), quarries restoration, collection & transport of CDW, provisions for excavation waste, specifications for secondary materials.
- Identification, through the aforementioned record/codification/evaluation of all the significant gaps and contradictions that set barriers to the sound CDW management in a national level and are related to PROs functioning, Public Works legislation, Public Procurement, provisions for quarries restoration, forest and town planning legislation, landfill gate fees, secondary material market and law enforcement issues.
- Proposals for specific legislative drivers and amendments focusing on financial incentives, quality demands and technical specifications, quarries restoration processes, PROs functioning, new construction activities and law enforcement

For the fulfilment of the activity, crucial was the close cooperation with the legislative actors (YPEN, MoIT) and HRA (as the competent authority for recycling policy in Greece and for approving PROs), while specific proposals were also provided from some PROs. Key feedback included: (a) Internal Review of the legislative framework – Suggestions for improvement (b) point out specific provisions (e.g. circulars, internal reports) non-easily accessible to the Public (c) update on pending regulations.

1.3.3 Activity 3

The methodology of the Consultant was based on the fulfilment of 2 subtasks, i.e. a Cost Benefit Analysis (CBA) for all stages of CDW management Processes and a Good Practice Guide concerning the improvement of construction & demolition practices in the work sites

Cost Benefit Analysis dealt with all the stages of a CDW management process, i.e. CDW production, separation, collection, logistics, recycling process and secondary materials market issues. Crucial parameters for determining cost of the recycled/secondary materials (e.g. separation at source, etc.) were highlighted and evaluated.

A Good Practice Guide for relevant stakeholders concerning the improvement of construction & demolition in the work sites was conducted. The Guide was based on International Literature, European experience and Circular Economy Principles, combined with Consultant's experience on the field. The Guide makes a distinction between design and execution phase for each project while demolition and construction projects are examined separately. The Guide include a) Guidelines for improving source separation b) Guidelines for selective demolition and dismantling c) Special provisions for excavation waste d) Instructions for audits and WMPs prior to construction/demolition e) Extensive list of C&D materials that must be removed from buildings prior to demolition (e.g. hazardous CDW) f) Other proposals for improving CDW management such as encouragement and financial incentives for participation in international projects that will contribute to the exchange of know-how.

For the Good Practice Guide key feedback included suggestions, proposals and data from YPEN, HRA, MoIT and PROs (e.g. Business Plans).

1.3.4 Activity 4

Activity 4 was carried out in the prism of minimizing the significant barriers that lead to a highly uncompetitive market for recycled CDW, not only in Greece but also across almost all MS. Those barriers include, among others, quality issues, very low raw material prices, low/free landfill costs, wrong public impression on the recycling process environmental footprint and the absence of EoW criteria.

In view of the above findings, a uniform Quality Assurance Plan/Protocol (QAP) was developed, so as to promote quality assurance for all stages of secondary materials production process (i.e. form CDW source to market). The development of QAP was based to the fact that, harmonized European standards that apply to primary materials also apply to recycled ones and CDW recycled materials must be assessed in accordance with requirements of European natural product standards. For that reason, the production of at least qualitatively competitive secondary materials, is of mayor importance.

For purpose of developing the QAP, extensive literature survey was conducted, focusing on combining, where possible, several good practices and paradigms from the European and global experience. According to the Consultant's methodology, 2 phases of secondary materials production were distinguished, i.e. the Primary Process (including source separation, collection and logistics) and the Production Process (including CDW handling/processing and secondary materials storage, testing and marketing). Other provisions for a sound and complete QAP were also included, such relation of the QAP to EoW criteria, safety issues and a process for updating the QAP.

All Activity and Task Management is presented on Table 1.1.

1.4 Structure of the Report

This report presents the main findings of the study and aims at giving a global picture of the current situation of CDW management practices in Greece.

In Chapter 2 the results of data collection and statistical analysis are presented. All different sources of data are illustrated and evaluated and specific remarks are made for data gaps and contradictions. Specific proposals are made for enhance data quality in the future. Chapter 3 presents in detail the legal and institutional framework of CDW management in Greece, focusing on specific gaps, overlaps and barriers. Concrete proposals are illustrated for improvement, in close cooperation with key Stakeholders.

Chapter 4, focuses on best CDW management practices within a typical construction and demolition site. A Good Practice Guide is presented, based on EU experience, success stories and Consultant's experience on the field. In Chapter 5, the Cost Benefit analysis for all the stages of CDW management is presented and the crucial parameters affecting costs are highlighted and analysed. Finally, Chapter 6 illustrates the Quality Assurance Plan/Protocol on the basis of improving CDW management practices at all stages and producing secondary (recycled) materials that may meet technical and environmental specifications so as to be accepted in national and international market.

The Annexes of this Report provide information about TORs, meetings and co-operation with Stakeholders, Tables, Charts, Data Sheets, Photos and all other relevant information about the project successful fulfilment. Finally, in order to reinforce the know-how of the key stakeholders,

several good practices were identified, related to all the types of intervention and implementation across the EU (legislative actions, techniques, non-legislative initiatives etc.) that may positively affect CDW Management. All those practices are presented in a special Annex of the current Assessment, while they are also constituting the base of several suggestions and interventions proposed from the Consultant.

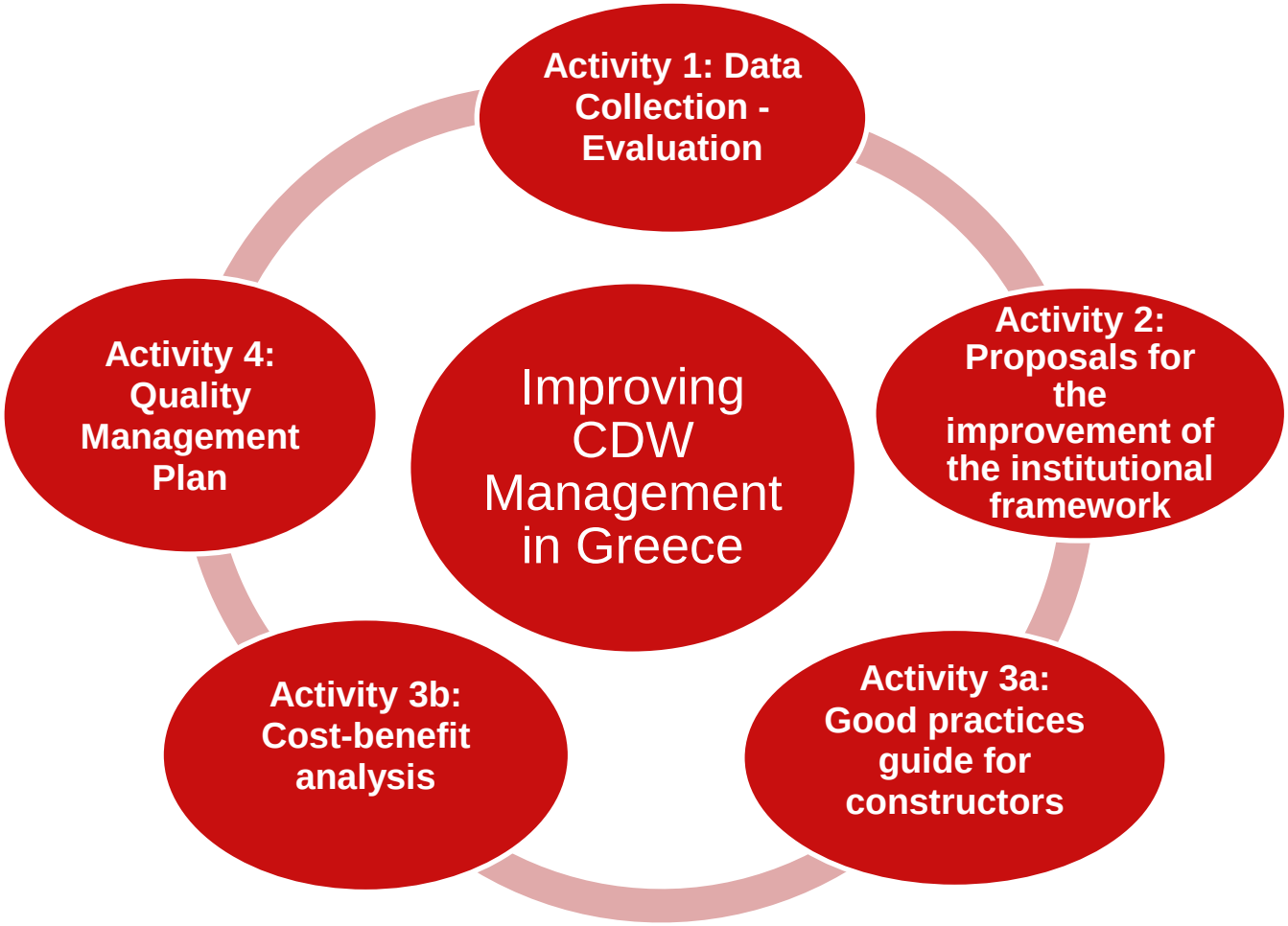

Figure 1.1: Structure of the study - activities

Table 1.1: Activity & Task Management

	9 Feb	23 Feb	8 Mar	22 Mar	5 Apr	19 Apr	3 May	17 May	28 May	30 Jun	15 Jul
Activity 1											
Task 1.1: Data Collection ELSTAT											
Task 1.2: Data Collection HRA											
Task 1.3: Data Collection PROs											
Task 1.4: Alternative Sources of data											
Task 1.5: Development of Algorithms											
Task 1.6: Data Management/Evaluation											
Activity 2											
Task 2.1: Gathering EU/National Legislation											
Task 2.2: Codification											
Task 2.3: Evaluation – Results - Remarks											
Activity 3											
Task 3.1: Data Collection/Literature Review											
Task 3.2: Cost Benefit Analysis											
Task 3.3: Good Practice Guide											
Activity 4											
Task 4.1: Literature Review											
Task 4.2: QAS											
Review - Draft Final Report											
Final Review - Final Report											

2. CDW Management Performance – CDW Statistics

2.1 General Context

The main objective of Activity 1, as defined and the TORs and described in the introductory chapter, was to collect detailed information concerning CDW management in Greece, focusing also on recycling and recovery performances. This objective was fulfilled, to the extent possible, through a thorough screening phase. More specifically, the type of requested data, the main stakeholders involved, the challenges faced and the alternative data sources are presented in Table 2.1. Data collection was also aimed at giving a preliminary insight on performance and practices (practical and legal) and at identifying potential barriers and drivers, especially towards the 2020 recovery target (70%). Thus, the specific activity constitutes a very important first step, laying the ground for further analysis on specific topics in CDW management practices in Greece.

Data collected cover with satisfactory accuracy the period 2016-2019. It should be mentioned that the intention of the Consultant was also to collect data for year 2015, but some PROs do not respond, while problematic were also the annual reports collected from HRA. In view of that, only data for the period 2016-2019 are presented and evaluated hereinafter.

2.2 PROs established and geographical coverage

A list of all active PROs in Greek area is presented in Annex 5, along with their respective geographical coverage (Map, Annex 6). The development of PROs is satisfactory, covering almost 78% of the Greek territory and 90% of the Greek population. It is reminded that the establishment of PROs started in 2011 and within 9 years most of the Greek area has been covered.

2.3 CDW and EW generation data

2.3.1 Theoretical Approach – ELSTAT data

Data regarding the generation of CDW and EW in Greece can be derived utilizing sources from the Hellenic Statistical Authority (ELSTAT) concerning construction activity for the whole Greek territory. The same sources may also provide CDW data for Regional Units that no PROs are activated.

Construction Activity Data

In Tables A3.1, A3.3, A3.5 and A3.7 (Annex 3) the construction activity data for the Greek territory are illustrated. Note that data referred only to private works. Construction activity is dived into 3 broad categories i.e. new constructions/additions, demolitions and excavations.

As a general comment it can be said that there is an increasing trend in the construction activity for the years 2016 - 2019. That trend is mainly due to the gradual come-back of the construction sector as a result of the exit from the economic crisis and the restart of the national economy. Thus, an increasing trend for CDW generation is also expected.

Table 2.1: Requested Data

Requested Data (2015-2019)	Source	Collected (Y/N)
List of PROs	HRA/Internet/PROs direct contact	Y
Geographical Coverage of PROs	HRA/Internet/PROs direct contact	Y
Quantity of CDW produced per 6-digit code per year	HRA/PROs Annual Reports/YPEN/PROs direct contact	Due to the different recording and the non-uniformity of the available data from the PROs, it is impossible to separate the managed AEKK per six-digit EWC code or per ECDW group of codes. Not available for 2019 for some PROs
Quantity of CDW delivered to Treatment Units per 6-digit code per year	HRA/PROs Annual Reports/PROs direct contact	Due to the different recording and the non-uniformity of the available data from the PROs, it is impossible to separate the managed AEKK per six-digit EWC code or per ECDW group of codes. Not available for 2019 for some PROs
Quantity of CDW recycled per year	HRA/PROs Annual Reports/PROs direct contact	Not available for 2019 for some PROs
Quantity of secondary materials produced per year	HRA/PROs Annual Reports	Not available for 2019 for some PROs
Quantity of residues produced per year	HRA/PROs Annual Reports	Y (Based on mass balance)
Quantity of secondary materials sold per year	HRA/PROs Annual Reports	N
Quantity of materials used for backfilling or similar uses	HRA/PROs Annual Reports/PROs direct contact	Y
Quantity of materials end up to landfills	HRA/YPEN*	N
Total Number of PROs Contractors (Producers, Transporters, Recycling or Temporary Storage Facilities)	Internet/PROs direct contact	Y
Quantity of CDW collected/transported	DWR	Only for years 2017 and 2018
Construction/Demolition Activity per Regional Unit	ELSTAT	Y (only private works)
PROs Business Plans	HRA/PROs	For limited number of PROs

*YPEN provided data for CDW, (2013-2015), under Article 11 par. 2b of the Directive 2008/98/EC.

CDW generation

In fact, ELSTAT data are transformed to CDW quantities by implementing a specific mathematical model developed by the Environmental Science and Technology Unit of the School of Chemical Engineering of the NTUA [Fatta et al, 2003, Kourmousis F., 2013, LIFE03/TCY/CY/018]. The term "waste density" is introduced and waste generation rate employing "volume per area" factor is used instead of "weight per area" like other scholars suggest [Ahmad et al, 2012, Yunfu et al

2018]. The model also uses some satisfactory assumptions for the waste generation rate and density, quite representative of the characteristics of Greek CDW status.

The basic input of the model derives from ELSTAT data on Construction Activity. The parameters taken into account in the model for estimating the generated quantities of ECDW are:

- Surface of new constructions and building additions / extensions (source: ELSTAT)
- Estimation of volume of CDW produced per 100m^2
- Waste density (volume / weight ratio)

Thus, the amount of construction waste generated is calculated by the equation 1:

CW = (NC + EX) * VW * D (1)

where

CW: Construction waste in tn

NC: New building surface in m^2

EX: Surface of new additions to existing structures in m^2

VW: Volume of waste generated per construction area in m^3 / m^2

D: Waste density in tn/m^3

Different algorithms are used for the generated ECDW derived from demolition, renovation/addition and excavation activities for private works. For the parameters of the algorithm, specific values for the Greek case are used [Fatta et al, 2003, Kourmousis F., 2013, LIFE03/TCY/CY/018].

The amount of demolition waste generated is calculated by the equation 2:

DW = ND * SD * WD * D (2)

where:

DW: Demolition Waste in tn

ND: Number of demolitions

SD: Average surface area of demolished buildings in m^2

WD: Volume of waste generated per m^3 / m^2 per demolition area in m^3/m^2

D: Waste density in tn/m^3

The amount of excavation waste generated is calculated by the equation 3:

EW = NDc * ES * ED * D (3)

where:

EW: Excavation Waste tn

ND: Number of new buildings permits

ES: Average excavation area in m^2

ED: Average excavation depth in m

D: Waste density in tn/m^3

The values of different parameters used in the above equations are presented in Table 2.2.

Table 2.2: Parameters used for the equations, adjusted to the Greek Practice [Fatta et al, 2003, Kourmousis F., 2013, LIFE03/TCY/CY/018**]**

Parameter	Value
VW	0,06 m^3/m^2
D Construction	1,6 tn/m^3
WD	0,8 m^3/m^2
D Demolition	1,6 tn/m^3
SD	130 m^2
ES	130 m^2
ED	3 m
D Excavation	1,4 tn/m^3

At this point it should be noted there is no specific CDW calculation for renovation activities. That is due to:

- No data for renovations are available in the TPAs and E,
- Most renovation activities do not even need a license from TPAs, so they are rather considered a non-significant CDW stream.

Table 2.3 provides the estimated CDW and EW in tones for the whole country for period 2016 - 2019, as calculated by the above equations, based on the data of the construction activity from ELSTAT. In Tables, 3A.1, 3A.3, 3A.5 and 3A.7 (Annex 3), CDW data calculated per Regional Unit are presented. It is noted that the above calculated waste concerns exclusively private projects which are carried out within the areas of interest, given the non-registration by ELSTAT of the construction activity regarding Public Works. Based on data from the international literature and the management experience of relevant cases in the past, ENVITERRA P.C. considers that the CDW from Public Works constitute approximately 60% of the CDW coming from Private Works [Bravo et al, 2015, Coelho and de Brito, 2010].

Table 2.3: CDW generation data in Greece based on different Sources (values in tones)

Year	CDW Managed (HRA)	CDW Managed (PROs)	CDW Production (ELSTAT)	CDW Collected/Trasnported(DWR)
2016	525,276	517,106	3,249,132	No data
2017	985,029	969,645	3,737,492	1,549,306
2018	2,566,906	2,409,102	4,300,505	2,226,587
2019	No data	4,627,590	4,644,283	No Data

In Figure 2.1, an overview of the total ECDW produced, according to ELSTAT data, is illustrated. A steady increase of CDW production for the period 2016-2019 is obvious, with a maximum quantity attributed to year 2019 (4.644.283tn). On the other hand, there is an over 600% CDW production compared to projections of NWMP at 2015.

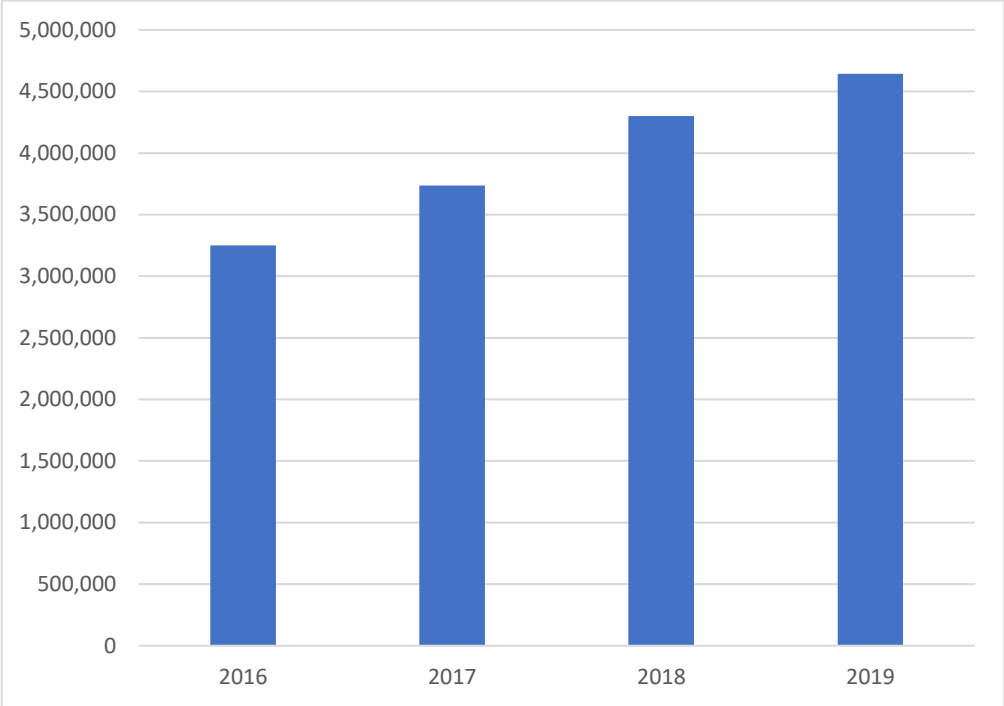

Figure 2.1: Total CDW production in tons based on construction activity (ELSTAT data)

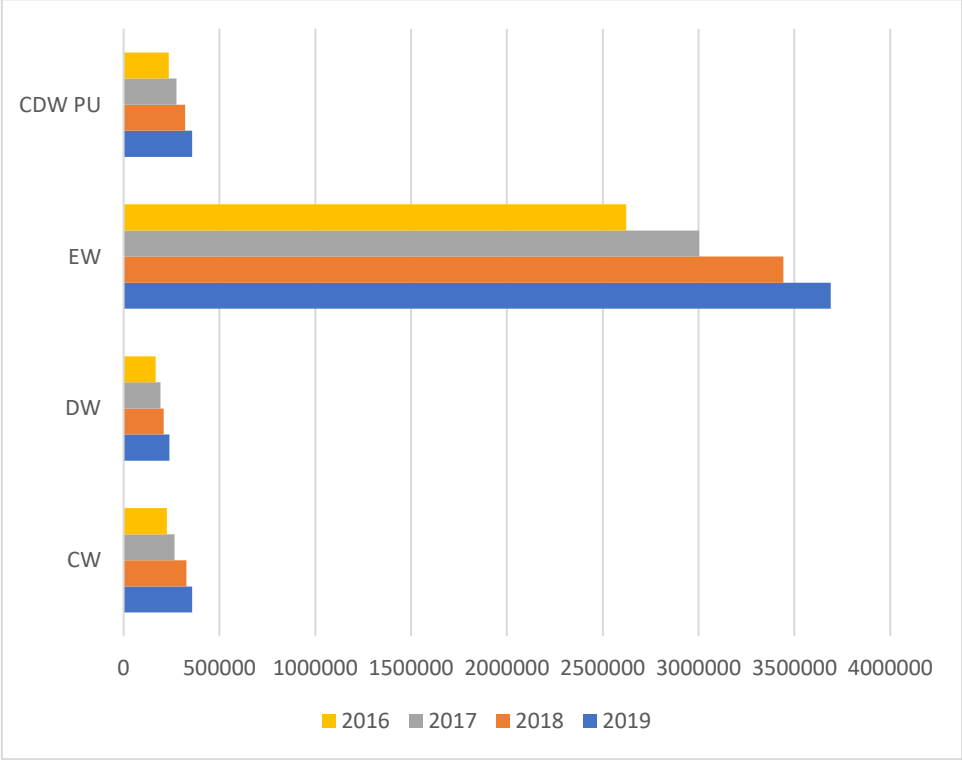

Figure 2.2: Distribution of CDW produced (2016-2019 values in tons) in different streams (values in tons) based on construction activity (ELSTAT data)

In Figure 2.2 a distribution in different waste streams of the total production is presented. It is obvious that EW represent almost 80% of the total ECDW production for years 2016 – 2019.

2.3.2 NWMP approach

NWMP conducted in 2015, made some predictions for CDW production for the years 2016 – 2019. The predictions were based on ELSTAT data and NTUA algorithms. Nevertheless, due to the intense economic crisis confronted back then, the predictions proved to be highly underestimated.

In Figure 2.3, a comparison between NWMP 2015 predictions and ENVITERRA calculations based on real data is shown. It is concluded that, there is an over 600% higher CDW production compared to projections of NWMP at 2015.

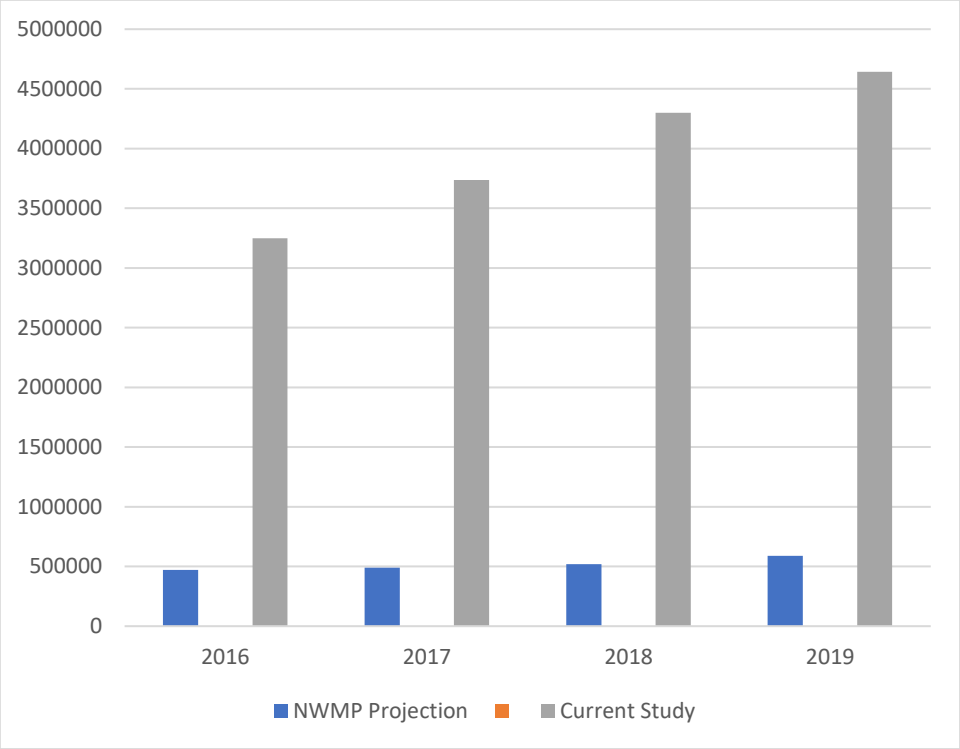

Figure 2.3: NWMP 2015 vs Study calculations for CDW production (in tons) for the period 2016-2019

Within a framework of the new NWMP (2020), there is a common approach for ECDW calculation [YPEN, 2020] since the predictions of the Plan are also based on NTUA algorithms and ELSTAT data. Nevertheless, there are differentiations on the assumptions and the values of some parameters, namely:

- There is no prediction for CDW coming from Public Works in the NWMP
- In the NWMP the Demolition Surface (SD) is assumed equal to 260m^2 (while the current study assumes 130m^2)
- There is no provision for EW coming from Demolition activities in the NWMP

A demolition surface of 260m^2 is considered, in our opinion, excessive. It assumes, at least 2 demolished floors with an area of 130m^2 each. Based on the experience from construction/demolition industry in Greece, most of the demolished buildings in Greece are single-floored, while, even in case of 2 floors buildings, usually each floor hardly possesses an area

larger than 65m^2. It should be also mentioned that, PROs BPLs submitted for approval to HRA, also consider a 130m^2 demolition area, in order to predict CDW quantities that PROs will manage.

On the other hand, NWMP considers that demolition activities do not produce any EW. That is based probably on the assumption that each demolition is followed by a construction i.e. the respective EW quantities are attributed to the construction. From ENVITERRA's experience on the field, that is not true. Many of the demolished buildings (especially the last 5 years) are not replaced by a new construction, at least within a short period of time. Consequently, there will be an underestimation considering the total EW production.

In Figure 2.4, the NWMP's versus ENVITERRA calculations are illustrated. Note that there is small deviation to the final results, because the difference attributed to the larger demolition area (NWMP) is balanced by the inclusion of EW-demolition and the CDW coming from Public Works (ENVITERRA).

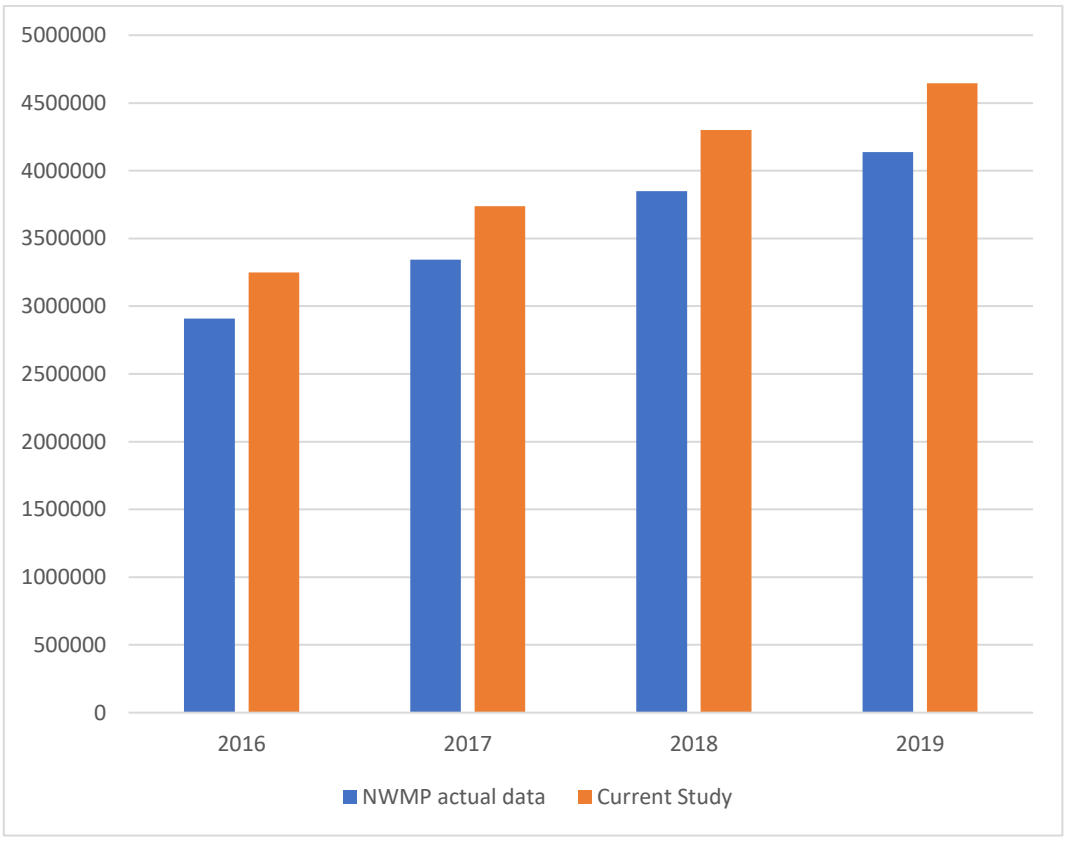

Figure 2.4: NWMP 2020 vs Study calculations for CDW production (in tons) for the period 2016-2019

2.3.3 Actual Data (PROs, HRA, DWR)

PROs, HRA

Since the establishment of PROs started in 2011, it is expected that the quality of reported data is improving significantly over years. A clear objective of the current Activity was to gather and analyze data for all Regional Units of Greece, in order to obtain a view of the performance and management practices of CDW in Greek Territory. Another objective was to gather data per 6-digit EWC code if possible. As it shown in Table 2.1, the first objective was vaguely achieved, but

not the second, due to the different recording and the non-uniformity of the available data from the PROs. Once more, PROs and HRA data do not contain EW from Public Works.

An overview of the CDW generation data from all possible sources is illustrated in Table 2.3. Comparing data from HRA annual reports (submitted by PROs) and those provided individually from each PRO to the Consultant (see Figure 2.5), a small difference is observed (1,5 – 6%). The greatest difference is observed for the year 2018, but also the quantities of CDW managed at that year are large. More or less, those differences are considered normal and attributed mainly to minor mathematical or reporting errors.

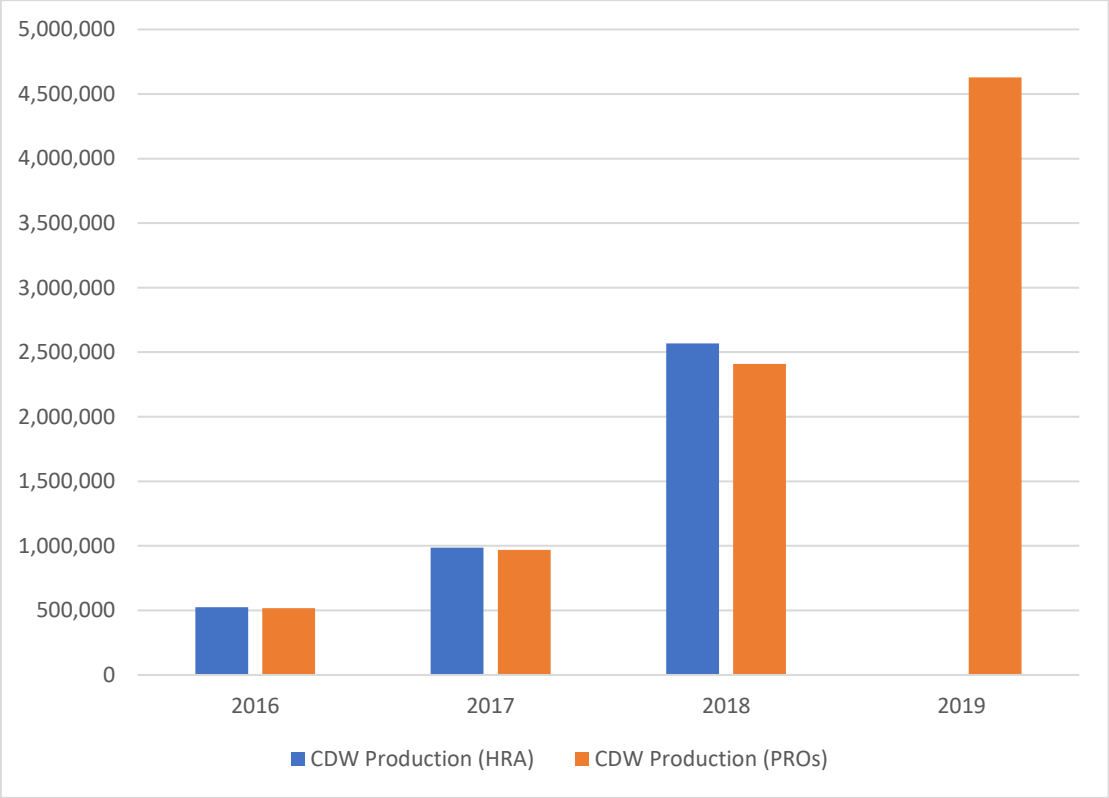

Figure 2.5: PROs and HRA data on CDW managed (no data from HRA for 2019 were available)

In Tables 3A.2, 3A.4, 3A.6 and 3A.8 (Annex 3), data on CDW management provided by PROs, per Regional Unit, are provided for years 2016 - 2019. Examining the results per regional unit for 2016, unexpectedly, in the island of Syros (central Aegean) the larger quantities of CDW were produced reaching an 32% of the total CDW production, followed, as it was expected by Thessalonica (24%) and Attica (19%), since the latter are highly urbanized areas.

For 2017, as it was expected, the areas of Attica (45%) and Thessalonica (12%) have reported the largest amounts of CDW. Note that in Chalkidiki regional unit (south of Thessalonica) there was also a significant CDW production reaching a 15% of the total quantity reported.

For 2018, more than half of the total CDW were produced in Attica (54%), followed by Thessalonica (9%) and Larisa (6,3%) (also a relatively high urbanized area). It should be mentioned that the total quantities reported for 2018, are almost 2,5 times greater than those of 2017.

Finally, for 2019 the total amount of CDW reported was almost 200% greater than the respective amount of 2018. Attica was the area with the highest production (47%), followed by Thessalonica and Hania (Crete) with a 9% contribution.

Another important remark refers to the significant generation of CDW at the island regions of Greece which is rapidly increasing, as the tourism industry has experienced a significant boost over the last years. Increased construction of tourist accommodation has spurred CDW generation as well, while the proper CDW management on the islands is an acute problem due to the limited space [Deloitte, 2015].

In general, there is a great difference between quantities calculated by the ELSTAT data and those provided by the PROs for the 2016, but that difference decreases for 2017 and 2018, while, for 2019, there is a remarkable balance between CDW reported by the PROs (4.627.590t) and those calculated by the selected mathematical model (4.644.283t), given the impression that almost the totality of CDW produced are managed through PROs.

Nevertheless, even for the year 2019, this convergence is rather plasmatic. Looking at the data from individual Regional Units, there are significant differences between real and theoretical data, especially for the Regional Units with the higher CDW production. For example, in the region of Attica (see also Figure 2.6), the total quantity managed through PROs for 2019 amounts to 2.182.661tn while the theoretical calculation gives less than half amount (1.031.034tn) i.e. the CDW quantity that managed through PROs are 2 times greater than the one calculated based on construction activity data. The reasons of the great deviation may be:

- The, inevitable, error in the calculation algorithm
- Incorrect data from PROs
- Especially in island areas, excavation waste from large private projects (e.g. wind farms) are not managed by PROs.
- PROs are recording data based on the location of each RU. On the other hand, RUs are licensed for operating in prefectural level. Therefore, the transfer of CDW from different Regional Units (belonging to the same Prefecture) to the same RU is possible.
- Some quantities of CDW may be produced the previous year and temporarily stored in RUs, subjected to treatment (and reported) the next year

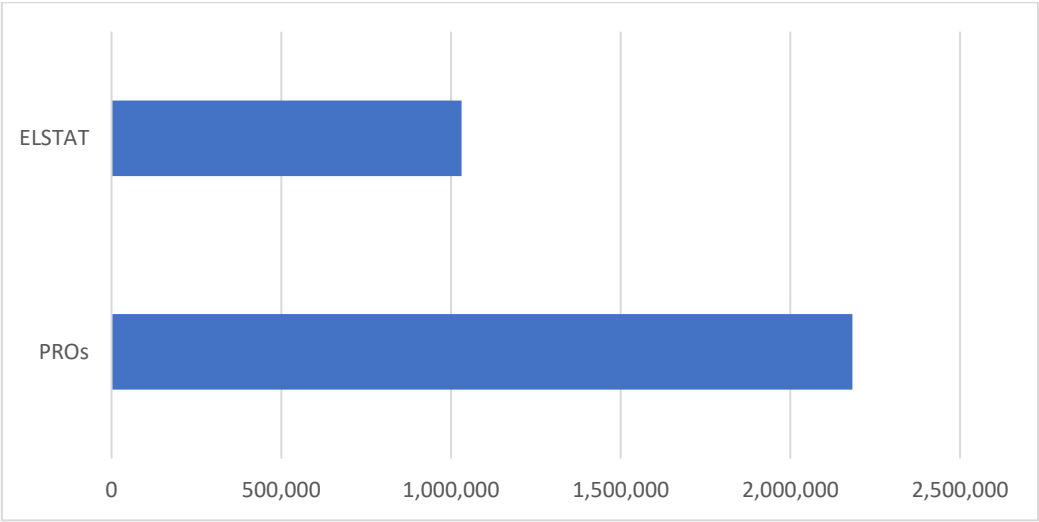

Figure 2.6: Difference between ELSTAT based CDW calculation and PROs report for CDW managed in Attica Region for 2019 (values in tons)

DWR

An alternative source for obtaining data per 6-digit EWC code was the Digital Environmental Registry (DWR). In fact, the Registry could provide data on the total amount of CDW collected/transported, per 6-digit EWC code, as those quantities are submitted to the annual reports of the registered CDW transporters. Unfortunately, data from DWR were available only for years 2017 and 2018, since (a) data for 2015 and 2016 have not been evaluated yet and (b) data for 2019 will be available after the 31/07/2020, since the deadline for Waste Reports submissions for 2019 has been extended due to the COVID-19 pandemic.

DWR data may be compared with PROs data only on the basis of total quantities and not per geographical unit (see Table 2.2 and Figure 2.7). In that context, total quantities of CDW derived from DWR for year 2017 appear significantly increased compared to those declared by PROs. That may be attributed to the following reasons:

- Incorrect recording of data by the stakeholders, given that they were not familiar with the DWR process.
- From the personal experience of the Consultant, many transporters recorded waste data of previous years (2015 and 2016) to the 2017 report.
- Since PROs do not cover the totality of the Greek territory, it is expected that in several regional units, CDW were transported by registered stakeholders, but they didn't manage through PROs.
- There is always the case of illegal dumping or landfilling.

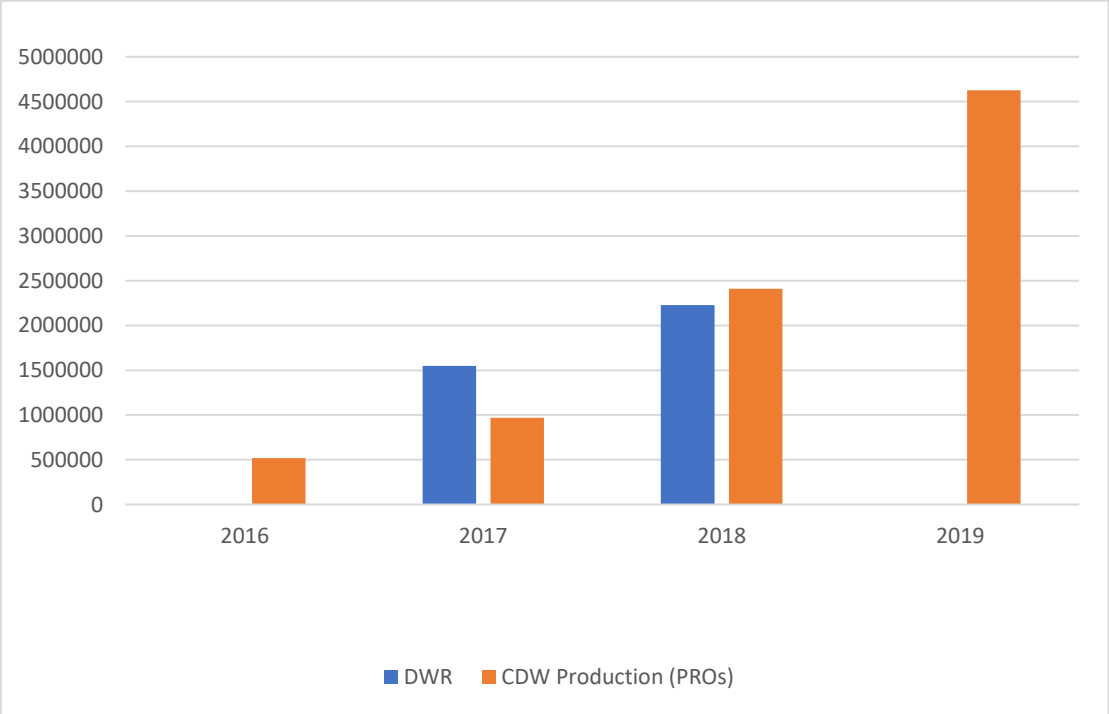

Figure 2.7: Comparison of data provided by DWR (2017, 2018) and PROs for CDW management (values in tons)

A totally different picture is presented for 2018, with respect to the comparison of DWR and PROs data. The latter are presented almost 15% increased with respect to DWR registrations. That change of picture may be attributed to:

- DWR users were getting more familiar and accurate with respect to the use of DWR platform
- The effectiveness of PROs functioning, along with Public awareness, has been increased
- PROs have increased their geographical coverage between 2017 and 2018

2.3.4 Hazardous Waste

Exports of hazardous CDW is a reality in a series of Member States which are not equipped for dealing with the specific treatment of these waste types. While these CDW have to be declared as being generated, they do not appear in the national statistics as far as treatment is concerned (the MS importing these CDW accounts for these additional amounts of treated waste in their own statistics). This phenomenon of hazardous CDW exports is often correlated with the size of the country (e.g. in Malta, Cyprus, Luxemburg). Small countries are likely not to invest in appropriate facilities for hazardous waste handling, probably more expensive than exporting this waste. Hence, in such countries, due to the lack of appropriate facilities for hazardous waste handling, most of hazardous CDW has to be exported for treatment.

In Greece, there is no data available concerning the exports and imports of CDW. However, data on notified shipments of hazardous waste under the Basel Convention exist. CDW hazardous waste data refer mainly to asbestos-containing CDW Asbestos CDW (EWC codes: 17 06 01*, 17 06 05*). The destination of the exported construction and demolition asbestos waste is usually Germany for the purpose of final disposal (landfilling) in designated hazardous waste landfills. Nevertheless, there is no way to estimate what portion of e.g. asbestos has derived from CDW and in the CDW treatment quantities, the amount of hazardous waste exported for landfilling (asbestos waste) is not included.

A way for overcoming the above CDW data gap will be to gather information from DWR. All hazardous waste exported should be notified to the Registry by both the producer and the transporter. Especially for hazardous waste transportation, there are very few Companies activated in Greek Territory and they can be easily approached in order to provide individual data on hazardous CDW exports.

2.4 Excavation Waste from Public Works

It is not possible to calculate the amount of excavation waste derived from Public Works and record it for the same period (2016 – 2019). In general practice CDW treatment on site is not reported as CDW management but it is integral part of the construction project activities (see also Chapter 3). As long as the EW from Public Works do not managed through PROs, there is no other official record. On the other hand, the inability to calculate the quantities of waste generated by excavations in public works is due to the delayed operation of the Alternative Management Systems, which are legally competent to accept them for processing. So this amount could be captured, although it is a distinct but part of the work being done.

After all, the variety of Public Works that can lead to the creation of EW (e.g. road construction, ports, railways, etc.) is so great that it is almost impossible to propose a type of calculation or

mathematical model that covers all cases. Even for the same type of work (e.g. road construction), the local conditions (e.g. geological) are so different that no single estimation algorithm/model can be implemented. Furthermore, especially for linear type of projects (such as road or railway construction), the excavations quantity and quality differentiate from place to place due to the relevant differentiation of the local conditions (e.g. in Km position + 0.00Km the geology is different from Km position + 2.00Km).

In any case, based on the current national public work and environmental legislation (see Chapter 3), there is an obligation for submitting a special template, from the beginning of the project, which includes the volume or quantity of excavations that will occur and the corresponding amount of backfilling (for the needs of the project) operations. There are also specific provisions for the fate of "surplus materials". This table, accompanied with the appropriate technical assessment, is subjected to approval by an independent Authority and the Public Body that auctions the project. Thus, critical details about EW management in Public Works, may be available and should be notified to the Authorities responsible for CDW management (e.g. YPEN, HRA, PROs or even the Decentralized Authorities), creating a channel for the accurate reporting of EW derived from Public Projects.

2.5 CDW Treatment and Recovery data/Targets

Targets for the recovery of CDW in Greece is found in JMD 36259/1757/E103/2010. The quantitative target for the recovery of waste from excavation, construction and demolition activities, excluding codes 17 05 04 and 17 05 06 of the European Waste Catalogue (EWC), according to Decision 2001/118/EC is:

- From January 1st, 2012 onwards, reuse, recycling and recovery of CDW should reach at least 30% relative to the total weight of the produced CDW.
- From January 2015 onwards, reuse, recycling and recovery of CDW should reach at least 50% relative to the total weight of the produced CDW.
- From January 2020 onwards, reuse, recycling and recovery of CDW should reach at least 70% relative to the total weight of the produced CDW.

Actually, the % reuse/recycling/recovery (RRR) is estimated as follows:

$$\%RRR = \frac{Quantity\ of\ CDW\ Processed\ for\ RRR}{Total\ Quantiry\ of\ CDW\ produced}$$

Note that the method of target calculation does not contain the term "Excavation Waste", while "backfilling" also creates several misconceptions as it is analyzed in Chapter 3.

For the estimation of CDW processed/treated data, there are 2 main data sources (a) the annual reports of HRA (b) the data provided directly from PROs. Unfortunately, the second source is not considered reliable, as the treatment figures given include backfilling, which must be declared separately. Therefore, the treatment performance of Greece can be approached only for the years 2016 – 2018, while for 2019 only (recovery + backfilling) data may be given.

According to the annual reports from HRA, only the total quantities of recovered/backfilled CDW may be provided, since the PROs do not provide data per Prefecture or per Regional Unit. Those total quantities are presented in Tables 2.4, 2.5 and 2.6.

Table 2.4: Total Quantities of recovered and backfilled CDW (years 2015-2018 all values in tones)

Year	Total Quantity of CDW managed (HRA)	Total Quantity of CDW managed (PROs)	Total Quantity of CDW produced (ELSTAT)	Total Quantity of CDW collected/transported (DWR)	Recovery other than energy recovery - Except backfilling (HRA)	Backfilling (HRA)
2016	525.276	517.106	3.249.132	No data	144.480	129.076
2017	985.029	969.645	3.737.492	1.549.306	170.907	473.256
2018	2.566.906	2.409.102	4.300.505	2.226.587	646.659	1.519.771
2019	No data	4.627.590	4.644.283	No data	Misreported	Misreported

Table 2.5: % Recovery Rate based on different CDW generation sources

Year	% Recovery (HRA)	% Recovery (PROs)	% Recovery (ELSTAT)	% Recovery (DWR)
2016	27,5%	27,9%	4,4%	No data
2017	17,4%	17,6%	4,6%	11,0%
2018	59,2%	63,1%	35,3%	68,3%
2019	No data	Misreported	Misreported	No data

Table 2.6: % Backfilling Rate based on different CDW generation sources

Year	% Backfilling (HRA)	% Backfilling (PROs)	% Backfilling (ELSTAT)	% Backfilling (DWR)
2016	24,6%	25,0%	4,0%	No data
2017	48,0%	48,8%	12,7%	30,5%
2018	25,2%	26,8%	15,0%	29,0%

For the estimation of "Total Quantity of CDW produced", ELSTAT data on construction activity, should be used. Alternatively, one may consider DWR data on collected/transported CDW (2017 – 2018) as "Total Quantity of CDW produced" assuming that the quality produced = quantity collected/transported.

Regarding the target estimation, it is questioned whether "backfilling" shall be added on the quantity of CDW processed, considering backfilling as a "low quality recovery" (see also Chapter 3), or whether backfilling quantities and the respective backfilling rate should be reported separately.

In Figure 2.8 National RRR Target estimation (%) is illustrated for years 2016 – 2018 with backfilling reported separately. In Figure 2.9, backfilling quantities are included in the estimation of National RRR Target. When backfilling is not included, %RRR starts from 4,5% at 2016 and increases to 15% at 2018. Backfilling rate is estimated at 4% at 2016 and reaches a 35% at 2018. When backfilling is included as an RRR, the target is estimated at 8% for 2016, reaching a maximum of 50% for 2018.

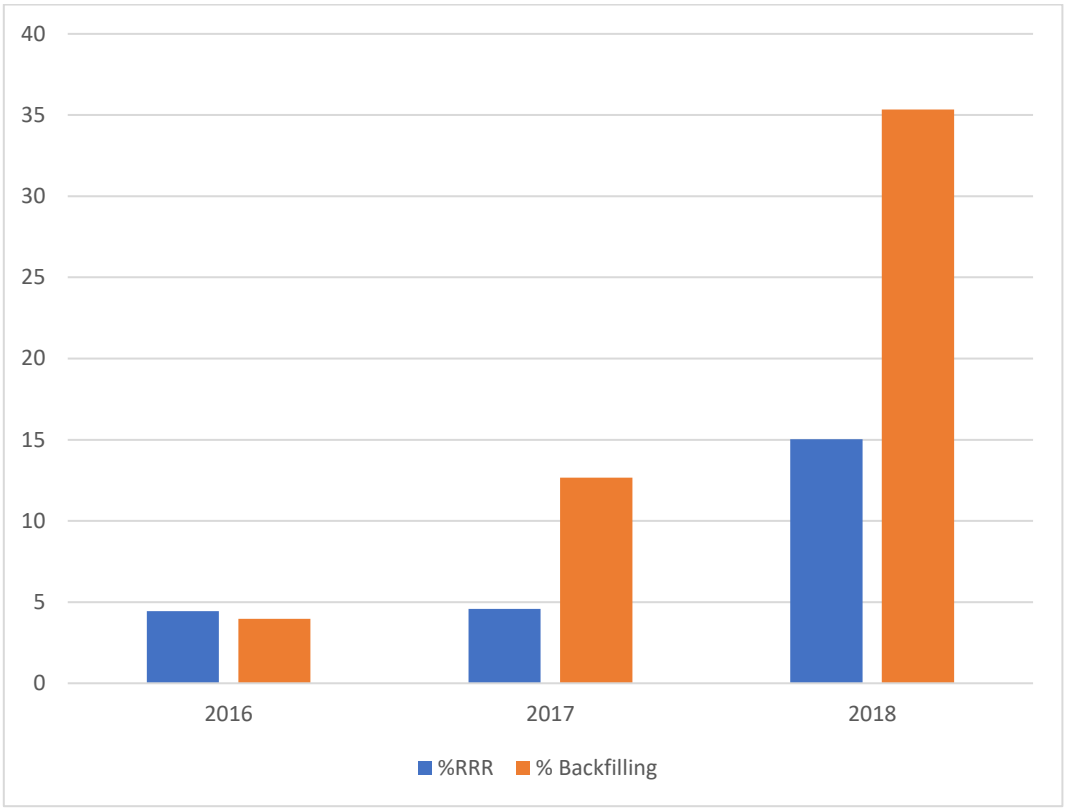

Figure 2.8: National RRR Target estimation (%), with backfilling reported separately (values % – No data for 2019)

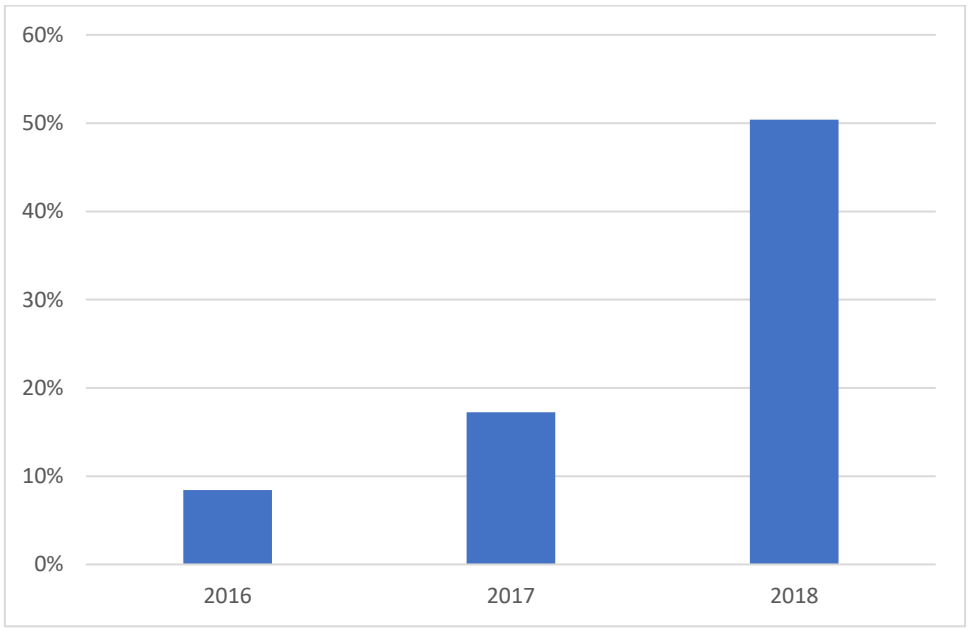

Figure 2.9: National RRR Target estimation (%), including backfilling (values % – No data for 2019)

2.6 Data on Secondary Materials Market

According to the above mentioned, the production of secondary materials in Greece, based on the data from the HRA and the PROs is given in the Table 2.7. Obviously, there is a significant increase in the availability of secondary (recycled) materials over the years. In fact, in 2018 more than 1,5 million tons of recycled materials were produced.

CDW has been used in the previous years for the covering and rehabilitation of existing landfills as well as dumping sites forced to close down. The amounts of CDW used for that purpose are not reported as being recovered or backfilled and therefore are not included in the official statistics. At the same time, some quantities of this waste were illegally disposed of, even outside the areas of uncontrolled burial in water recipients (streams), etc.

The existing CDW treatment facilities in Greece treat mainly the mineral fraction of CDW, while materials such as metals, plastics and glass (when present) are sent to other recycling facilities that handle each specific material fraction. The main secondary materials produced are aggregates (sand, gravel etc.) Wood wastes sometimes are treated in the CDW treatment facilities or alternatively disposed. All CDW treatment facilities in Greece are affiliated with the certified PROs.

From the data collected by PROs, no clear overall picture is given for the type and market of secondary materials. The data provided include various types of secondary materials that arise depending on the input (CDW) entering the Recycling Units and which are categorized in a different way. It should be mentioned that part of the materials that are recovered concern soil and stones as well as vegetable soil. In addition, some of the PROs claim that all the materials entering the RUs are used entirely for backfilling activities, including restoration of quarries. Especially the latter procedure raises questions, as neither the process by which the secondary materials end up in a quarry nor which quarries are used is clarified.

From the processing of the data provided to the Consultant, an approximate distribution of the secondary materials produced is given in Figure 2.10. Considering sales and prices of secondary materials, very few PROs provided data on this matter. Some PROs claimed that almost all secondary materials have been sold, but they are not giving details on prices. Other PROs provide some data on prices, but there are very local depended.

Table 2.7: Material Recovery from CDW according to PROs data

Year	Materials Recovered (secondary materials)
2016	144,480
2017	170,907
2018	1,519,771
2019	Misreported

Secondary materials prices, depended on the input, varying between 0 – 4 euro/tone, according to some PROs information and the experience of the Consultant. Note that the price 0 refers to recycled materials that are given to Municipalities or other Public Authorities, for low scale public works, free of charge. More details about secondary materials market and the economics of recycling are provided in Chapter 5 of the current document.

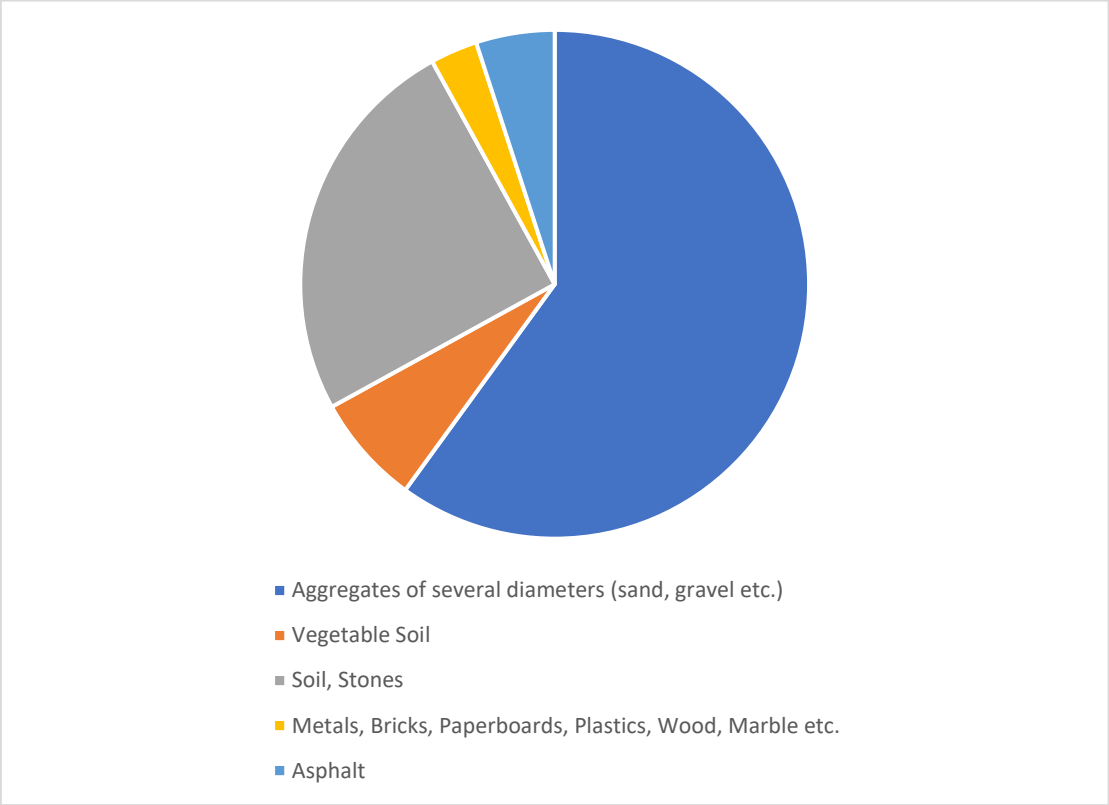

Figure 2.10: Distribution of Secondary (Recycled) Materials Produced

2.7 Data on CDW Holders

An overview of the CDW Holders status and their relation with the PROs, is provided in Figures 2.11– 2.13. There is an impressive increase in the number of contracts for all type of holders (i.e. collectors/transporters, producers and RUs). According to the data provided by the PROs, there is a 294% increase between 2016 and 2019 in the collectors/transporters affiliated with the PROs, while the respective increase for producers is 621% and 389% for RUs. In fact, more than 6,000 contracts between holders and PROs are valid today. Note that the numbers in Figures do not correspond to the actual number of holders, since one holder may be affiliated with more than one PRO. According to DWR data, up today, there are **1650** Collectors/Transporters registered and **216** RUs.

In the following years, it is expected that the number of affiliated holders will further increase, since both the activation of the PROs and the Public awareness are intensified too.

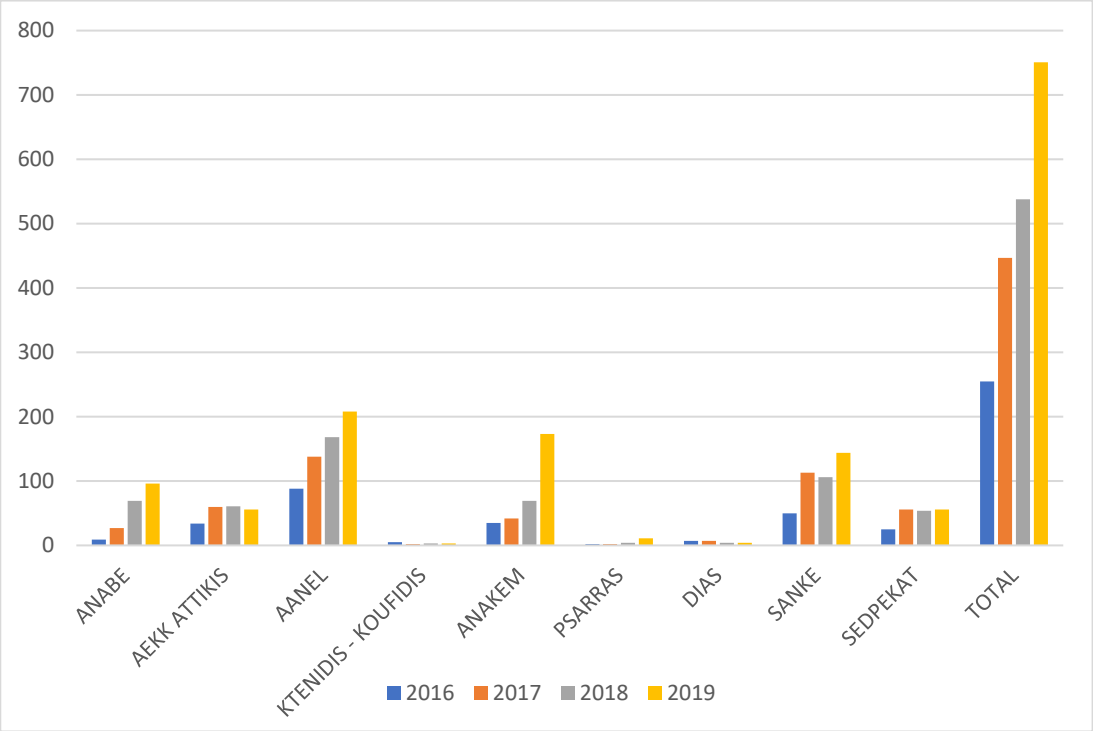

Figure 2.11: Contracts numbers with Collectors - Transporters per year (2016-2019)

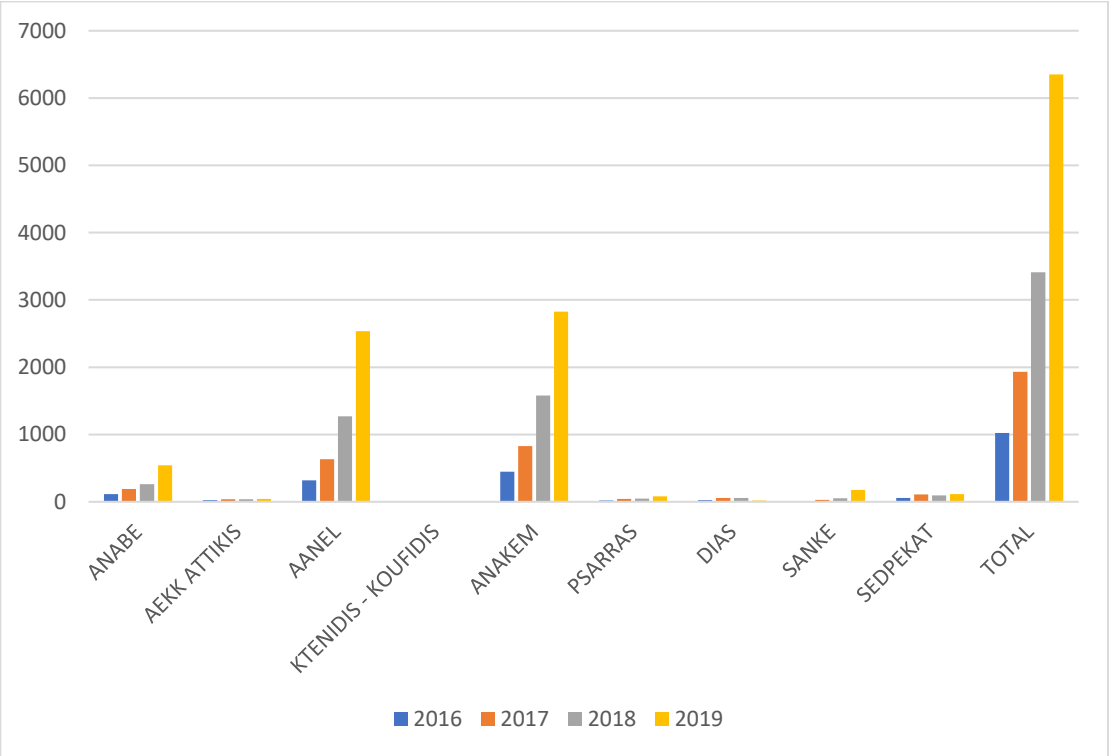

Figure 2.12: Contracts numbers with CDW Producers per year (2016-2019)

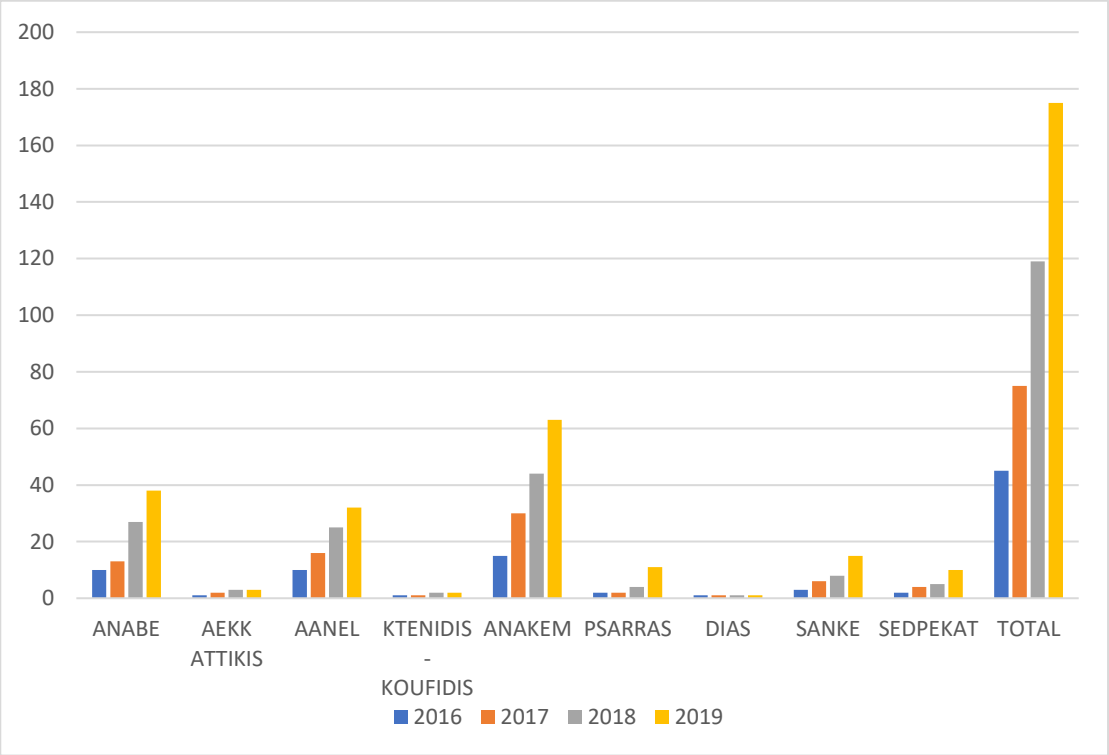

Figure 2.13: Contract numbers with Recycling Units per year

2.8 Other Materials Recycling

In all MS, including Greece, recycling of several other materials has proven to be more difficult [EU, 2016]. These materials constitute smaller fractions of CDW and recycling of these fractions usually requires more input. For example in Greece, as it is shown in Figure 2.10, only 3% of the recycled materials are attributed to metals, wood, glass, plastics etc.

In Netherlands, there is a progress on recycling several materials coming from CDW namely [EU, 2016]:

- Flat glass: A collection scheme exists for flat glass initiated by the glass industry and the glass can be delivered to collection points for free.
- PVC windows: A collection scheme exists for PVC windows, and also these can be delivered for free to collection points.
- Gypsum: A few years ago an agreement was made between government and industry to make the Netherlands a leader of the recycling of gypsum. Gypsum is kept separate mainly in order to not affect the quality of recycling of inert C&D waste.
- PVC pipes: One recycler has developed a recycling process for PVC pipes. PVC is micronized in order to meet the requirements for use in new PVC pipes.
- Roofing material. Bitumen roofing material can be recovered and processed, and used partly in new roofing constructions and partly in asphalt.

In Annex 8, some selected BPs for waste, other than CDW, treatment and processing are illustrated.

3. National and EU legislative framework for CDW Management

3.1 General Context – Codification of CDW legislation

The principles governing the management of CDW in Greece and all other MS are the following:

- The principle of waste prevention,
- The principle "the polluter pays"
- The principle of co-responsibility of all stakeholders
- The principle of the extended producer responsibility
- The principle of publicity to users and consumers regarding measures taken to implement the legislative framework in order to highlight their role in alternative waste management

In general, the legislative framework for waste management in Greece is defined by **Law 4042/2012** which transposes the EU Waste Framework Directive - WFD (2008/98/EC) into Greek law. All provisions in the WFD related to CDW are valid for Greece and form the legal basis for the management of CDW in the country.

YPEN is responsible for setting the scope of national policy concerning the management of waste, drawing the draft legal framework for waste management and delivering the NWMP.

The fundamental EU and national legal framework constitute of the legislative acts is illustrated in the next paragraphs.

3.1.1 EU Legislation

The fundamental EU legislation regarding CDW management is presented below:

- **Commission Decision2000/532/EC:** Replaces Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C (2000) 1147) - *Classification of waste according to their source of origin, their type and their attributes, with a 6-digit code. CDW are classified in Chapter 17.*
- **Directive 2008/98/EC**: On waste and repealing certain Directives – Waste Framework Directive (WFD).
- **Commission Decision 2011/753/EU**: Establishes rules and calculation methods for verifying compliance with the targets set in Article 11(2) of Directive 2008/98/EC of the European Parliament and of the Council.
- **Commission Decision2014/955/EE**: Amends Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council.
- **Directive 2018/851/EU: Amendment of the Directive2008/98/EC on waste (WFD)**: The goal is to incorporate, in the WFD, the targets of the Circular Economy.

3.1.2 National Legislation

All the national legislative acts concerning CDW management in Greece is presented hereinafter. Relevant acts (including pending ones) are presented in different categories, covering the different aspects of CDW management and other relevant social and environmental issues. It should be mentioned that, during the conduction of the current Assessment, the new Environmental Law4685/2020 (GGD 92A/7.5.2020) was published, amending several provisions of the existing legislative framework for CDW.

Waste Management Framework

- **Law 4042/2012 (GGD 24A/13-2-2012)**: "*Criminal protection of the environment - Harmonization with Directive 2008/99/ EC - Waste generation and management framework - Harmonization with Directive 2008/98/EC - Regulation of the Ministry of Environment, Energy and Climate Change"*– The environmental protection through criminal law is instituted, HRA substitutes EOESDAP and PRO responsibility is defined.

Alternative Management

- **Law 2939/2001 (GGD 179A/6-8-2001):** *"Packaging and alternative management of packaging and other products. - Establishment of a National Organization for the Alternative Management of Packaging and Other Products (EOESAP) and other provisions*" - For the first time the concepts "Alternative Management" and "Alternative Management System" as long as their basic operating principles are defined. EOESDAP is also instituted (transformed to HRA by Law 4042/2012).
- **JMD 36259/1757/E103/2010: "***Measures, conditions and program for alternative management of excavation, construction and demolition waste (ECDW)"* **-** Fundamental definitions for ECDW (per 6-digit code -chapter 17, including 01 04 03 and 10 13 14 codes), PROs and ECDW Alternative Management Systems, obligations of PROs, general conditions for ECDW management (collection, transport, recycling) and quantitative targets for reuse, recycling and recovery of materials from CDW.
- **Circular No. Pr. 129043/4345/8-7-2011:** *"Implementation of legislation for the management of non-hazardous solid waste"* - Facilitate the implementation of current legislation related to solid (non-hazardous) waste management, including CDW. More specifically, the legal framework for collection and transportation of CDW is clarified.
- **Law 4496/2017 (GGD 170A/8-11-2017)**: *"Amendment of Law 2939/2001 on Alternative Management of Packaging and Other Products, Harmonization with Directive 2015/720/EU, Regulations of the Hellenic Recycling Agency (HRA) and other provisions*"–The Law includes detail provisions for the operation of PROs and their legal obligations. It also amends specific articles of Law 2939/2001.

Town Planning Legislation

- **Law 4067/2012 (GGD 79A/9-4-2012):***"New Building Regulation"* - Article 17 stipulates that for the construction of any building and the landscaping of the building surroundings, the provisions of the relevant legislation for alternative management of waste from excavation, construction and demolition waste should be applied.
- **Law 4495/2017 (GGD 167A/3-11-2017):** *"Control and protection of the Building Environment and other provisions"* - Provides for the mechanisms and means of quality control of the

building environment, regulates the framework of construction, the control of the implementation of spatial planning, the issues related to public areas and the environmental balance. It also addresses arbitrary construction and other matters within the competence of YPEN

Waste Management Plans

- **MD 51373/4684/2015 (GGD 2706/B` 15.12.2015**): *"*Approval of the National Waste Management Plan (NWMP) and the National Strategic Waste Prevention Plan"*.*
- **MD 62952/5384/2016 (GGD 4326/ B` 30.12.2016): *"****Approval of the National Hazardous Waste Management Plan (NHWMP), according to article 31 of Law 4342/2015"***

Environmental Legislation/Environmental Permits

- **Law 4014/2011 (GGD 209A/21.9.2011): *"****Environmental licensing of projects and activities, regulation of arbitrariness in connection with the creation of an environmental balance and other provisions under the competence of the Ministry of Environment"* - Describes the framework, conditions and demands for Environmental Licencing.
- **MD 1958/2012 (GGD 21B/13-1-2012):***"Classification of public & private projects and activities in categories and subcategories according to article 1, par. 4, of Law 4014/2011 (Government Gazette 209A / 2011)" as has been amended and is in force"****.***
- **No. DIPA/37674/ 10.8.2016 (GGD 2471B/2016): *"****Amendment and codification of the ministerial decision 1958/2012 - Classification of public and private projects and activities in categories and subcategories according to article 1 paragraph 4 of Law 4014 / 21.9.2011 (Government Gazette 209 / A / 2011) as amended and in force"***.
- **JMD 43942/4026/2016*: "****Organization and operation of Digital Waste Registry (DWR), in accordance with its provisions Article 42 of Law 4042/2012 (A '24), as in force"* - Regulates the organization and operation of the DWR, the mandatory electronic registration and recording of bodies, companies and facilities involved in the production and processing of waste, as well as in the waste collection and transport processes.
- **YPEN/Directorate of Environmental Permit/11936/836/2019:** *"Determination of procedure and supporting documents for the installation and operation of projects and activities of "Environmental Infrastructure Systems* - Relates environmental permitting procedure with CDW Processing Facilities and the Organized areas for disposal of inert materials and residues from CDW processing.
- **Law 4685/2020 (GGD 92A/7-5-2020):** *"Modernization of environmental legislation, integration into the Greek legislation of the Directives 2018/844 and 2019/692 of the European Parliament and of the Council and other provisions"* - Article 89 amends Law 4495/2017 regarding construction/demolition activities. Also, Article 85 excludes Collectors/Transporters of non-hazardous solid waste (including CDW), from any licensing obligation.

Quarries/Forest Legislation

- **Law 998/79 (GGD 289A/ 29-12-1979)***"On the protection of forests and forest areas in general of the country"* - A first attempt was made to restore the environment, after permitted interventions of article 57, in accordance with the more specific provisions of Articles 16 and 45 of the same Law. It was amended by Law 4280/2014

- **Law 4030/2011 (GGD 249A/25-11-2011):** *"New way of issuing building permits, construction control and other provisions"* - Especially, Article 40 deals with issues related to ECDW treatment in relation with quarries reclamation.
- **Law 4280/2014 (GGD 159A/9-8-2014):** *"Environmental upgrading and private urbanization - Sustainable development of settlements. Forest law regulations and other provisions".* Article 52 stipulates the possibility of deposition and processing of CDW in inactive mines and quarries by the certified systems of alternative CDW management. Article 51 also modifies the Article 40 of **Law 4030/2011** for issues related to ECDW treatment in relation with quarries reclamation
- **Law 4512/2018(GGD 5A/17-01-2018):** *"Regulations for the implementation of the Structural Reforms of the Economic Adjustment Program and other provisions".* It regulates issues concerning the location and operation of quarries. Articles 43 and 46 clarify the scope of application and relate the quarry areas to CDW and secondary products, while Article 55 refers to the restoration of quarries and the operation of units within quarry holdings.

Public Works

- **ΔΜΔ/ΔΙΠΑΔ/ΟΙΚ/273/2012 (GG B 2221/2012):** "Approval of four hundred and forty(440) Greek Technical Specifications (ETEP), with mandatory application in all Public Works ".
- **Circular no. 4834/25 -1-2013 of the Ministry of Environment, Energy and Climate Change: "***Management of surplus excavation material coming from public works - Clarifications on the requirements of JM 36259/1757 E10/2010 (GGD 1312 B)"*- Deals with management of excess excavation materials from Public Works and provides clarifications on the requirements of the JMD 36259/1757/E103/2010, exempting the management of excess materials from excavation activities during public works through the certified systems of alternative CDW management, as long as the excess material is handled in sound environmental manner.
- **Circular no. 11/19-06-2017 of the Ministry of Infrastructure and Transport: "***Publication of the Regulation of Invoices for public works contracts"* - It particularly clarifies the issues related to the inclusion of the cost of CDW management in public works contracts.

3.2 Waste management plans (WMP) and Strategies

The new Greek Waste Management Plan (WMP) has been delivered in 2015 along with National Strategic Waste Prevention Plan (WPP).In the current WMP all waste streams are analysed and specific measures are proposed for the environmentally sound management of each waste stream following the principles or waste prevention and the efficient use of waste, according to the waste hierarchy as presented in the Waste Framework Directive (2008/98/EC) and the National legislation for waste (Law 4042/2012).There are dedicated chapters for CDW and the management of asbestos waste which is an important hazardous waste stream in Greece.

The Waste Prevention Plan identifies food waste, paper waste, packaging waste and Waste Electrical and Electronic Equipment (WEEE) as priority waste streams for waste prevention. Specific measures are presented for these four waste streams. There is also a section for CDW where a few measures for waste prevention are presented as well. Waste prevention measures for CDW are mostly limited to promoting information and education about waste prevention and engaging business, while there are no binding prevention targets attached to this waste stream.

Apart from the NWMP, the administrative regions of Greece have adopted their own regional WMPs. However, the current regional WMPs do not cover specifically the CDW stream, they are

rather outdated and fail to meet the requirements of Directive 2008/98/EC. There is a need for the regional WMPs to be updated taking into account the provisions found in the substantial new body of legislation (adopted after 2010, including the transposition of the WFD in national law) and the national planning of waste management as presented in the new National WMP.

WMP and WPP are currently under amendment and the new Plans are about to be delivered by the end of June 2020.

3.3 CDW Management/Alternative Management

The management of CDW in Greece involves a wide range of actors from the public and private sectors. An outline of the basic actors involved in the CDW management value chain is presented in Figure 3.1.

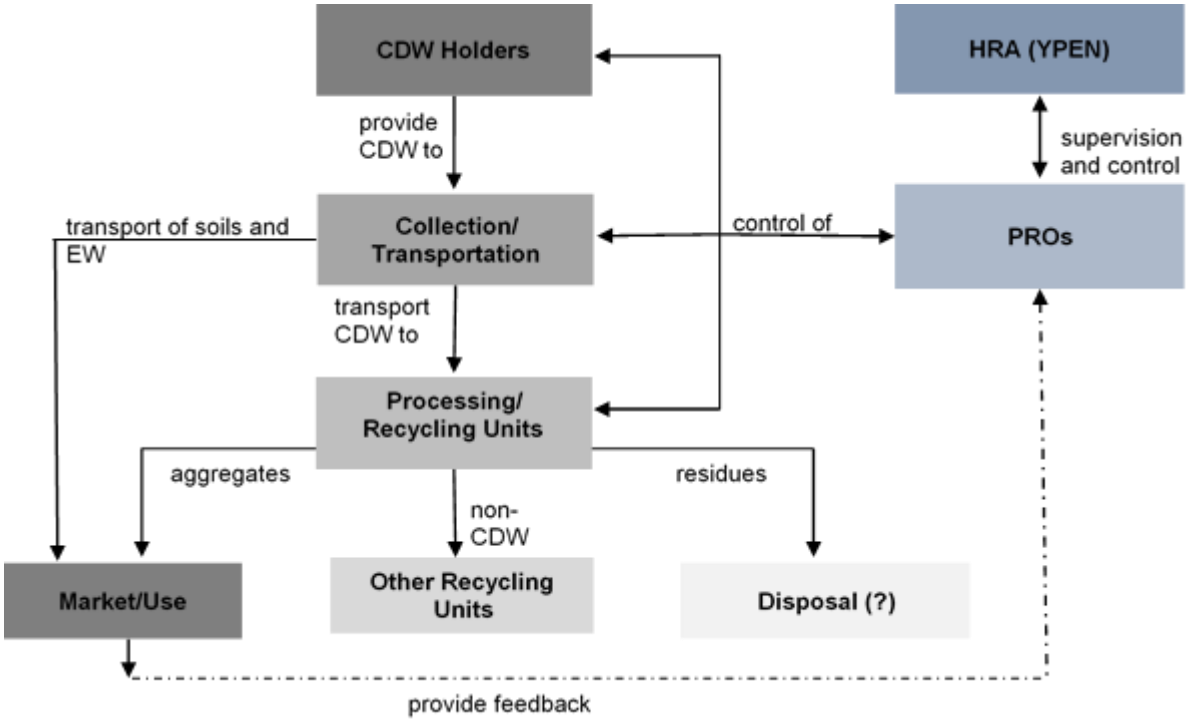

Figure 3.1: Stakeholders & their interaction in CDW Management in Greece

According to National Legislation, "Alternative management" is defined as: "*the collection, transport, temporary storage, reuse, processing and recovery of CDW, so that by reusing or recovering them they return to the current market or be promoted to other uses*".

The creation of Alternative Management Systems is based on the principle of Extended Producer Responsibility (EPR), which uses financial incentives to encourage producers to design more environmentally friendly products and renders them responsible for the cost of product management at the end of their life cycle. Greece has included in the institutional framework of alternative management a range of waste streams for which there are clear quantitative targets for recycling and recovery in European legislation, but not necessarily in the context of extended producer responsibility, such as ECDW (Excavation, Construction and Demolition Waste). Thus, the JMD 36259/1757/E103/2010 has been issued, containing terms and conditions for the alternative waste management for ECDW. In this context, all producers/holders (manufacturers,

traders, importers) are obliged to either organize or participate in Alternative Management Systems.

For the implementation of the legislation for the alternative waste management in Greece, the HRA has been established (under the control of YPEN) to supervise all operations regarding the re-use, recycling and recovery of all waste streams. Individual or collective Systems are approved, monitored, and controlled by the HRA. The Systems constitute private entities known as Producer Responsible Organizations (PROs) which are set by law for the alternative management of the waste generated by their operations.

PROs are non-profit organizations and they are responsible for organizing and supervising the operations of alternative management (collection, transport, recovery etc.) of CDW conducted by public or private legal bodies on behalf of the System and for informing the public administration and CDW holders about their obligations according to law.

The approval of the PROs by HRA is valid for six years and may be renewed by amending or revising of the PROs Business Plans. Law 4496/2017 had modified Law 2939/2001, includes all the necessary provisions and the regulatory framework for the operation of the PROs.

The roles of all actors involved in CDW management are sufficiently articulated in national legislation. However, it is common that other actors might operate ad-hoc or by-passing the legislation, especially concerning the collection and disposal of CDW in unauthorized dumping sites after removing valuable recyclable materials (e.g. metals, plastics).

The structure of actors and their responsibilities within the system of CDW management is theoretically sufficient to divert significant quantities of CDW from landfills or illegal dumping to recovery. However, persistent inadequacies in implementation has not allowed increased recycling over the last few years in Greece to take place. The development of PROs is satisfactory, covering almost 78% of the Greek territory and 90% of the Greek population, although further progress is needed if Greece is to come even close to the target of the WFD by the end of 2020 (see par. 3.5).

A PRO can be activated in a specific Regional Unit only if there is at least on RU operating in that region (JMD 36259/1757/E103/2010). In practice, the Unit(s) is having the “responsibility” of tracking down the holders and inform them for their obligations, if they are not already aware.

3.4 Targets

Targets for the recovery of CDW in Greece is found in JMD 36259/1757/E103/2010. The quantitative target for the recovery of waste from excavation, construction and demolition activities, excluding codes 17 05 04 and 17 05 06 of the European Waste Catalogue (EWC), according to Decision 2001/118/EC is described in par. 2.5.

3.4.1 Target Estimation

Code 17 05 06 in the ECW code book is described as: *dredging spoil other than those mentioned 17 05 05* (i.e. not containing dangerous substances). In Greek legislation has been translated as: *excavation debris,* which is wrong. On the other hand, the particular code is not included in the target setting for CDW proposed by the Waste Framework Directive (2008/98/EC) in Article 11(2). Nevertheless, Law 4030/2011 (Article 40, par. 5) abolishes the exemption of waste code 17 05 06 for the calculation of the above national targets. However, with Commission Decision

2011/753/EU, establishing rules and calculation methods for verifying compliance with the targets set in Article 11(2) of Directive 2008/98/EC, it becomes evident that the waste code 17 05 06 should be excluded from the calculation of the target. Consequently, Greece is following the rules in 2011/753/EU for the calculation of the target but, at the same time, retains in place contradicting legislation about including waste code 17 05 06 for the calculation of the target.

Conclusively, there is high risk of questionable data influencing the achievement of the national and WFD targets by 2020.

3.4.2 Target Achievement – The "backfilling" issue

The 2012 and 2015 national targets were not achieved and there is doubt whether the 2020 national target can be achieved or not. There is lack of reliable data on CDW generation and treatment and therefore it is difficult to monitor the performance of CDW management in Greece. With the establishment of the PROs and their expansion to most of the Greek territories, the flow of reliable and traceable data is improving and better statistics enable the monitoring of CDW recovery performance towards the national and WFD targets.

Backfilling concept, creates 2 major issues:

- Whether backfilling can be incorporated to the National RRR targets
- Whether the reported quantities of ECDW backfilled are estimated correctly

According to 2018/851/EE Directive: "*material recovery" means any recovery operation, other than energy recovery and the reprocessing into materials that are to be used as fuels or other means to generate energy. It includes, inter alia, preparing for re-use, recycling and backfilling.*

"Backfilling" is not a term which has been defined in the WFD, however it is included in the target for re-use and recycling of CDW within Article 11/2b: "*By 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight*".

A definition of backfilling is given in the Directive 2011/753/EE: "*backfilling means a recovery operation where suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials*". According to this definition, backfilling meets the definition for "recovery" under the WFD, but fails to comply with the specific requirements for recycling (or for preparation for re-use). Hence, backfilling can be considered as low-quality recovery.

The 2018/851/EE Directive provides, a more detailed definition of backfilling: "*any recovery operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials, be suitable for the aforementioned purposes, and be limited to the amount strictly necessary to achieve those purposes*". In the same Directive is also noted that: *"For the purposes of verifying compliance with point (b) of Article 11(2), Member States shall report the amount of waste used for backfilling and other material recovery operations separately from the amount of waste prepared for re-use or recycled. Member States shall report the reprocessing of waste into materials that are to be used for backfilling operations as backfilling".*

The inclusion of 'backfilling' as a poorly defined option for "recovery" within Article 11 2/b results in inconsistency in CDW data reported by all MS, including Greece. Activities classified as 'backfilling' vary depending on established practices in different MS and matters are more confused by widespread land recovery through restoration with inert soils (waste code 17 05 04), which involve a waste and a recovery process excluded from the 70% target in Article 11 2/b. The inclusion of the term 'backfilling' in the present wording of Article 11 2/b has caused, and continues to cause misunderstanding, creating a disincentive to achieving the resource efficient objective of high-quality recycling to quality standards.

Backfilling is used in Greece in different applications (both in Private and Public Works), mostly for rehabilitation of spent mines and quarries (not by PROs for the time being) or landscaping as well as for landfill cover. Backfilling operations are carried out utilizing mainly EW (17 05 04) and less CDW. Based on the exemption of Public Works for reporting to PROs for their EW management (see also par. 3.1.2, 3.6 and 3.7.1), those quantities used for backfilling in Public Projects are not reported.

Pursuant to the current legislation, all generated EW from Private Works should be diverted to certified PROs and the amounts of EW used for backfilling are, more or less, appropriately reported. According to data from PROs (see Chapter 1), it is reported that quantities of recycled CDW that is cannot be marketed (due to low demand – undeveloped market for recycled CDW) is also diverted to backfilling.

3.5 Provisions for CDW Holders/Contractors

Private Works

The Contractor is obliged to submit, as a part of the licensing process for a construction/demolition project, to the competent TPA, a WMP for the specific work, along with other supporting documents required) and a letter of guarantee in the amount of 0,2% and 0,5% on the total project budget for excavation works and construction/demolition projects respectively.

The Contractor within 30 days after the completion of his obligation for CDW management, must submit to the competent TPA a Certificate of receipt of CDW from a PRO, as well as accurate data on categories and quantities of the CDW that were managed, based on specific documents. Within 10 days from the submission of the above Certificate the letter of guarantee is returned to the Contractor.

Public Works

The management of CDW, including excavation waste, derived from public projects it is included as a condition in the Environmental Licensing Decision or be included as a condition in the project contract. Public Contractors are also obliged to submit a WMP.

With the completion of all waste management works, the Contractor is required to submit to the Supervisory Authority a certificate of receipt CDW from a PRO.

Excavation Waste (often referred as "surplus materials") management **is not obligatory through a PRO**. Nevertheless, EW should be managed according to the relevant Environmental License issued and EW management should be sufficiently described in the project contract.

Municipalities

Local authorities are obliged to collect CDW that come from their activities (e.g. constructions, repairs, renovations, demolition, excavation, asphalt removal etc.) (article 17 par. 3 of Law 2939/2001, as replaced by the article 5 par. 1 of Law 3854/2010) and abandoned CDW by private construction projects (usually small scale) (article 75 of Law 3463/2006 as amended by article 94 of Law 3852/2010)

The alternative management of CDW is organized either by each Municipality itself as Individual System or in collaboration with a PRO (usually the latter).

3.6 Barriers/Drawbacks

The aforementioned legislative framework presents significant gaps, contradictions and overlaps. Hereinafter, an attempt is made to highlight the most important of them.

3.6.1 Public Works

Alternative Management Costs

Although there is an obligation, prior to construction permitting, for setting up a WMP concerning the construction project, by the contractor, alternative management of CDW provisions consistently missing from the Tendering procedures of public works. That was also revealed in meeting no 4 (See Annex 2) with MoIT executives. In fact, the cost of CDW management has not been incorporated in current public contracts. For new contracts, the Circular 11/19-06-2017 of the Ministry of Infrastructure and Transport, regarding the Publication of the Regulation of Invoices for public works contracts, clarifies some of the issues related to the inclusion of the cost of CDW management in public works. Nevertheless, Circular 11 is adopting provisions only for the cost of collection and transport of CDW and does not include the contribution (fee) to the PRO regarding further CDW management.

Excavated Material/Waste

Although it is clear that CDW coming from Public Works are obliged to be managed through PROs, there is a contradicting legislation about excavation waste (EW) in public works, which allows excess excavated material to be exempted from management through the PROs. More specifically, Circular 13 of the Ministry of Environment, Energy and Climate Change no. 4834 of 25-1-2013 is making specific provisions for EW from Public Works, exempting them from the alternative management. As a result, construction public works systematically report the generated EW as excess/surplus excavated material and not waste, avoid sending it to the PROs and as a result saving the costs of treatment.

However, there are other provisions in the Public Works Legislation and the respective environmental licensing process, that are not in line with the view of excavation material as waste and yet support to some extent sustainability purposes. In particular, the use of materials resulting from a public project is allowed, both for the needs of the specific project (reclamations, plantings, for quarries restoration, even for the production of aggregates) and for future public projects. Also, the relevant legislation includes the provision for the creation of repositories (areas for temporary storage of surplus materials), which in fact can be used in the future by a public project for obtaining materials.

Nevertheless, estimated quantities of EW generated missing accuracy and in the case of re-using of EW within the same construction project no reporting on this waste is expected.

Green Public Procurement (GPP)

There is an absence of any initiative for **Green Public Procurement (GPP)** in national legislative framework, i.e. the obligatory use of a portion of secondary (recycled) material to Public Projects. In Italy, for example, there is the legislative instrument Decree 205/2010 as implementation of WFD, including GPP. In a legislative framework the drive of GPP requirements, that incentive waste recovery, has important role. Indeed, the use of recycled materials becomes mandatory and strategic in the assignment of the tender. In other words, any project must contain and foresee for the use of a specific percentage of secondary raw materials.

Generally, there is lack of any financial incentives for waste recovery and marketing of secondary materials.

3.6.2 Town Planning Authorities (TPAs), WMPs and Waste Audits

TPAs play an important role in CDW management in Greece, since they approve WMPs for Private Works and also issue the permissible land uses (as a fundamental part of the Environmental Licensing procedure) for the installation of Recycling Plants. Nevertheless, they lack specific knowledge and expertise on CDW management issues and they are not in position to have a holistic approach for both WMPs and Recycling Units.

On the other hand, there is no legal obligation for detailed Waste Audit prior to any construction/demolition activity. The template for the WMP is sufficient, but there is no written justification for the codes of CDW selected. Moreover, there is a non-justifiable estimation of the respective CDW quantities.

3.6.3 Landfill Tax

The Greek Government adopted **Law 4042/2012** which required that as of January 2014 organisations or enterprises disposing of untreated waste into landfills have to pay a tax starting at EUR 35/tonne and reaching EUR 60/tonne; if these charges are paid by final consumers, they amount to an additional cost of EUR 50-150 per household per year [Zahariadis T, 2017].

However, this tax has not been implemented yet for three main reasons. The stated reason for these postponements was the concern that the tax would worsen the bad financial situation of local authorities – implying that local authorities would have to pay for the landfill tax but would not be able to pass the extra costs through to their citizens. An increase in the cost of official waste disposal might also lead to a rise in illegal dumping of waste, thereby causing failure to achieve both environmental and revenue-raising objectives.

The second reason, is that, no legal municipal waste landfill can accept CDW waste, since none of the 6-digits codes of Chapter 17 of EWC are included in the environmental permit of those sites. On the other hand, there are no inert waste landfills licensed in Greek Territory. Consequently, there is no alternative option for CDW management and waste should be driven to RUs or temporary stored.

The third reason is the non-operation of solid waste treatment plants, especially excavation and demolition products.

3.6.4 Quarries as CDW Treatment Sites/Quarries Restoration

According to the philosophy of the national waste and CDW legislation, quarries should play an important role in CDW management since:

- They considered “ideal” sites for the installation of Recycling Units
- Especially public inactive quarries that have not been restored, they should exploit the inert residues of the Recycling Units and other ECDW for reclamation/restoration purposes.

In fact, the responsibility for the restoration of spent or inert public quarries lies on the PROs (Law 4030/2011, Article 40 as amended by Law 4280/2014, Article 5), with the condition that they have HRA’s approval. In practice, PROs are submitting an amended BPL to HRA, including the provisions for quarries restoration. The PRO should conduct all the studies required by law (study of morphological and vegetative restoration and environmental impact assessment study) and proceed to quarry restoration, after signing a contract with the relevant Decentralized Administration, utilizing CDW or CDW treatment residues.

For the above Laws, in order to be implemented, there was a demand of a Ministerial Decision (MD) (normative action) to be adopted, which will determine the terms and other details of the concession agreement and the contract between Decentralized Administration and a PRO. That MD has not been adopted yet, but Law 4685/2020 (Article 89, par.7) seems to render its adoption optional. Nevertheless, more details must be provided on this matter, for example the structure and the provisions of the contract between the Public and the PRO. At any case, any exploitation of the CDW and/or treatment residues has been significantly delayed.

Quarries, in most cases, are developing in forest areas, as those defined in the respective Forest Legislation (**Law 998/79 and Law 4512/2018, Article55, par 5)**. Nevertheless, according to the same legislation a spent or inert quarry, public or private, **is declared as a re-forestated area** and specific provisions are implemented which are different from those in force for forest areas. For example, almost all activities are forbidden within re-forestated areas, including recycling activities. Obviously, that may cause significant licensing problems to CDW Recycling, since Law 4280/2014 is only referred to forest areas in which such RUs can be installed.

Finally, there are incomplete or absent records on inactive or spent mines and quarries which could serve as location for CDW treatment sites.

3.6.5 Law Enforcement

Specific problems related to law enforcement and legal provisions are currently revealed with respect to CDW management. Most important of them are summarized below:

- Human resources allocated to waste law enforcement are not considered sufficient
- There are ineffective controls and critical deficiencies in law enforcement
- No or little corrective action is taken in identified cases of non-compliance with legislation and sanctions are rarely applied.
- No fines are administered in cases of non-compliance concerning CDW management
- Pre-demolition audits are not compulsory
- Containers situated in public places are not properly supervised for the insertion of non-CDW (e.g. municipal or hazardous waste)

For monitoring and enforcement of the waste legislation in Greece, YPEN maintains a special unit of Environmental Inspectors with the mission of conducting inspections and determine whether

compliance with the environmental terms in projects and activities of public and private sectors across the country is respected [YPEN, 2020, Deloite, 2015]. Measures to ensure compliance with existing waste legislation include administrative sanctions as well as fines. Furthermore, on top of administrative sanctions, the infringement case files are sent to competent prosecutors for investigation of criminal offense.

However, the special unit of Environmental Inspectors is understaffed and the current workforce comprising the unit is not sufficient for the effective control of environmental violations throughout the territory of Greece. Compliance with waste legislation is only a part of the duties of the inspectors, as they have to cover and monitor the entire environmental legislation package existing in Greece at the moment.

3.7 End of Waste (EoW) Criteria

Achieving End of Waste is the accepted way to turn a waste into a product. The revised (by 2018/851/2018) WFD establishes certain conditions that have to be complied with the end-of-waste requirements. A given waste may only cease to be a waste if:

- The substance or object is to be used for specific purposes;
- A market or demand exists for such a substance or object;
- The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products
- The use of the substance or object will not lead to overall adverse environmental or human health impacts.

The use of waste in replacement of primary materials, in particular if used by final consumers, is often prevented by the waste status of the material [JRC, 2009, DMoITE, 2017]. Waste is associated with discarding and users may fear to use waste instead of primary materials with a predicted quality. End-of waste may help to alleviate any user prejudice, to increase the confidence of the users on quality standards and to encourage the use of secondary materials.

For certain wastes such as CDW, end-of-waste criteria can promote the production of higher quality secondary products by defining technical and environmental minimum requirements to be fulfilled by the materials. Information on the product characteristics facilitates their comparison and may enhance the final quality of the final product leading to an increase in their demand and a positive on the recycling rates.

The conditions set out in the WFD, the rationale for the establishment of end-of-waste criteria and the detailed data collected are the basis for the elaboration of the operational end-of-waste criteria through a number of steps. The main target of the criteria is to ensure the fulfilment of product quality requirements; however, in some cases it may prove to be more effective in technical and economic terms to define requirements on the quality of the source materials or on the treatment process, or both. The end-of-waste criteria may be defined at one or more stages of the recovery chain.

There are only 4 MS which have national legislation or protocols to turn inert waste into a recycled product, namely Netherlands, Austria, United Kingdom and France. Requirements in those criteria are divided to the following categories [DMoITE, 2017]:

- Input material: Only specific EWC codes can be accepted (e.g. 17 01 01, 17 01 02 etc.)
- Production control: Depending on the use (e.g. aggregates for concrete), relative production standards must be fulfilled and the product must not require further processing (e.g. size reduction)
- Product quality: Includes tests according to existing standards (e.g. EN), leaching tests (e.g. according to EN 12457-4 L/S = 10g/L) and composition tests (e.g. asbestos should be absent, plaster should be < 1% etc.)
- Quality Assurance

Nevertheless, several, mainly administrative, barriers should be overcome. For example, when EoW status is achieved, the material may need REACH registration (depending on the type of recovered material), i.e. another administrative and costly burden is added.

In general, the need of harmonized EoW regulations in all MS is required to stimulate the European market of recycled CDW and thus support the Circular Economy principles.

3.8 Proposed Drivers

3.8.1 Financial Incentives

A powerful driver for higher utilisation of CDW is the financial incentives through taxes and charges which redirect large amounts of CDW away from unauthorized landfills and enable the recovery and recycling of most of the materials found in CDW. The same effect can be achieved by implementing landfill bans for several CDW fractions. Financial incentives or bans must be coupled with good enforcement to ensure CDW is managed legally.

Another financial incentive in the direction of using more recycled aggregates could be the reduction or elimination on VAT for recycled materials, with a simultaneous taxation and/or levy of the natural (virgin) materials. For example, in some Member States, including Belgium and the Netherlands, the use of concrete aggregate is made an economically attractive option through government measures including fees and taxes on virgin materials.

GPP (Green Public Procurement) through the introduction of mandatory percentages of recycled aggregates, at least in large civil engineering projects, will also be a critical driver for the higher utilization of secondary materials. Under the **European Green Deal**, the Commission will consider legal requirements to boost the market of secondary raw materials with mandatory recycled content for new construction materials.

3.8.2 Quality Demands

In order to render secondary materials as an attractive option for the market, the quality of the CDW collected and transferred to the Recycling Units should be improved. In this direction, the following measures are proposed, through modification of the legal framework:

- Sorting on site should be compulsory, at least for large scale projects: improved separation of materials reveals a strong trend for higher levels of recovery compared to a status with high levels of mixed waste. Source separation is more likely to occur where there are legal requirements, such as selective demolition. As a financial incentive for promoting sorting, could be the increase, as much as possible, of the fee for mixed waste (code 17 09 04).

Nevertheless, that increase should be made with caution and backed-up with efficient law enforcement, since high fees on mixed waste may increase illegal dumping or landfilling practices.

- The surveillance and protective measures for the containers, especially those situated in public places, should be a clear responsibility of the Contractor. Inspections should be made, by TPAs and other Competent Authorities and fines imposed to those Contractors that are not sufficiently supervising their containers. Except from quality issues, poor supervision can pose significant threats to human health, since, in many cases, hazardous and municipal waste are dumped in CDW containers and they have to be manually separated when they enter a Recycling Unit
- For further promotion of surveillance and also for the reassurance of waste traceability, during transportation of CDW from the construction site to the RU, containers should be obliged to have barcodes and tracks should possess a GPS system, so as to know where the waste are at all times [AANEL, 2020]
- Pre-demolition audits should be compulsory along with WMPs. Additionally, the Competent Authority should possess the appropriate background in order to evaluate those audits. It is proposed that Regional Environmental Authorities should evaluate and approve both pre-demolition audits and WMPs. The approval will then be submitted as a part of the Town Planning Licence.
- Especially for demolition processes, selective demolition and post-demolition reporting should be compulsory. The procedure should be described in detail within the pre-demolition audit/Waste Audit and approved by the Competent Authorities.

3.8.3 Quarries

The adoption of the MD needed for permitting PROs to restore inactive or spent public quarries, seems to be non-compulsory, under the provisions of Law 4685/2020 (amending Law 4030/2011 and Law 4280/2014). Significant quantities of CDW or treatment residues can be diverted for purposes of environmental restoration. Since un-restored quarries are an “open wound” to the general environment, their restoration by utilizing waste will have a double value. Nevertheless, there is no precedent for the particular process and the contradicting quarries/CDW/forest legislations may pose significant obstacles. It is necessary that, especially PROs and the Decentralized Authorities to be reinforced with specialized personnel (engineers, advocates and environmental specialists).

PROs in co-operation with YPEN and HRA should take initiative of creating a data base for all spent or inert quarries (public and private) in their geographical region and prioritize restoration process among them. On the other hand, PROs should accelerate the environmental licencing procedure by conducting the appropriate studies.

Finally, there should be a clarification for the inclusion of quarries’ areas declared re-forestated, to the provisions of Law 4030/2011, as amended by Law 4280/2014 and Law 4685/2020, referred to the installation of Recycling Units and quarries restoration.

3.8.4 PROs

It is of utmost importance that PROs should cover the totality of the Greek Territory. A national target should be set, probably within the revised NWMP, for expansion of PROs jurisdiction to the 100% of Greek Territory within the next 2 years.

PROs do not have a common method of CDW data gathering and reporting. Each PRO has different method of Categorization of CDW in group of waste codes (each of this group represents a specific waste steam e.g. EW, Demolition Waste etc.) and in categories and sub-categories. For example, EW can be divided, according to their origin and quality, to 3 or 4 different sub-categories, with different fee for each sub-category, from PRO1, while PRO2 may accept EW on a single sub-category.

The categorization of CDW in streams, categories or even subcategories is different for each PRO as it was analyzed in Chapter 2. Except form creating problems to data reporting, there is a totally different fee between PROs for the same waste stream (e.g. EW), thus creating great confusion and skepticism to the Waste Holders. The categorization should take place on a central level by HRA and YPEN and should be common for all PROs, so as the Waste Holders may compare fees for each waste stream they have to manage.

The BPL of many PROs should be rationalized, mainly with respect to the operation of the RUs. It seems to be a great margin for profit according to the BPLs, allowing RUs not only to over-cover their operating costs through fees, but also have profit through sailing secondary materials. A RU is collecting 75-80% of the fee for a specific waste code. Since the profit of an RU is over-covered from the fee, their motivation for recycling is lowered.

To ensure a cross-check of the CDW data, the method of dividing the process of CDW data collection and evaluation between different national organizations closely cooperating, may work (e.g. DWR, HRA and ELSTAT). These kinds of collaborations also showed in some Member States that each actor thoroughly achieve its task.

In order to ensure a statistical control (quality checks) and correction of the data external controlling organizations (e.g. as it happens in Germany) or experts from ELSTAT (e.g. as it happens in Czech Republic and Denmark) should perform manual checks and/or automatic checks.

DWR can also play a key role to appropriate data gathering and reporting, since Waste Producers, Recycling Plants and CDW Transporters are obliged to submit annual reports for the amounts and the categories of CDW managed. If properly exploited, through a legislative instrument, DWR may provide a valuable source of CDW data collection.

3.8.5 Public Works

The issue of EW management is particularly complex and difficult to resolve at this stage due to the following reasons:

- It is considered difficult and unrealistic for PROs to handle such large amounts of excavation at this time, given the lack of proper reception areas.
- The cost of alternative management and especially the fees are not incorporated to the Invoices of Public Works. Any EW management through PROs will over-charge the project's budget
- The EW could be channelled through the PROs to specific uses such as the restoration of quarries, without requiring their collection and transfer from the project to any reception area. However, this is not immediately applicable, as explained in the par. 3.8.3 for quarries
- In any case, it is more than questionable, that EW (codes 17 05 04) may be calculated to the national RRR target, as it was thoroughly presented in par. 3.4.

- The cost of entering the excavation waste in Alternative Management Systems results from the approval of their Business Plans, but it has a wide range of variations from one System to another, making it impossible to approach the corresponding cost unless first achieved by horizontal tackles by Competent Ministries (Environment & Infrastructure).

For all the above reasons, it is not suggested, for the time being, that EW should be managed through PROs. Nevertheless, reporting for all the surplus materials should be conducted and submitted to the Competent Authorities (Decentralized Administration, HRA).

3.8.6 Law Enforcement

For improving the effectiveness and the consistency of law enforcement, the following measures are proposed:

- YPEN in cooperation with HRA should identify and set minimum resourcing levels needed to adequately enforce CDW related legislation
- The Unit of Environmental Inspectors should be significantly strengthened and staffed with specialized personnel focusing on law violations regarding CDW legislation (e.g. illegal dumping).
- Ensure all CDW hazardous waste is correctly identified and managed
- Close co-ordination of DWR with HRA for cross-checking annual waste reports referred to CDW. In general, the role of DWR should be upgraded with legislative intervention, especially with regard to the intersection of data reported from different CDW managers (collectors/transporters, producers, recycling units)

4. Best Practices for C&D in work site

4.1 General

There are 3 main categories of Works (both Public and Private) that may lead to the production of ECDW:

- Private Works: Demolitions/Additions/Reforms/Renovations
- Private Works: Constructions
- Public Works: road, railroad, airport, port etc. construction as long as renovation and demolition activities

It is noted that, for the excavation waste resulting from public works, there is no obligation to manage them through PROs. However, it is estimated that some of those waste, especially in the Attica Region, will be managed through PROs and therefore should be taken into account when describing Best Practices.

Best Practices will be examined in the context of the aforementioned categorization and each category may be divided in 2 distinct phases

- Design Phase
- Execution Phase

For the purpose of the current assignment, Best Practices (BPs) will be described for every category of Work, differentiating between the 2 Phases.

It is very important to note that, most best practices will only be successful if the legal requirements for correct and safe CDW management are complied with for most/all related activities. Many MS, including Greece, possess insufficient resources to enforce existing legislation properly. The situation has worsened due to public funding cuts/ austerity measures during the current decade. However, this is possibly the worst time to cut back on enforcement, when the temptation to reduce costs through non-compliance could be higher than in better economic times.

4.2 Stakeholders involved

The C&D activities and the subsequent implementation of BPs require the direct involvement of the following stakeholders:

1. The property owner is responsible for appointing an auditor to draw up a waste audit for the identification and classification of waste as well as preliminary planning of its handling;
2. The authority issues demolition or renovation permits (TPA in Greece) and should establish mechanisms to ascertain (directly or with the intervention of third parties) that waste audits are performed including a quality check system and their recommendations followed;
3. The Auditor or Auditor team as an expert responsible for the conducting a WMP and a WA.
4. The Contracting Entity is responsible for demolition/deconstruction/renovation operations defined in the contract with the owner. The contractor should contribute to the traceability aspects of waste.

5. The waste manager is responsible for the appropriate management and disposal of the waste received from the waste holder or producer. The waste manager should also contribute to the traceability aspects of waste
6. The products manufacturer that may contribute to the waste audit providing solutions and/or requirements for the reused/recycled materials and components
7. The PROs operating and organizing the alternative management of CDW

4.3 Waste Audits (WAs)

As a general Best Practice, regardless the type of work, a detailed and comprehensive Waste Audit should be conducted. A very detailed and comprehensive guideline for WAs has been issued in 2018 by EU [EU, 2018], while the Nordic Council of Ministers has also produced a satisfactory guide [Wahlström et al, 2019]. A complete WA should constitute of the following parts:

1. Desk study
2. Field Survey
3. Inventory of Materials
4. Waste Management Recommendations
5. Report

The auditor or Auditor team is an expert responsible for the conducting a WMP and a WA. The auditor must be a qualified expert with appropriate knowledge of current and historical building materials (including hazardous materials), current and historical building techniques and building history and familiar with demolition techniques, waste treatment and processing as well as with (local) markets.

4.3.1 Desk Study

The desk study aims to gather all the relevant information from the documentation of the building or other work. It is of great importance to collect at least:

- The age of the building or infrastructure - information about the history of the building and the type of materials and construction techniques to expect.
- The design documents - architectural plans and technical drawings contain information that is useful for planning the field survey and drawing up a waste inventory.
- The documentation of use - in particular the history of maintenance and renovations is essential as the materials may be different from the year of the first building completion. Descriptions of production activities and exploitation permits are a useful source for information on storage and use of hazardous products (that may have contaminated other materials).
- A list of dangerous substances - the auditor will have to take relevant measures to ascertain that health and safety issues are covered when performing the site visit.
- The surroundings and accesses - the knowledge of the environments is essential to plan the best strategy to perform sound waste management.
- The local facilities – knowing where to find a local salvage yard

At this stage, the auditor should collect as much information as possible to plan the site visit correctly. Based on the study of all documentation, a first draft of possible materials and uncertainties will have to be checked during the site visit (see below). The information can be

complemented by computer models or IT solutions or other tools developed by the auditors themselves.

4.3.2 Field Survey

The Field Survey consists of visual inspections, comparisons of findings with collected documents, planning of inspections and measurements, preliminary planning of deconstruction techniques and waste handling on site as well as communication between actors engaged by the owner to the process. A good and efficient approach consists of 4 parts:

- Site visit and general analysis of the building bearing in mind the findings of the desk study evaluating the consistency of the design and other documents
- Identification of materials present and collection the necessary information to quantify and localize them in the building.
- The different parts (e.g. rooms) are inventoried in detail (floor coverings, lighting units, interior walls, false ceilings, etc.)
- Sample taking and analysis (chemical, mechanical) for those materials that cannot be visually identified.

The site visit should implement non-destructive or destructive techniques in order to correctly assess the whole range of materials. The destructive techniques may include opening of false ceilings and walls, opening of technical shafts etc. Since it is highly probable that destructive techniques should be required, the field survey is best carried out when the building is no longer in use.

If the desk-based study suggests the existence of hazardous substances at the site, protocols to work with hazardous substances should be established and worker protection measures applied during the site visit, mainly during destructive stages. The site visit should allow the auditor to complete the information collected during the desk-based study and take any sample required to perform the materials assessment.

It is the duty of the waste holder to gain knowledge about the objects and substances intended to be discarded and their potentially hazardous nature and contamination. The inventory of the materials and building elements is therefore the basic output of the waste audit arranged by the waste holder (usually the owner of the building or infrastructure) and performed by the auditor. The inventory is typically based on the materials assessment provided by the desk study and/or the field survey.

4.3.3 Inventory of Materials

The minimum set of data to be included under this section should be a summary of the information shown above for the whole building. The information about constructive and non-constructive elements (such as pillars, beams, walls, slabs, etc. and also furniture, lightning, electronics, paper, etc.) and corresponding materials should also be organized to provide not only the total amount of waste, but also the total amount of the different types of materials. Even if this set of data is considered as the minimum for a full materials assessment, to take advantage of waste audits' full potential it is recommended to:

- Separate the source of waste by the different levels of the building
- Consider the feasibility of separation

- Include photographs showing details to make the report easier to read.

Materials assessment should be completed considering the ease of recovery of these materials. This makes it very important to estimate if the waste will be technically and economically separable, to decide which different types of outlets should be proposed during the waste management planning stage of the waste audit.

All the information given above should be complemented with photographs to ease the work of the contractor when performing the construction, demolition or refurbishment activities. Photographs should be clear, and explicitly show the information they are intended to provide. (It is good practice to note on the photographs the location of the detail shown)

The materials assessment should include:

- The type of material to be classified as inert waste, non-inert, non-hazardous waste or hazardous waste, detailing the EWC code and description (since EWC codes do not provide enough information).
- Quantification in tones, cubic meters and/or other relevant units of measurement.
- An inventory of elements recommended for deconstruction and reuse.
- The location of the waste materials and elements in the building, in order to maximize the efficiency and safety of demolition or renovation.
- The quality of the material to assess the impurities that could be present. The fewer impurities in the waste fraction, the higher the value it may possess.
- Materials reusability potential depending on the nature of the material and material conditions.

4.3.4 Waste Management Recommendations

The waste audit can be completed with recommendations on how to perform waste management on site. The issues to be considered may include the following:

- Recommendations on the safe removal of hazardous waste
- Recommendations regarding possible health and safety precautions to take during the deconstruction phase or the waste management phase.
- Identification of potential waste diversion of certain identified waste streams (reuse, recycling, backfilling, energy recovery and elimination) and estimation of the diversion rates. Different alternatives can be provided for each materials group or waste streams.
- Identification of (economically or environmentally) beneficial on-site sorting activities that may include the description of the installation requirements for storage, handling, separation and for any other operation to manage the different waste streams.

4.4 BPs for C&D - Design Phase

The Design phase should be described in detail within the context of (a) a Waste Audit (b) a Waste Management Plan. As it was mentioned before, the conduction of a detailed WA is essential for to get insight into the nature, quantity and any contamination of the extracted materials. During the Design Phase of a demolition/renovation project, the following BPs may be proposed:

- Collect detail information about the history of the building, the type of materials and construction techniques to expect.

- Collect design documents such as architectural plans and technical drawings that contain information that is useful for drawing up a waste inventory
- Collect information upon history of maintenance and renovations. Descriptions of production activities and exploitation permits are a useful source for information e.g. on storage and use of hazardous products
- Collect information about the surroundings and accesses with emphasis to local CDW facilities
- Perform a chemical analysis of samples to confirm the identification of the materials if there is a significant uncertainty on their quality
    - Percentage composition of materials/substances
    - Mixing ratio
    - Harmful substances (i.e. those that may negatively affect mechanical properties)
    - Hazardous substances
- Perform mechanical testing to study properties of the materials in order to consider their reusability:
    - Size distribution
    - Resistance to cooling
    - Hardness
    - Compression level
- Detect those construction units that can support reusable materials from the construction site itself.
- Use non-destructive testing performed on site to contribute to a better identification of materials and/or to find hidden materials.
- Finding a space in work site for the proper collection of generated CDW, which allows to guarantee the characteristics of the CDW until the moment of its use, avoiding their contamination by hazardous waste.

If the Audit suggests the existence of hazardous substances at the site, protocols to work with hazardous substances should be established and worker protection measures applied during the site visit and the execution phase, mainly during destructive stages. The site visit should allow the auditor to complete the information collected during the desk-based study and take any sample required to perform the materials assessment.

4.5 BPs for C&D - Execution Phase

Execution phase can also be described, to an extent, within the WA and the WMP. Nevertheless, in practice, several working parameters maybe altered and both the Contractor and the Waste Manager should adapt accordingly.

4.5.1 Selective Demolition Process

The implementation of a Selective Demolition (SD) process is fundamental for almost every BP, since it may contribute to the best possible quality of the CDW collected, while it is also very important concerning effective hazardous waste removal.

Selective demolition comprises a series of sub-activities, as presented in Table 4.1.

Table 4.1: Sub-activities of Selective Demolition Process [Silva et al, 2016]

No	Sub-activity	Materials	Remarks
1	Selective removal of accessible materials with high marketable value	Valuable architectural materials, stained glass, decorative carved doors and wall paneling, decorative wrought iron and tiles, double glazed glass window and door units, electrical fittings, metals	Without proper management, the materials may be stolen or even sent to a landfill
2	Selective removal of accessible materials, which, if not removed, will cause CDW to be considered as hazardous	Asbestos and other hazardous materials.	This will reduce the amount of CDW that has to be treated as hazardous
3	Selective removal of materials, which, if not re-moved, will lower the value of the remaining CDW when crushed	Wood, plastic, glass, gypsum plaster	This will raise the value of the CDW-derived aggregates subsequently produced
4	Chemical treatment in situ of exposed building parts, contaminated during the building's life cycle, followed by removal	Surface materials (roofing, walls, floors) that have been subjected to chemical alteration/contamination	This is a relatively new concept/activity. It is only likely to be appropriate in the case of industrial structures

Focusing on specific works in the context of a selective demolition process the following steps are included [Saez et al, 2019]:

- Removing decorative elements.
- Dismantling neatly carpentry, sanitary equipment
- Uninstalling heating networks, plumbing, electricity, etc.
- Dismantling exterior elements, false ceilings and recoverable coatings.
- Dismantling roofs, covers and interior divisions.
- Demolishing the structure in a controlled manner.

Following the aforementioned general steps will ensure that the resulting CDW will largely consist of inert materials, predominantly concrete, mortar, bricks, ceramic materials and gypsum. If these are not necessary on-site for filling or landscaping (thus avoiding transportation of NA or clean soil), then they can be trans-ported to a recycling facility, where they are upgraded for use in other applications, the effectiveness of which also depends on the sorting success during construction and demolition operations. Assuming that all directly reusable components are separated and the remaining is subjected to categorization by type of material, resulting CDW are more likely to contain fewer contaminants. Thereafter, upon processing in certified recycling facilities, there is a greater chance of producing high-quality RA.

4.5.2 Factors affecting materials recovery

The extent to which materials may be recovered effectively in the demolition process depends on a range of factors, including the following:

1. Safety, which may increase project costs
2. Time. Selective demolition needs more time than traditional demolition, so higher costs are expected. Optimal solutions regarding potential recyclability and re-use should be considered.

3. Economic feasibility and market acceptance. The cost of removing an element (e.g. a roof tile) should be compensated for by its price, while, at the same time, the re-used element should be competitive and accepted by future users. For some materials, e.g. iron/metal/scrap, market prices fluctuate strongly depending also on seasonality.
4. Space. When there is a space limitation on a site, separation of materials collected should take place in a sorting facility. Space limits specifically require good planning.
5. Location. The number of recycling facilities in the surroundings of the project site or the local supply waste management services may limit the potential recovery of materials from a deconstruction project.
6. Weather. Some techniques may be dependent on certain weather conditions that may not coincide with project timing.

The advantages, both economic and environmental, of using RA as an alternative to NA are greatly affected by transportation [Bravo et al, 2015, Silva et al, 2016a]. Owing to the potentially great distances between demolition sites to the nearest CDW recycling plant, haulage distances may significantly increase the cost and ecologic footprint of RA. As a result, the attractiveness of using RA to manufacturers and contractors will greatly decrease. Still, depending on the sites' raw material availability and their target construction application, mobile recycling plants are, in many cases, preferred to stationary ones thereby practically eliminating haulage operations by road.

However, the potential of acquiring the permits for establishing a mobile recycling plant on site, should be carefully examined. Especially for works taking place within a municipal area, permits cannot be given so easily

4.5.3 Other BPs

Other BPs during the execution phase of a Demolition/Renovation Project may include [Silva et al, 2016a, b, Giorgi et al, 2018, Saez et al, 2019]:

- Focusing on quality rather than quantity: value the best material to be recycled in terms of effectiveness and sustainability, not heavier ones; through the separation of recycling targets (percentage well-defined for every type of waste material) related to the quality target;
- Estimating the mass and volume of waste to be generated, as well as the type and quantity of containers required.
- Planning the number of containers and size required in each activity. For this, the use of tools to estimate the amount of waste that will be generated (within the context of the pre-demolition audit and the WMP) during the process are recommended.
- Recording the date of withdrawal, the quantities and characteristics of the waste that leaves the work site to obtain data of CDW generation, as a result of a specific demolition/renovation process.
- Performing periodic controls on the use of CDW containers to avoid that different categories of CDW are placed in the wrong container.
- Following the plans of the project and the recommendation made in WA so as not to perform any more unexpected works and thus produce more CDW.
- Performing on-site segregation of each waste category. The segregation of waste results in higher purity waste, with greater possibility for its recovery and cheaper management costs (through PROs).

- Establishing a container for each type of CDW and respect its use.
- Distributing small containers in the working areas to facilitate the segregation of the different types of waste (per 6 digit-code if possible).
- Following the manufacturer's instructions in the collection of materials. Bad practices in the handling of materials in the works are causing a loss of approximately 15% of the raw materials, increasing the amount of construction waste to be managed.
- Organizing talks and training for the operators in the subject of waste management to achieve a correct management of the waste on site.
- Training and informing all personnel of the correct labelling of containers and their responsibilities in the field of waste.
- Planning CDW coordination and review meetings to ensure that measures are being taken for proper management of CDW.
- Hiring authorized and properly licensed companies for the management of waste. Under Greek legislation, the validity of a contract between a waste manager and PRO is mandatory
- Creating documents that collect instructions regarding the different processes that generate waste to ensure that each task is well defined.
- Use of machinery for the management of CDW (crushers and compactors), if that process can be licensed within the specific work site.

4.5.4 Hazardous substances/waste removal

The WA should result in an organized list of hazardous materials, detailing what materials are present and where they may be found.

A List of C&D materials that need to be removed from the building before demolition according to the Austrian Standard ÖNORM B3151 (2014) include:

- Loose artificial mineral fiber (if hazardous);
- Components or parts containing mineral oil (such as an oil tank);
- Smoke detectors with radioactive components;
- Industrial smoke stacks (e.g. fireclay boxes, bricks or lining);
- Insulating material made up of components containing Chlorofluorocarbon ((H)CFC) (like sandwich elements);
- Slags (for ex., slags in inserted ceilings);
- Oil-contaminated or otherwise contaminated soils;
- Fire debris or otherwise contaminated debris;
- Isolations containing polychlorinated biphenyl (PCB);
- Electrical properties or equipment with pollutants (for ex., vapor discharge lamps containing mercury, fluorescent tubes, energy-efficient lamps, capacitors containing PCB, other electrical equipment containing PCB, cables containing insulation liquids);
- Cooling liquid and insulations from cooling devices or air-conditioning units containing Chlorofluorocarbon ((H)CFC);
- Materials containing polycyclic aromatic hydrocarbon (PAH) (like tar bitumen, tar board, cork block, slags)
- Components containing or impregnated with salt, oil, tar, phenol (e.g. impregnated wood, cardboard, railway sleepers, masts);

- Material containing asbestos (for ex., asbestos cement, sprayed asbestos, night storage heaters, asbestos flooring);
- Other hazardous materials, depending on the use of the site/building

Especially for managing **asbestos**, there is a sufficient regulatory framework in Greece. Some of the key legislative acts, including removal and handling of asbestos contaminated material are summarized below:

- **JMD 4229/395/2013 (GGD 318/B`/15.2.2013): "***Requirements for the establishment and operation of enterprises carrying out demolition and asbestos removal works and/or materials containing asbestos from buildings, structures, facilities and vessels, as well as maintenance, coating and encapsulation of asbestos and/or materials containing asbestos"*. The conduction of demolition or asbestos removal works can be carried out only by enterprises that have permit issued by the Ministry of Labor, Social Security and Welfare.
- **Circular 5885/557/4-3-2013: "***Adoption of the JMD 4229/395/15-2-2013 concerning the determination of the legal conditions for the establishment and operation of enterprises dealing with asbestos management works"*. Interpretation of the above JMD
- **PD 212/2006 (GGD 212A'/ 09-10-2006)**: "*Protection of workers exposed to asbestos at work, in compliance with Directive 83/477/EU as amended by Directive 91/382/EU and Directive 2003/18/EU of the European Parliament and Council"*. Bans the use of asbestos as a material in any new application by any method and activities which involve the use of insulating or soundproofing materials containing asbestos, but their density is less than 1g/cm^3. Prohibits any activities which expose workers to asbestos fibers during the mining/extraction of asbestos or the manufacture and processing of asbestos products or the manufacturing and processing of products containing asbestos by voluntary addition

C&D Materials representing or containing impurities:

- Stationery machinery (building services, electrical devices)
- Floor construction and double floor constructions
- Non-mineral flooring and wallcovering (except wallpaper)
- Suspended ceilings
- Non-plastered synthetic installations
- Facade constructions (glass front, thermal insulation composite systems)
- Sealings (e.g. roofing cardboard)
- Building materials containing gypsum
- Partition walls from cork, porous concrete, cement-bounded wood, wood, plastics
- Glass, glass walls, glass bricks
- Loose mineral rock wool, glass wool or other insulating material
- Doors and windows
- Plants and soil

Schemes such as Recovinyl (See BPs Annex 8) are good approaches to removing specific materials from the construction and demolition activities in a controlled and selective manner. Extending this approach to more product streams could be an effective way to ensure materials separation as a priority.

4.6 BPs for Construction - Design Phase

4.6.1 Life Cycle Assessment approach

The Design phase for a Construction Process should include a **Life Cycle Assessment Study (LCA)** along with a **Waste Management Plan (WMP)**. To achieve a sustainable recycling management during a construction process, it is important to consider material recycling with the approach of **Life Cycle Management**, as an integrated approach, based on technology and process defined considering LCA results. This approach can be useful to support the waste hierarchy of WFD, to make a decision about the best way to reuse, recycle or dispose waste materials. Obviously, prevention is often the best possible solution for the environment avoiding the replacement and prolonging the service life of components.

A life cycle approach is important to move towards an upcycling of waste, to improve the economy and creating an effective sustainable market. The primary effort therefore should be to engage in waste prevention and reduce the amount of waste generated in the first place i.e. minimize the resources needed to do the job. Prevention is financially advantageous as it reduces the purchase of construction materials and obviates the need to remove wastes from site. It is important to emphasize the potential for certain purchasing procedures to contribute to a reduction in excessive material wastage on site.

4.6.2 Designing Out Waste

Preventive design (or designing out waste) consists of minimizing waste at every stage of the life cycle of a building construction during its design. The identification of opportunities for waste prevention during design activities and the implementation during its construction or use are considered BPs [JRC, 2018]. The most common preventive measures would consist of the use of prefabricated elements, modern methods of construction, rental and reuse of auxiliaries (e.g. scaffolds, formworks), reduced requirement of cuttings through smart design, etc.

4.6.3 Design for deconstruction

Design for deconstruction is a technique that considers the implementation of key design features for the easy disassembly of construction elements and the planning for possible reuse of construction elements [JRC, 2018]. Some key concepts are followed in the implementation of this BP:

- Transparency - all elements are visible
- Regularity - same materials are used for the same applications
- Simplicity
- Limited number of materials and components and easy-to-separate materials.
- Design the building based on the dry assembly of materials to facilitate the deconstruction and segregation at the end of their useful life

4.7 BPs for Construction - Execution Phase

The BPs for the execution phase of a construction project are focusing on Waste prevention and management and Material use efficiency. In this context, the following BPs are recommended: [Lean Business Ireland, 2016, GIZ 2017a, GIZ 2017b, EU, 2016, JRC, 2018]:

- Ensuring materials are ordered on an "as needed" basis to prevent over supply to site

- Purchasing coverings, panelling or other materials in shape, dimensions and form that minimizes the creation of excessive scrap waste on site
- Ensuring correct storage and handling of construction materials to minimize generation of damaged materials/waste e.g. keeping deliveries packaged until they are ready to be used
- Ensuring correct sequencing of operations
- Assigning individual responsibility (through appropriate contractual arrangements) to sub-contractors for the purchase of raw materials and for the management of wastes arising from their activities, thereby ensuring that available resources are not expended in an extravagant manner at the expense of the main contractor.
- Use prefabricated systems that hardly generate waste and avoid the generation of waste by cutting and transforming elements on site.
- Provide space for collecting and storing CDW
- Estimate the mass and volume of waste to be generated, as well as the type and quantity of containers required.
- Hire authorized companies for the management of waste.
- Purchase of bulk materials to reduce packaging and generate less waste.
- Buy materials that avoid unnecessary wrapping.
- Hire suppliers who manage the waste of their products and/or having some type of environmental certificate.
- Maximum use of materials and products, using mixing systems with mechanical dosing.
- Manage the reception and collection on the work of the products according to the needs of use in each moment to avoid the generation of waste of damaged/expired material.
- Observe the manufacturer's instructions regarding the transportation, collection, and commissioning of materials to avoid breakage.
- Establish a container for each type of CDW and respect its use.
- Use small containers in work areas.
- Train and informing all personnel of the correct labelling of containers and their responsibilities in the field of waste.
- Use of machinery for the management of CDW (crushers and compactors).
- Record the date of withdrawal, quantities and characteristics of the waste.
- Create documents that collect instructions regarding the different processes that generate waste to ensure that each task is well defined.

4.8 BPs for Public Works/EW

The BPs presented above for C&D Projects may also implemented for the respective Public ones. On the other hand, the waste stream that is produced in large quantities during Public Works and needs the identification of different good practices is the excavation waste (EW), often referred as "surplus materials".

Prior to any work that may lead to the production of excavation materials/waste, a detail audit should be performed for the calculation of the quantities that are about to be produced. According to the Greek Environmental Law (4011/2011 as amended by Law 4685/2020) especially for large scale Public Works, those calculations are a discrete part of the Environmental Impact Assessment Study and the subsequent Environmental Permit, while, in case of backfilling operations, a Technical Environmental Assessment (TEA) should be submitted and approved,

describing in detail quantities of materials backfilled along with the proposed backfilling method and purpose.

In almost all cases, there is a significant quantity of materials that cannot be reused, at least within a short term, and thus must be treated as excavation waste (EW). The legislative framework of EW produced by Public Works has been analyzed elsewhere (Chapter 3). Hereinafter, some good practices will be deployed for purposes of the sound management of EW derived from PWs. Note

- Prepare a WA and a WMP, especially if no environmental permit is required
- Follow the plans of the project and the recommendation made in WA so as not to perform any more unexpected works and thus produce more EW.
- Determine total quantity of excavated material.
- Determine characteristics of excavated material. If the work plan foresees excavation in depth > 1m, boreholes should be situated for the collection of specimens necessary
- Determine the different types of excavated materials and assign possible re-use according to specific tests.
- Note, that contamination of materials is not out of the question, especially if works are taking place in a site with a contamination history. In that case, specific tests for hazardous waste should be performed and EW characterized accordingly (e.g. 17 05 03*).
- Determine the quantities that are about to be re-used (according to their characteristics) for:
    - backfilling
    - planting
    - landscaping
- Excavation waste will be considered all the (earth) material that cannot be used for one or more of the above purposes or those that cannot be used within a specific time period.
- EW should be properly characterized, per 6-digit code if possible. All different types of EW should gather in different storage areas or containers within the work site.

Obviously, many of the BPs described for Construction/Demolition may also be implemented for EW, such as:

- Train and informing all personnel of the correct labelling of containers or storage areas and their responsibilities in the field of waste.
- Record the date of withdrawal, quantities and characteristics of the EW.
- Performing periodic controls on the use of EW containers to avoid that different categories of EW are placed in the wrong container. Special attention should be drawn to contaminated EW.
- Create documents that collect instructions regarding the different processes that generate waste to ensure that each task is well defined

5. Cost Benefit Analysis

5.1 Cost Benefit Analysis for selected scenarios

Cost Benefit Analysis (CBA) calculations are performed for the most complex work of demolition, from which the majority of the CDW's quantities are produced. Calculations were performed by considering the demolition of a 130m^2 building (mean area of buildings to be demolished in Greece), from which about 100m^3 or 160t of CDWs are produced. It is considered that the calculations performed are also representative for Construction, Addition and Renovation works, for which the respective management of CDW is considered similar and simpler.

Selective demolition (Deconstruction)

As it was analyzed in Chapter 4, selective demolition requires the gradual dismantling of structural and other elements of the building, with the cost being directly depended on the amount of employed staff and the corresponding working hours. According to the international literature and the field experience of the Consultant, it is estimated that for the demolition of a 130m^2 building, about 85 manhours are required, employing unskilled workers, machine operator and supervisor. Selective demolition cost is formed by:

- the labour cost
- the operating costs of motor equipment

According to relevant literature and the field experience of the Consultant, the costs for selective demolition are illustrated in Table 5.1.

Labor costs are formed as follows a) Unskilled worker 4,5€/h, b) Equipment operator 7,5 €/h, c) Supervisor 8 €/h. Taking into consideration 10% raise for unpredictable, total cost is calculated at **1.000€** approximately or **6,25€/t**.

Motor equipment cost is formed as follows: Operating time = 22,3h X Average diesel consumption 30lt/h X Average diesel price 1,40 €/lt = 936,60 €. Taking into consideration 10% raise for unpredictable, total cost is calculated at **1.030€** approximately or **6,44€/t**.

Total costis calculated at **2.030€** or **12,69€/t**.

Traditional demolition

Traditional demolition is by all means simpler than selective. The separation and sorting of the individual elements takes place not on site but in the processing unit to which the CDWs are channeled. According to the international literature and the field experience of the Consultant, it is estimated that for the traditional demolition of a 130m^2 building, about 5,5manhours are required. On the other hand, the employed human resources and the operation of the motor equipment are limited.

According to relevant literature and the field experience of the Consultant, the costs for selective demolition are illustrated in Table 5.2.

Table 5.1: Costs of Selective demolition (Deconstruction)

	Unskilled worker	Hours	Cost (€)	Equipment operator	Hours	Cost (€)	Supervisor	Hours	Cost (€)	Total Manhours	Total Cost
Plaster removal	4	9,0	162,00	1	1,5	11,25	1	1,5	12,00	12	185,25
Covering wood removal	2	7,2	64,80	1	1,0	7,50	1	1,0	7,50	9,2	80,30
Cork removal	2	2,0	18,00	1	0,2	1,50	1	0,2	1,60	2,4	21,10
Door removal	2	6,0	54,00	1	0,5	3,75	1	0,5	4,00	7,0	61,75
Window removal	3	5,0	67,50	1	0,5	3,75	1	0,5	4,00	6,0	75,25
Ceiling removal	2	2,0	18,00	1	0,3	2,25	1	0,3	2,40	2,6	22,65
Toilet fixtures removal	1	1,0	4,50	1	0,3	2,25				1,3	6,75
Taps removal	1	1,0	4,50							1,0	4,50
Traditional demolition	2	1,0	9,00	1	1,0	7,50	1	1,0	8,00	3,0	24,50
Post separation of elements	3	9,0	121,50	1	9,0	67,50	1	3,0	24,00	21,0	213,00
Cleaning and loading	2	8,0	72,00	2	8,0	120,00	1	3,0	24,00	19,0	216,00
Total		51,2	595,80		22,3	227,25		11,0	88,00	84,5	911,05

Table 5.2: Costs for Traditional demolition

	Unskilled worker	Hours	Cost (€)	Equipment operator	Hours	Cost (€)	Supervisor	Hours	Cost (€)	Total Manhours	Total Cost
Traditional demolition	1	1,5	6,75	1	1,5	11,25	1	1,5	12,00	4,5	30,00
Cleaning and loading	2	4,0	36,00	2	4,0	60,00	1	4,0	32,00	12,0	128,00
Total		5,5	42,75		5,5	71,25		5,5	44,00	16,5	158,00

Labor costs a) Unskilled worker 4,5€/h, b) Equipment operator 7,5€/h, c) Supervisor 8 €/h. Taking into consideration 10% raise for unpredictable, total cost is calculated at 170€ approximately or **1,06€/t**.

Motor equipment cost: Operating time = 5,5 h X Average diesel consumption 30 lt/h X Average diesel price 1,40 €/lt X 2 = 462,00 €. Taking into consideration 10% raise for unpredictable, total cost is calculated at 510€ approximately or **3,19€/t**.

The total cost is calculated at 680€ or **4,25€/t** approximately.

Collection and transportation

An average transport distance (up to the RU) of **20km** will be considered, for both scenarios. According to average market prices, for transporting CDW there is a charge of 0,07 €/tn/km. Consequently, for both scenarios the cost amounts to **224,00 €** (for transporting 160tn of CDW) or **1,40€/t**.

Recycling Unit Costs

Average Treatment costs, according to PROs data, are providing in **Table 5.3**. Obviously, costs are depending on the quality of the CDW input.

For selective demolition we consider the average treatment cost for demolition waste/separated at source, which amounts at **4,25€/t**, i.e. for treating 160t of CDW the total cost will be 4,25€ X 160t = **680€**

For traditional demolition we consider the average treatment cost for demolition waste/not-separated at source, which amounts at **10,50€/t**, i.e. for treating 160t of CDW the total cost will be 4,25€ X 160t = **1.680€**.

Table 5.3: Treatment Costs in the Recycling Unit (source PROs)

Waste stream	Price (€/ton)	Average price (€/ton)
Excavation waste	0,7 – 3,0	1,85
Construction & Demolition waste separated at source	1,5 – 7,0	4,25
Construction & Demolition waste not separated at source	7,0 – 14,0	10,50
Repairand renovation waste	20,0 – 25,0	22,50

Total Costs

1. Selective Demolition: 18,34€/t or 2934€ for managing 160t of CDW

2. Traditional Demolition: 16,15€/t or 2584€ for managing 160t of CDW

5.2 Analysis of Results - Recommendations

According to market data, collected from some PROs and the personal experience of the Consultant, even for the better-quality materials (as those derived after contacting selective demolition and separation at source), the market price for recycled (secondary) materials in Greece has an upper limit of **4€/t**. Considering the results from costs presented in par. 5.1,(18,34€/t for selective demolition and 16,15€/t for traditional demolition)it is obvious, that under the current circumstances recycling is highly uneconomical in Greece.

An obvious choice for rendering recycling more attractive, could be the reduction of RUs treatment cost. As it was mentioned elsewhere (Chapter 3) the BP of many PROs should be rationalized, mainly with respect to the operation of the RU, since the profit of an RU is over-covered from the gate fee. In other words, the RUs may produce secondary materials with lower cost.

In-situ treatment may significantly reduce treatment costs [Saez et al, 2019, Silva et al 2014b]. Nevertheless, in most cases, in situ treatment is impossible (especially for structures within the city borders), due to limited space and licensing issues. In any case, as it also pointed out by MoIT's representatives in Meeting 4 (see Annex 2), licensing of in-situ CDW treatment units should be thoroughly examined.

Financial incentives through legislative framework (e.g. GPP) are more than necessary in order to boost secondary materials market and lowering the total recycling costs, as it is extensively analyzed in Chapter 3. Moreover, both the State and the PROs should further support the RUs to participate in international programs that will contribute to the exchange of know-how and the application of innovative and more economical technologies at all stages of the recycling process.

6. Quality Management Plan (QMP)

6.1 Quality Management Context

Quality management is a crucial step towards increasing the confidence in the CDW management processes and the trust in the quality of CDW recycled materials. The qualitative value of recycled construction materials is based on their environmental features and on their technical performance. The implementation of appropriate *quality management procedures* and *protocols* allow suppliers to control and secure their processes and the quality of products. Thus, there is a need to promote quality assurance of the primary processes (from demolition site to waste logistics), as well the provision of reliable and accurate information about the performance of the recycled or re-used products.

In theory, there could be several ways to validate the quality of recycled materials, including certification, accreditation, labelling and marking [EU, 2016]. However, harmonized European standards that apply to primary materials also apply to recycled materials. CDW recycled materials must be assessed in accordance with requirements of European product standards, when covered by them.

One must fully acknowledge variability in quality of secondary materials will always exist, which can, nonetheless, be appraised based on their most basic physical properties [Silva et al., 2014b]. In all stages of a construction and demolition life cycle, waste materials must be sorted on the basis of their nature and characteristics, in order to separate potentially high-quality RA from low quality ones. By doing so, a wide array of recycled products with varying, yet certifiable, quality becomes commercially available, which can be used in their most suitable application.

Material recycling in construction has been practiced for many years now. However, there are several emerging issues relating to material specifications, testing and compliance protocols, characterization procedures, design practice and material durability that need to be established. Whereas industry standard quality assurance procedures and product performance protocols are rapidly evolving, the need exists for tighter regulation given the diversity of feedstock sources and variations in the mode of secondary materials production.

A high proportion of conventional demolition waste, particularly the fraction derived from concrete, brick and tile, is well suited to being crushed and recycled as a substitute for newly quarried (primary) aggregates. These materials are currently widely used in lower grade applications, most notably engineering fill and road sub-base applications. The use of such recycled concrete aggregates in more demanding applications, such as new concrete production, is much less common and technically much more demanding.

In spite of the extensive literature concerning the influence of recycled aggregates on the properties of several construction materials, the aggregates used in those studies are mostly laboratory made and uncontaminated versions of the reality. In practice, RA from CDW recycling plants can exhibit widely varied composition, be highly contaminated, uncertified and thus incapable of being used in high-grade applications (Rodrigues et al. 2013, Bravo et al. 2015)

6.2 Barriers to be overcome

6.2.1 Quality

In most cases, distrust concerning the RA's technical feasibility is claimed by clients, concrete producers and contractors. Similarly, to what happens in many other scientific fields, lack of confidence is typically complemented by lack of enlightenment on the subject matter. Assuming that the product complies with high-quality standards, the use of RA in structural concrete manufacture is widely accepted in the scientific community as a realistic alternative to NA [Nagataki et al., 2004; Pedro et al., 2014, Silva et al, 2016a]. In fact, experience has shown that, one of the main excuses for not considering the use of RA is the high inconsistency of their properties.

It is also true that the professionals working in most recycling plants are often either uninterested in producing reasonably high-quality RA for high-grade construction applications or are simply unaware of the most appropriate processing methods to obtain them. In both cases, since the quality of the final product may vary daily and normally is low, distrust concerning its technical feasibility will endure.

However, one must fully acknowledge that this **variability in quality** will always exist, which can, nonetheless, be appraised based on their most basic physical properties [Silva et al., 2016b]. In all stages of a construction and demolition life cycle, waste materials must be sorted on the basis of their nature and characteristics, in order to separate potentially high-quality RA from low quality ones. By doing so, a wide array of recycled products with varying, yet certifiable, quality becomes commercially available, which can be used in their most suitable application.

6.2.2 Environmental Footprint

There is a general belief that the environmental impact of CDW processing is greater than that of natural aggregates. In spite of this being accurate in circumstances in which the adhered mortar of recycled concrete aggregates (RCA) is removed by heating it to very high temperatures alongside mechanical processing, when treated with the same techniques normally applied to conventional aggregates, RA display a considerably lower carbon footprint (Braga, 2015, Silva et al, 2016b).

6.2.3 Marketing

Marketing of recycled products requires technical specifications and documentation of those products. The demand for cheap and recycled products on the private market might lower the requirements and the technical specifications. On the professional market for building and construction products, the RA should fulfil the specifications of the primary (virgin) products.

One of the most significant barriers observed is the unfavorable market conditions of CDW for all Member States. The extensive lack of trust in recycled products (quality issues), coupled with very low raw material prices and low/free landfill costs, leads to a highly uncompetitive market for recycled CDW materials.

Another significant barrier for importing recycled products to the market, is that, according to the **CE** marking requirements the original manufacturer of the product (raw material) must be known and in position to guarantee the technical quality of the material. In case of CDW coming for

further processing, obviously, the CDW stream (as raw material) cannot be verified, as it happens with virgin materials e.g. coming from a licensed and accredited quarry.

6.3 Contents of the Proposed QMP

Critical steps for overcoming the barriers noted at par. 6.2 could be:

- Improving quality of the raw material and/or provide Certification of the "raw material" (CDW)
- Certification of the CDW processing (Recycling Units)

Without doubt, the use of existing general quality management schemes such as ISO 9000, and environmental management systems such as ISO 14001 and EMAS may guarantee the quality of the environmental management process with respect to CDW management. In Greece, some of the RUs have also accredited the recycling equipment (CE marking).

For the purposes of the current study, an attempt to propose a QAP (or QP), for the whole life cycle of secondary materials is conducted, so as to assure the production of competitive recycled products and their placing on the Greek and European Market. Moreover, recommendations for future research that can guide the industry towards a more sustainable practice, with respect to secondary materials production, are also highlighted.

The Quality Management Plan (QMP) or Quality Protocol can be divided in 2 broad categories i.e.:

- QMP for the Primary Process (up to the arrival to the RU)
- QMP for Products

6.4 QMP for the Primary Process

6.4.1 CDW Identification & Source Separation

The basic steps for the QAP at that stage include:

- Pre-demolition audit & WMP
- Selective demolition/Separation at source
- Identification and separation of hazardous waste
- Proper Codification of CDW

The first steps in the supply chain of recycled building materials are essential. Quality control during pre-demolition, demolition and construction should be taken seriously, both in terms of occupational safety and recyclability of the CDW materials.

Recycling is most effective when it is driven by the client and is considered from the start of the project. Early involvement of all key players in the supply chain will yield the most economic and environmental benefits. Also, early-applied quality control, by means of a more suitable separation and subsequent storage of CDW (see also Chapter 4), is vital to achieve the highest possible quality in RA thereby increasing potential for reuse in new construction applications.

A prime demand for the recycled products is to be clean and that do not pollute the environment. Documentation of the sources of the materials and their purity is essential to gain confidence of the both the market and the building owners.

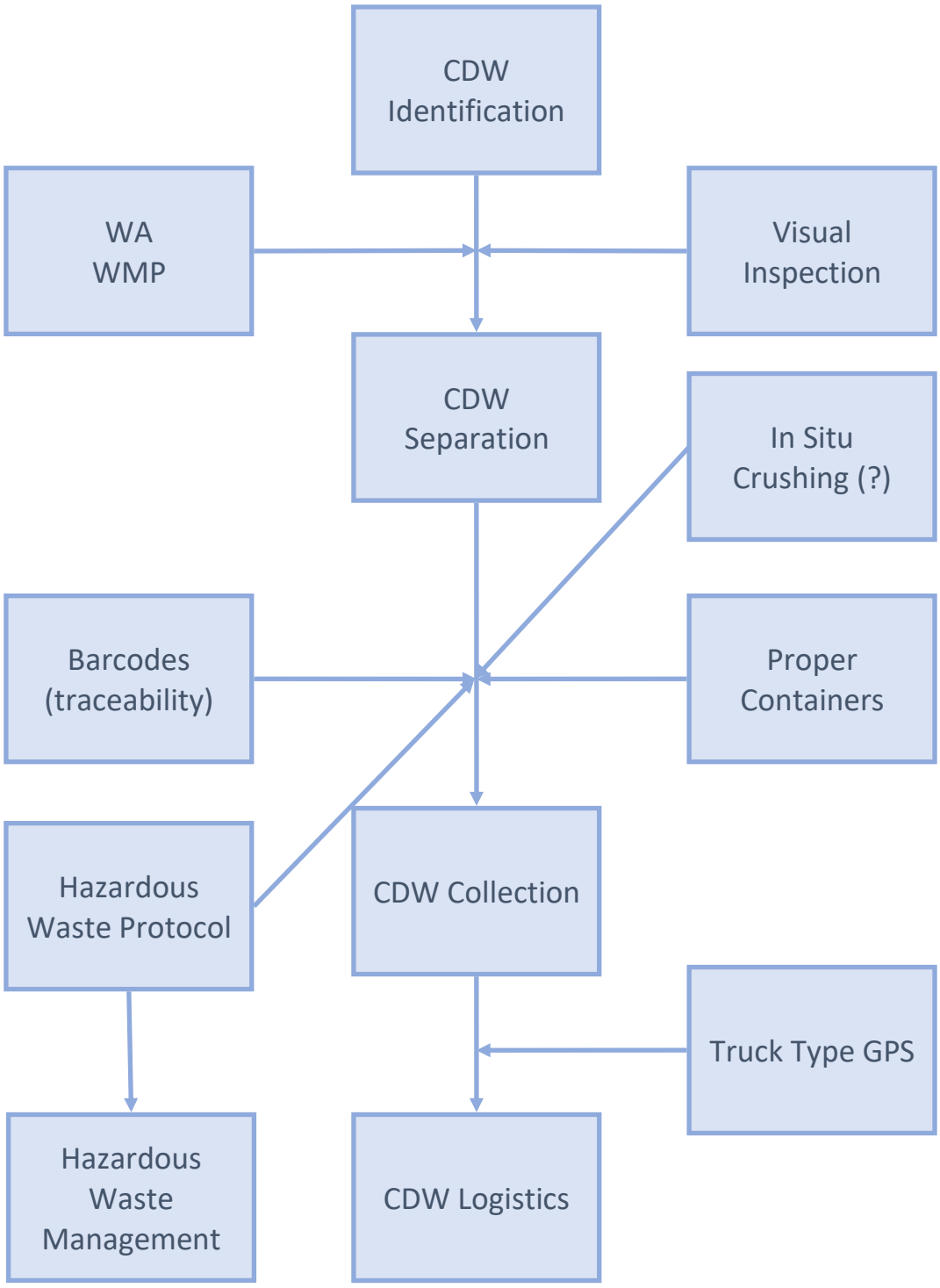

Figure 6.1: QAP for the Primary Process

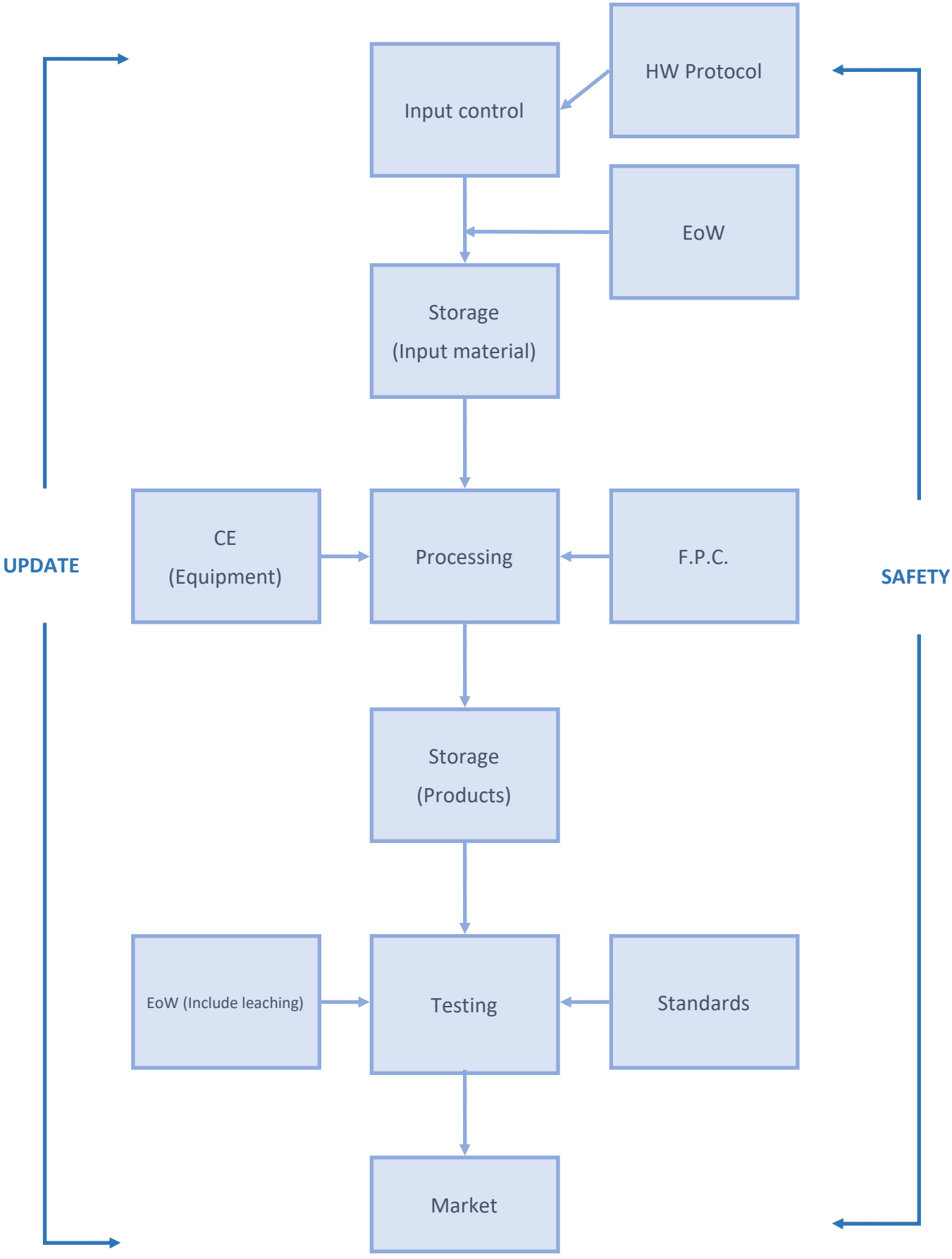

Figure 6.2: QAP for the Product

Best Practices for improving construction/demolition in work sites, including specifications for Waste Audits and WMPs, identification of hazardous waste and effective separation of CDW, have presented elsewhere in this document (Chapter 4). The implementation of those BPs will significantly contribute to the effective QM of the, so called, primary process. Especially, the approval of WA from a third party will be of significant value for Quality Assurance.

Some MSs have voluntary quality management certification schemes for demolition projects and processes. In the Netherlands, most contractors are certified by the demolition process scheme **BRL SVMS-007** which is controlled by third parties and the Council of Accreditation (See Annex 8).

6.4.2 Materials/Waste Covered by the QMP

Table 6.1 lists all the input materials and their relevant "waste code" according to the European Waste Catalogue (EWC). Those waste are considered inert and acceptable for the production of recycled aggregate for the purposes of QMP. The table includes notes to clarify any limits and restrictions relating to specific waste types. Waste inputs must not contain or be contaminated with dangerous (hazardous) substances. Incidental quantities of inert physical contaminants (such as soils, peat, clays, silts, wood, plastics, rubber, metal) may be present with the input material but must be removed during the processing of the waste to comply with the constituent requirements of aggregates standards.

Table 6.1: Acceptable inert waste input materials

Code	Description	Restrictions
17 01 01	Concrete	Must not include concrete slurry
17 01 02	Bricks	
17 01 03	Tiles & Ceramics	
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	
17 03 02	Bituminous mixtures other than those mentioned in 17 03 01	Allowed only if: Bituminous mixtures from the repair and refurbishment of the asphalt layers of roads and other paved areas (excluding bituminous mixtures containing coal tar and classified as waste code 17 03 01). Must not include coal tar or tarred products. Must not include freshly mixed bituminous mixtures.
17 05 04	Soil and stones other than those mentioned in 17 05 03	Must not contain any contaminated soil or stone from contaminated sites.
17 05 06	Dredging spoil other than those mentioned in 17 05 05	Allowed only if: Inert aggregate from dredging. Must not contain contaminated dredging. Must not contain fines.
17 05 08	Track ballast other than those mentioned in 17 05 07	Allowed only if: Does not contain soil and stones from contaminated sites.
17 09 04	Mixed CDW other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	Allowed only if: The waste is generated from utilities trenching. The waste consists of sub base aggregates i.e. granular material.

		The waste contains only materials that would be described by entries 17 01 01, 17 03 02 and 17 05 04 in this appendix if the waste was not mixed.
01 04 13[1]	Waste from stone cutting and sawing other than those mentioned in 01 04 07	
10 13 14[1]	Waste concrete and concrete sludge	

[1]: The specific waste codes are including to the provisions of the Alternative Management of PROs according to JMD 36259/1757/E103/2010

6.4.3 CDW Collection & Transport/Logistics

CDW Collection

Waste collection containers that may be used include (see photo – Annex 4):

- Containers of rectangular or trapezoidal cross-section skip-type of various capacities (from 5 to 40m^3) depending on the quantity and type of CDW produced
- Containers of rectangular or trapezoidal cross-section roll-type, of various capacities (from 5 to 40m^3) depending on the quantity and type of CDW produced.

For purposes of QAP, the above containers should be with a closed top in order to avoid any contamination but also for the protection of the environment form dust emissions.

For certain waste codes (17 01 07, 17 05 04, 17 05 06), for which the collection in containers is usually not feasible, the process should be done by mechanical means available or manually, if all the safety and environmental standards are satisfied and the CDW will be loaded directly to reversible open type trucks for transportation. Note that for the QA it is forbidden to load directly into trucks CDW with code different from those mentioned above.

Where the mechanical collection is implemented, an effort should be made to minimize the manual transport of waste, in order to minimize the contact of workers with CDW and the avoidance of insertion of impurities in to them.

CDW Transport/Logistics

According to current legislation (Law 4685/2020), there are specific provisions for CDW transport from work-site to the RU, namely:

- Transporter/Carrier should be approved and registered to the DWR
- Transporter/Carrier should co-operate (under specific contract) with a PRO
- Transporter/Carrier should possess an insurance policy in force for environmental damage, of a minimum amount of 100,000€

For purposes of Quality Assurance, the minimum requirements are:

- Transporter should fill in detail a waste identification form for every type of waste
- CDW will be transferred to a licensed facility (RU) that will be indicated by the cooperating PRO, as defined in JMD 36259/1757/E103/2010
- The collection of CDW from the predefined collection points – work sites will be done using:
    - Reversible Open type trucks only for the codes 17 01 07, 17 05 04, 17 05 06.
    - Trucks type skip - loader (chain) for skip type containers
    - Trucks type Hook - Lift (Hook) for roll-type containers

- Special provisions/declaration for hazardous waste should take place.

Drivers employed by the Company for the transport of CDW should be specially trained so as to:

- Work is carried out with the least possible nuisance and the maximum safety
- In case of emergency it is able to manage immediately and effectively any event.

Some other general provisions for QAP include:

- Apart from special circumstances, such as severe weather conditions, damage to machinery or accidents, no type of waste is allowed to remain or be stored in a truck for more than 24 hours.
- No vehicle is used to collect or transport waste if its design is such as to endanger the dispersion or diffusion of waste into the road.
- All vehicles used to collect and transport CDW are well maintained and washed thoroughly after the end of each working day.
- The use of trucks specified for other waste types (e.g. muds, municipal or hazardous waste) for purposes of CDW transport is prohibited.

CDW Traceability

To further develop the market for recycled construction materials, the traceability and tracking of waste flows is essential. As it was already mentioned (Chapter 4), tracking and tracing procedures, can help to build trust in secondary construction materials and can be considered as an essential part of quality management.

Transparency needs to be assured throughout all phases of the CDW management process [EU, 2016]. Traceability is important for building confidence in the products and processes, and to mitigate any negative environmental impacts. Registration of CDW constitutes a vital step for tracking and traceability and in order to register waste, it is necessary to know what types of CDW are expected. Therefore, a waste audit (Chapter 4) is of high importance. But equally important is to check afterwards that the waste has been processed according to plan and that rules and regulations for the handling of these waste streams have been enforced. Tracimat – a Belgian example of a C&D waste tracking and French Electronic Traceability System – are considered as a BP for the traceability of CDW (See Annex 8).

6.5 QMP for the Products

6.5.1 Waste acceptance criteria

To ensure only inert waste is accepted, the RU (in co-operation with the PRO) must develop “acceptance criteria” specific to each site/location. These criteria must be followed at all times. The acceptance criteria must incorporate all statutory requirements relating to the receipt of incoming CDW. These requirements include those arising from an environmental permit, waste management license or a waste exemption, and the duty of care.

Acceptance criteria should also include:

- A list of the types of waste that are accepted (including waste codes)
- Source/place of origin of the waste
- Supplier and transporting agent
- Method of acceptance

- Input control (for example asbestos protocol);

Every load must be inspected visually, both on initial receipt and after tipping, to ensure compliance with the acceptance criteria. A procedure for dealing with non-conforming incoming waste must be set up, for example, rejection of loads, quarantine or disposal. Records must be kept of how that procedure has been implemented (see also par. 5.5.6).

6.5.2 Storage & handling of Input Material

Basic steps towards the Quality Assurance include:

- Input materials must be stocked in a controlled manner in clearly identified locations.
- Input materials taken from stock for processing must be checked for deterioration.
- Input materials should be handled and stored to minimize the creation of airborne dust.
- Engineering control measures such as containment, enclosed silos/bins/hoppers, local exhaust ventilation, sprays suppression systems, etc. should be used where there is a risk of airborne dust creation.
- Open conveyor handling systems should be provided with wind boards or other protection to prevent wind-whipping.
- Manual handling of the input materials should be minimized through the use of mechanical aids wherever possible. Account should be taken of the Manual Handling Regulations and care should be taken when lifting by hand.
- Input materials are considered inert, but dust and fine particles should be prevented from entering watercourses and drains. Deposition of dust on vegetation and surrounding property should be avoided by controlling the release of dust at source.

6.5.3 CDW Processing/Treatment – Factory Production Control

A RU is considered as a “Factory” of producing construction materials. Every factory production run needs to comply with the procedures of the European Construction Products Regulations (CPR) 305/2011/EC. This requires a conformity assessment procedure. The scope of the CPR is to ensure reliable information on construction products in relation to their performance. This is achieved by providing a “common technical language”, offering uniform assessment methods of the performance of construction products. The CPR lays down conditions for the placing or making available on the market of construction products by establishing harmonized rules on how to express the performance of construction products in relation to their essential characteristics and on the use of CE marking on those products.

In practice, FPC is the permanent control of production exercised by the manufacturer. All the elements, requirements and provisions adopted by the manufacturer are documented in a systematic way containing written policies and procedures. This production control system documentation ensures a common understanding and conformity evaluation. It enables checking the required product characteristics and the effective operation of the production control systems. FPC brings together operational techniques and measures that allows the maintenance and control of the conformity of the product with its technical specifications. The manufacturer establishes documents and maintains an FPC system to ensure that the products placed on the market conform to the stated performance characteristics and the samples of the type testing.

For purposes of QAP, an FPC manual must be produced which documents how the FPC is implemented and sets out procedures for establishing the approval, issue, distribution and

administration of documentation and data for internal and external use. A management representative must be nominated as responsible for ensuring the FPC is implemented. The FPC must be reviewed periodically by management to ensure its continuing suitability and effectiveness. Records of such reviews must be kept. Controls on sub-contractors must also be defined.

Some important features of FPC that significantly contribute to Quality Management include:

- The manner in which processing equipment is maintained and adjusted during production must be defined.
- The finished product must be identifiable up to the point of sale.
- Procedures must be in place and implemented to maintain the quality of the product during handling, storage, transport and delivery.
- Procedures for the use, control, calibration and maintenance of inspection, measuring and test equipment must be setup and followed. Equipment must be uniquely identified.

6.5.4 Storage and Handling of Products

Basic steps towards the Quality Assurance include:

- Aggregates should be handled and stored to minimize the creation of airborne dust.
- Engineering control measures such as containment, enclosed silos/bins/hoppers, local exhaust ventilation, sprays suppression systems, etc. should be used where there is a risk of airborne dust creation.
- Open conveyor handling systems should be provided with wind boards or other protection to prevent wind-whipping.
- Manual handling of the aggregates should be minimized through the use of mechanical aids wherever possible. Account should be taken of the Manual Handling Regulations and care should be taken when lifting by hand.
- Aggregates are inert, but dust and fine particles should be prevented from entering watercourses and drains. Deposition of dust on vegetation and surrounding property should be avoided by controlling the release of dust at source.

Ideally, dedicated RA producers/suppliers should produce materials of the highest specification. This means they can also make room for retailing RA with a wider range of specified quality for several designated applications. However, in reality, many recycling plants tend to produce material of lower specification, in spite of the potentially high-quality input, because of inadequate quality control. In many of these situations, premium gate fees are also paid upon acceptance of highly mixed CDW and the extra processing costs involved in producing certified high-quality RA are deemed unjustified due to the small increase in revenue. Furthermore, the mixed source of the waste also means that the end product is not uniform, making it harder to guarantee consistent specification.

Quality control increase throughout the material's life cycle. It is possible to predict how the RA's quality will affect the performance of resulting recycled materials, as demonstrated in recent developments [Silva et al., 2014b, Silva et al, 2016]. However, it is crucial that the RA's contamination level is minimized throughout the recycling process (including construction and demolition activities), in order to produce a certifiable, fit-for-purpose high-quality material. Furthermore, new treatment approaches (e.g. storing RCA in a CO2-enriched environment)

capable of improving the physical properties of RCA has been gaining attention, which also enhances the performance of the resulting RAC (Tam et al., 2016).

The producer of secondary materials (aggregates) must comply with all the requirements of ELOT EN aggregates standards appropriate to the use for which the aggregate is destined for at the time it is produced.

In Table 6.2, Standards and specifications for the use of secondary materials in common applications are illustrated.

Table 6.2: Standards & Specifications for applications of secondary materials

RecycledProduct&Use	Standard	Description
Unbound* recycled aggregate: Pipe bedding Drainage	ELOT EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and roadconstruction
Unbound recycled aggregate: Granular fill, General fill, Capping	ELOT EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and roadconstruction
Unbound recycled aggregate: subbase	ELOT EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and roadconstruction
Recycled aggregate for concrete**	ELOT EN 12620	Aggregates for concrete
Recycled aggregate for asphalt	ELOT EN 13043	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
Recycled aggregate for hydraulically bound mixtures	ELOT EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
Reclaimed asphalt for use in bituminous mixtures	DIN EN 13108-8	Bituminous mixtures – Material specifications – Reclaimed asphalt

* unbound application: the aggregate is not bound to any agent

**bound applications: where the mixture contains a binding agent, such as cement or bitumen

The detailed description of tests for materials destined for the specific uses, is out of the scope of the particular Assessment. Nevertheless, for purposes of conducting the QAP, several provisions for the production procedure will be proposed, so as the secondary materials fulfil the specifications for each use.

6.5.5 Training

All personnel must be trained, especially on the FPC, at least to the following topics:

- Acceptance criteria
- Procedures for non-compliant input wastes and output products
- Sampling
- Testing
- Inspection

6.5.6 Records & Documentation

Records of relevant controls and inspections, calibrations, changes and training must be maintained for a suitable period of time. This period must be defined. A Method Statement of Production (MSP) must be produced and maintained. The MSP represents the recovery process for the incoming waste and it is part of the FPC. It must contain a description or representation of the production process for each product type including:

- Input materials
- Equipment used
- Actions undertaken at each stage from acceptance of waste to allocation to product stockpiles.

The aggregates must be produced to a recognized standard and/or specification. This specification will define the properties and characteristics of the product, as suitable for its application.

Delivery documentation should:

- Record the type of aggregate product dispatched
- State the site at which the product was produced
- State that the aggregate was produced under a quality management scheme conforming to the aggregates Quality Protocol.

If requested, purchasers must be provided with the results from the testing regime undertaken on each product. Historical records of test results must be kept and/or made available as summary results (for example, a graph of test results over time).

6.5.7 Testing of Final Product

Procedures for the use, control, calibration and maintenance of inspection, measuring and test equipment must be set up and followed. Equipment must be uniquely identified.

A test plan for production must be defined that includes:

- The type of testing for each product
- Sampling and testing frequency (see Table 6.3 below for information about minimum test frequencies).

Table 6.3 provides a summary of the frequencies required for the minimum testing requirements set out in the main standards.

The test procedures must be appropriate to the end use of the recycled aggregates and testing frequencies must comply with the standards/specifications for the aggregate produced.

Producers must have in place testing procedures to meet the testing requirements for each product. A summary of the frequencies required for the minimum testing requirements within the mainstream standards is provided in Table 6.3.

More detailed testing requirements are defined within the aggregate standards and specifications.

Table 6.3: Summary of testing requirements associated with particular secondary materials end uses and respective standards

End Use	Standard/Specification	Test	EN Test Reference	Minimum test Frequency
All end uses	EN 13242 EN 12620	Particle size Distribution	EN 933-1	1 per week
		Particle density	EN 1097-6	1 per month
		Resistance to fragmentation (LA)	EN 1097-2	2 per year
		Classification of constituents	EN 933-11	1 per month
		Water soluble sulfate	EN 1744-1	1 per month
Aggregates for concrete	EN 12620	Particle density and water absorption	EN 1097-6	1 per month
		Sulfur containing compounds	EN 1744-1	2 per year
		Chlorides	EN 1744-5	2 per year
		Influence on setting time of cement	EN 1744-6	2 per year

6.6 Other Provisions

6.6.1 Health & Safety Issues

All applications of aggregates should comply with recommendations from a designated Health and Safety Executive (HSE). A written evaluation of occupational hazards, containing detailed description for hazards mitigation (such as using appropriate personal protective equipment (PPE) and dust suppression measures), will significantly contribute to the QAP.

6.6.2 Updating the QMP

It is apparent that the Quality Assurance Plan should be reviewed and updated when considered appropriate. Triggers for a review/update could include:

- Pollution incidents
- Development in scientific understanding
- A change in the market

- A change in legislative framework
- A change to the agreed European standard for specific secondary material use.

Obviously, the QMP may be withdrawn if it becomes apparent that it is generally being misapplied and/or misused.

6.6.3 EoW Criteria

The QAP proposed in this Assessment may significantly contribute to the development of EoW for CDW. The QAP covers, not only the quality of the "product" but also all the steps of the production chain (treatment process, logistics etc.).

7. Conclusions & Next Steps

7.1 Conclusions

The collection of data for the production and management of CDW and their evaluation was a demanding process in the midst of the COVID-19 pandemic. Nevertheless, the working team, in close collaboration with GIZ and the relevant Stakeholders (YPEN, HRA, MoIT, YMEPERAA, DWR) tried to cover several fields of the CDW management issue and present a complete Final Report. It should be mentioned that, in the context of the consultation and review on the Study by the relevant Stakeholders , very interesting views were submitted, which were taken into account in the conduction of the Final Report.

The main Conclusions drawn from the current Study are summarized below.

- The expansion of the PROs (78% of Greek Territory and 90% of the population) has significantly contributed to the improvement of the management framework despite some deficiencies and operational problems detected. In fact, some of the PROs were contributed to the conduction of Study by providing aspects and ideas for the improvement of the CDW management framework
- The PROs show inhomogeneity in terms of price lists, categorization of incoming CDW and ambiguities regarding the outgoing RM.
- The quantities of CDW produced in recent years in Greece are significant and have exceeded all previous forecasts. It is assumed that in 2019, more than 4,500,000 tons of CDW have been produced, regardless the calculation approach (NWMP/ENVITERRA)
- The % RRR target calculation method needs to be clarified, especially with respect to the calculation of the total CDW quantities produced and the inclusion or not of backfilling operations to the quantity of CDW processed. According to the current Study approach, % RRR is reaching up to 50% for 2019 (including backfilling).
- The legal framework for managing CDW is extensive, complex and often contradictory at both national and European level. Especially for Greek legislative framework, is more than essential that all parties involved in the legislative process to be aligned towards the same target, avoiding the publication of contradicting and misleading legislative acts.
- It is not considered possible for the EW derived from Public Works to be managed by the PROs at this stage, mainly due to contradictive Public Works and CDW management legislation, but it is possible to record the quantities produced at an administrative level.
- Rationalization of PROs BPLs is required especially for purposes of encouraging and motivating CDW recycling
- Changes are needed regarding the role of TPAs, deposition fees, Law enforcement and quarry/forestry legislation, in order to remove entanglements and delays in the proper implementation of the management framework
- The EoW criteria are an important lever for upgrading and marketizing the RMs, however they present various problems in their application, both in National and European level
- Creating financial incentives, such as GPP, is probably the most effective way to render recycling more efficient and economical.

- The proposed Good Practice Guide has selective demolition and sorting at source as a cornerstone, while in the Annex of the Study, selected Good Practices from other Member States are provided.
- CBA has illustrated the uneconomic status of CDW recycling in Greece and at this stage only drastic legislative interventions and rationalization of PROs BPLs can change the landscape
- Given the impossibility of establishing specifications solely for RMs, the present Study proposes a Quality Management Plan (from source to production of the final product) which can ensure, at least, the minimum quality standards of the materials produced and compliance with the applicable specifications for natural materials.
- The QAP proposed in this Assessment may significantly contribute to the development of EoW for CDW, since it covers, not only the quality of the "product" but also all the steps of the production chain (treatment process, logistics etc.).

7.2 Next Steps

According to the findings of the current Study and the interaction with all relevant Stakeholders, the following next steps are proposed, in the direction of further improvement of CDW management in Greece:

- YPEN and HRA should impose specific criteria and guidelines for retrieving uniform reports from PROs in terms of CDW management. The impose of a uniform price (fee) list including 6-digit codes or at least common group of codes (waste streams) is of great importance
- The partnership between RUs and Research Institutes should be encouraged. New technologies for effective and economic CDW treatment should be implemented and the import of know-how, as a result of that partnership, is essential.
- YPEN should provide specific guidelines for the theoretical calculation of CDW, based on NTUA algorithms and ELSTAT data. For the time being, NWMP and PROs use different assumptions for demolition area, demolition EW and the inclusion or not of CDW from Public Works
- DWR may play an important role in the future in terms of gathering and evaluating CDW management data, but it is essential to upgrade its role and competence.
- YPEN should gather data from DWR for hazardous CDW, especially those exported and included to the revised NWMP.
- The inclusion of EW derived from Public Works to the competence of the PROs is a matter of critical importance. Since there are several barriers and contradictive legislative acts, close co-operation and dialogue between the relevant Stakeholders is essential.
- The holistic approach on CDW management issues in also very important. The experience of the past and the challenges of the future render the close co-operation of relevant Stakeholders critical in administrative and law-making level.

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9. Annexes

Annex 1: Terms of Reference

Terms of Reference.pdf

Annex 2: List of Meetings

List of Meetings during the project period

MeetingNo	Date/Time	Place/Content	Attendees
1	25/02/2020 10:00 – 12:30	YPEN, 147 Patision str. Presentation of Consultant Methodology, discussion, suggestions from Stakeholders	HRA, YPEN/WD, GIZ, ENVITERRA P.C.
2	09/03/2020 10:30 – 14:30	YPEN, 147 Patision str. Data Collection (annual reports from PROs, view of Business Plans) and discussion upon gaps and alternatives	HRA, YPEN/WD, GIZ, DWR, ENVITERRA P.C.
3	11/03/2020 14:30-16:30	YPEN, 119 Mesogeion str. Brief update for TORs, discussion upon methodology, suggestions for improvement	YPEN, ENVITERRA P.C.
4	08/05/2020 12:00–14:00	Skype – Meeting Discussion for CDW management context, focusing on Public Works, on Specific CDW barriers with respect to Public Works and specifications for secondary (recycled) materials	MoIT, YMEPERAA, YPEN, HRA, GIZ, ENVITERRA P.C.
5	30/06/2020 10:00 – 13:00	Teleconference Presentation of the Draft Final Report	MoIT, YMEPERAA, YPEN, DWR, HRA, GIZ, ENVITERRA P.C.

Annex 3: CDW Data per Regional Unit (ELSTAT, PROs)

Table A3.1: Construction activity and assumptions for CDW calculation based on ELSTAT data (2016)

Regional Unit	New Constuction	Extensions	Demolitions	Surface of new Construction	Surface of new Additions	CW	DW	EW (C)	EW (D	EW (total)	ECDW PR	CDW PU	Total
ATTICA	**535**	**214**	**336**	**206.195**	**209.574**	**39.914**	**55.910**	**292.110**	**90.854**	**382.964**	**478.789**	**57.495**	**536.283**
RODOPI	41	11	15	10.602	3.212	1.326	2.496	22.386	4.056	26.442	30.264	2.293	32.557
DRAMA	40	21	21	12.840	10.918	2.281	3.494	21.840	5.678	27.518	33.294	3.465	36.759
EVROS	30	19	10	7.921	4.595	1.202	1.664	16.380	2.704	19.084	21.950	1.719	23.669
THASOS	25	2	1	4.127	203	416	166	13.650	270	13.920	14.502	349	14.852
KAVALA	37	7	6	8.820	3.539	1.186	998	20.202	1.622	21.824	24.009	1.311	25.320
XANTHI	41	14	17	12.844	20.416	3.193	2.829	22.386	4.597	26.983	33.005	3.613	36.618
THESSALONIKI	139	60	49	59.220	94.628	14.769	8.154	75.894	13.250	89.144	112.067	13.754	125.820
IMATHIA	43	23	10	12.961	9.084	2.116	1.664	23.478	2.704	26.182	29.962	2.268	32.231
KILKIS	19	13	5	4.080	14.348	1.769	832	10.374	1.352	11.726	14.327	1.561	15.888
PELLA	53	15	7	9.660	26.898	3.510	1.165	28.938	1.893	30.831	35.505	2.805	38.310
PIERIA	76	57	10	18.591	29.559	4.622	1.664	41.496	2.704	44.200	50.486	3.772	54.258
SERRES	67	57	15	12.562	16.146	2.756	2.496	36.582	4.056	40.638	45.890	3.151	49.041
CHALKIDIKI	152	28	16	66.199	9.708	7.287	2.662	82.992	4.326	87.318	97.268	5.970	103.238
LOZANI	39	27	7	8.625	13.747	2.148	1.165	21.294	1.893	23.187	26.499	1.988	28.487
GRAVENA	18	4	1	5.597	2.010	730	166	9.828	270	10.098	10.995	538	11.533
KASTORIA	20	6	3	10.691	2.947	1.309	499	10.920	811	11.731	13.540	1.085	14.625
FLORINA	26	6	7	10.168	2.926	1.257	1.165	14.196	1.893	16.089	18.511	1.453	19.964
IOANNINA	63	11	16	29.131	12.473	3.994	2.662	34.398	4.326	38.724	45.381	3.994	49.375
ARTA	25	15	0	3.659	6.463	972	0	13.650	0	13.650	14.622	583	15.205
THERSPROTIA	38	6	3	5.928	6.907	1.232	499	20.748	811	21.559	23.291	1.039	24.329

Regional Unit	New Constuction	Extensions	Demolitions	Surface of new Construction	Surface of new Additions	CW	DW	EW (C)	EW (D	EW (total)	ECDW PR	CDW PU	Total
PREVEZA	37	22	6	12.732	7.548	1.947	998	20.202	1.622	21.824	24.770	1.767	26.537
LARISSA	76	32	23	53.412	27.370	7.755	3.827	41.496	6.219	47.715	59.297	6.949	66.247
KARDITSA	25	19	4	7.354	5.389	1.223	666	13.650	1.082	14.732	16.621	1.133	17.754
MAGNISIA	83	48	32	23.915	17.291	3.956	5.325	45.318	8.653	53.971	63.251	5.568	68.820
SPORADES	14	9	3	4.231	1.475	548	499	7.644	811	8.455	9.502	628	10.130
TRIAKALLA	56	33	12	12.800	8.687	2.063	1.997	30.576	3.245	33.821	37.880	2.436	40.316
FTHIOTIDA	107	62	27	21.949	24.832	4.491	4.493	58.422	7.301	65.723	74.707	5.390	80.097
VIOTIA	43	33	7	10.008	24.688	3.331	1.165	23.478	1.893	25.371	29.866	2.697	32.564
EVIA	155	67	24	37.770	21.966	5.735	3.994	84.630	6.490	91.120	100.848	5.837	106.685
EVRITANIA	9	10	1	1.433	1.740	305	166	4.914	270	5.184	5.655	283	5.938
FOKIDA	28	11	11	5.886	6.578	1.197	1.830	15.288	2.974	18.262	21.289	1.816	23.106
KERKIRA	100	27	8	23.856	17.547	3.975	1.331	54.600	2.163	56.763	62.069	3.184	65.253
ZAKINTHOS	83	28	10	38.253	15.947	5.203	1.664	45.318	2.704	48.022	54.889	4.120	59.010
ITHAKI	4	0	3	458	0	44	499	2.184	811	2.995	3.538	326	3.864
KEFALLINIA	95	26	10	17.915	3.456	2.052	1.664	51.870	2.704	54.574	58.290	2.229	60.519
LEYKADA	49	12	0	12.168	3.790	1.532	0	26.754	0	26.754	28.286	919	29.205
ACHAIA	165	43	44	44.176	24.529	6.596	7.322	90.090	11.898	101.988	115.905	8.350	124.255
ETOLOAKARNANIA	116	43	15	29.435	28.187	5.532	2.496	63.336	4.056	67.392	75.420	4.817	80.236
ILIA	89	24	7	13.705	19.928	3.229	1.165	48.594	1.893	50.487	54.880	2.636	57.517
ARKADIA	58	42	28	13.685	11.723	2.439	4.659	31.668	7.571	39.239	46.338	4.259	50.597
ARGOLIDA	56	23	14	17.055	26.000	4.133	2.330	30.576	3.786	34.362	40.824	3.878	44.702
KORINTHIA	106	58	20	22.046	49.114	6.831	3.328	57.876	5.408	63.284	73.443	6.096	79.539
LAKONIA	57	38	12	13.220	22.924	3.470	1.997	31.122	3.245	34.367	39.833	3.280	43.113
MESSINIA	105	40	19	25.471	19.731	4.339	3.162	57.330	5.138	62.468	69.969	4.501	74.469

Regional Unit	New Constuction	Extensions	Demolitions	Surface of new Construction	Surface of new Additions	CW	DW	EW (C)	EW (D	EW (total)	ECDW PR	CDW PU	Total
LESVOS	38	16	7	5.371	3.897	890	1.165	20.748	1.893	22.641	24.695	1.233	25.928
IKARIA	13	6	2	1.738	615	226	333	7.098	541	7.639	8.197	335	8.533
LIMNOS	12	5	2	2.213	494	260	333	6.552	541	7.093	7.685	356	8.041
SAMOS	18	5	4	3.712	1.871	536	666	9.828	1.082	10.910	12.111	721	12.832
CHIOS	51	18	13	10.944	8.963	1.911	2.163	27.846	3.515	31.361	35.435	2.445	37.880
SIROS	15	14	3	2.879	1.827	452	499	8.190	811	9.001	9.952	571	10.523
ANDROS	13	5	1	2.603	1.158	361	166	7.098	270	7.368	7.896	316	8.212
THIRA	72	17	7	34.232	7.598	4.016	1.165	39.312	1.893	41.205	46.385	3.108	49.494
KALIMNOS	26	9	0	4.485	4.378	851	0	14.196	0	14.196	15.047	511	15.557
KARPATHOS	12	2	2	2.811	380	306	333	6.552	541	7.093	7.732	383	8.115
KEA-KITHNOS	14	2	1	2.394	9.007	1.094	166	7.644	270	7.914	9.175	757	9.932
KOS	41	12	1	8.000	8.335	1.568	166	22.386	270	22.656	24.391	1.041	25.432
MILOS	24	6	3	3.927	4.336	793	499	13.104	811	13.915	15.208	775	15.983
MIKONOS	6	0	0	2.785	1.629	424	0	3.276	0	3.276	3.700	254	3.954
NAXOS	54	26	3	15.072	5.735	1.997	499	29.484	811	30.295	32.792	1.498	34.290
PAROS	66	20	7	17.004	6.054	2.214	1.165	36.036	1.893	37.929	41.307	2.027	43.334
RODOS	94	14	3	21.238	7.019	2.713	499	51.324	811	52.135	55.347	1.927	57.274
TINOS	13	2	3	3.014	2.355	515	499	7.098	811	7.909	8.924	609	9.533
IRAKLIO	213	66	22	79.875	39.661	11.475	3.661	116.298	5.949	122.247	137.383	9.082	146.465
LASITHI	57	24	8	12.336	11.193	2.259	1.331	31.122	2.163	33.285	36.875	2.154	39.029
RETHIMNO	97	22	13	35.182	13.838	4.706	2.163	52.962	3.515	56.477	63.346	4.121	67.468
CHANIA	113	26	3	31.391	28.397	5.740	499	61.698	811	62.509	68.748	3.743	72.491
TOTAL	**4.305**	**1.683**	**1.003**	**1.286.560**	**28.397**	**225.220**	**166.899**	**2.350.530**	**271.211**	**2.621.741**	**3.013.860**	**235.271**	**3.249.132**

Table A3.2: CDW quantities managed through PROs, per regional unit (2016) (units in tones)

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	% CDW management
ATTICA	14.868	20.670	63.167							98.706	18%
RODOPI										0	0%
DRAMA				3.133	7.081					10.215	28%
EVROS										0	0%
THASOS										0	0%
KAVALA				2.381	7.815					10.195	40%
XANTHI										0	0%
THESSALONIKI				117.799			7.700			125.500	100%
IMATHIA				29.686						29.686	92%
KILKIS										0	0%
PELLA				4.095						4.095	11%
PIERIA										0	0%
SERRES				319			9.095			9.414	19%
CHALKIDIKI									1.929	1.929	2%
LOZANI										0	0%
GRAVENA										0	0%
KASTORIA										0	0%
FLORINA										0	0%
IOANNINA										0	0%
ARTA										0	0%
THERSPROTIA										0	0%
PREVEZA										0	0%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	% CDW management
LARISSA										0	0%
KARDITSA										0	0%
MAGNISIA										0	0%
SPORADES										0	0%
TRIAKALLA										0	0%
FTHIOTIDA										0	0%
VIOTIA			88							88	0%
EVIA			30.468							30.468	29%
EVRITANIA										0	0%
FOKIDA										0	0%
KERKIRA						632				632	1%
ZAKINTHOS										0	0%
ITHAKI										0	0%
KEFALLINIA										0	0%
LEYKADA										0	0%
ACHAIA										0	0%
ETOLOAKARNANIA										0	0%
ILIA										0	0%
ARKADIA										0	0%
ARGOLIDA										0	0%
KORINTHIA										0	0%
LAKONIA						2.509				2.509	6%
MESSINIA						414				414	1%
LESVOS										0	0%
IKARIA										0	0%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	% CDW management
LIMNOS										0	0%
SAMOS										0	0%
CHIOS										0	0%
SIROS						164.475				164.475	1563%
ANDROS						148				148	2%
THIRA						2				2	0%
KALIMNOS										0	0%
KARPATHOS										0	0%
KEA-KITHNOS										0	0%
KOS										0	0%
MILOS						4.972				4.972	31%
MIKONOS										0	0%
NAXOS						1.148				1.148	3%
PAROS						18.538				18.538	43%
RODOS										0	0%
TINOS										0	0%
IRAKLIO					738					738	1%
LASITHI								3.235		3.235	8%
RETHIMNO										0	0%
CHANIA										0	0%
TOTAL	**14.868**	**20.670**	**93.723**	**157.413**	**15.634**	**192.838**	**16.796**	**3.235**	**1.929**	**517.106**	16%

Table A3.3: Construction activity and assumptions for CDW calculation based on ELSTAT data (2017)

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
ATTICA	633	225	424	287.916	239.483	39.914	55.910	292.110	90.854	382.964	478.789	57.495	536.283
RODOPI	31	8	7	7.203	3.351	1.326	2.496	22.386	4.056	26.442	30.264	2.293	32.557
DRAMA	22	22	9	11.873	14.424	2.281	3.494	21.840	5.678	27.518	33.294	3.465	36.759
EVROS	21	23	9	6.401	3.568	1.202	1.664	16.380	2.704	19.084	21.950	1.719	23.669
THASOS	28	2	0	11.482	593	416	166	13.650	270	13.920	14.502	349	14.852
KAVALA	36	6	13	18.996	4.821	1.186	998	20.202	1.622	21.824	24.009	1.311	25.320
XANTHI	55	17	18	14.746	5.118	3.193	2.829	22.386	4.597	26.983	33.005	3.613	36.618
THESSALONIKI	164	63	45	102.993	93.137	14.769	8.154	75.894	13.250	89.144	112.067	13.754	125.820
IMATHIA	43	32	9	9.959	16.066	2.116	1.664	23.478	2.704	26.182	29.962	2.268	32.231
KILKIS	19	6	3	14.191	2.888	1.769	832	10.374	1.352	11.726	14.327	1.561	15.888
PELLA	65	16	6	17.582	10.170	3.510	1.165	28.938	1.893	30.831	35.505	2.805	38.310
PIERIA	65	24	18	31.894	24.542	4.622	1.664	41.496	2.704	44.200	50.486	3.772	54.258
SERRES	55	45	15	26.245	8.768	2.756	2.496	36.582	4.056	40.638	45.890	3.151	49.041
CHALKIDIKI	181	40	17	54.380	24.641	7.287	2.662	82.992	4.326	87.318	97.268	5.970	103.238
LOZANI	51	17	13	16.772	17.467	2.148	1.165	21.294	1.893	23.187	26.499	1.988	28.487
GRAVENA	15	7	1	6.080	3.544	730	166	9.828	270	10.098	10.995	538	11.533
KASTORIA	13	4	2	3.340	6.134	1.309	499	10.920	811	11.731	13.540	1.085	14.625
FLORINA	26	5	5	9.774	6.386	1.257	1.165	14.196	1.893	16.089	18.511	1.453	19.964
IOANNINA	72	21	14	30.541	13.724	3.994	2.662	34.398	4.326	38.724	45.381	3.994	49.375
ARTA	24	9	3	13.000	9.198	972	0	13.650	0	13.650	14.622	583	15.205
THERSPROTIA	35	15	9	12.608	5.369	1.232	499	20.748	811	21.559	23.291	1.039	24.329
PREVEZA	44	18	7	12.553	8.704	1.947	998	20.202	1.622	21.824	24.770	1.767	26.537

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
LARISSA	118	46	22	44.990	47.232	7.755	3.827	41.496	6.219	47.715	59.297	6.949	66.247
KARDITSA	25	17	1	7.222	10.285	1.223	666	13.650	1.082	14.732	16.621	1.133	17.754
MAGNISIA	70	50	26	21.979	14.894	3.956	5.325	45.318	8.653	53.971	63.251	5.568	68.820
SPORADES	28	4	4	6.190	1.529	548	499	7.644	811	8.455	9.502	628	10.130
TRIAKALLA	55	32	12	21.004	8.960	2.063	1.997	30.576	3.245	33.821	37.880	2.436	40.316
FTHIOTIDA	95	57	7	20.462	49.332	4.491	4.493	58.422	7.301	65.723	74.707	5.390	80.097
VIOTIA	41	48	15	12.089	17.763	3.331	1.165	23.478	1.893	25.371	29.866	2.697	32.564
EVIA	183	79	16	35.596	22.779	5.735	3.994	84.630	6.490	91.120	100.848	5.837	106.685
EVRITANIA	4	9	0	281	2.742	305	166	4.914	270	5.184	5.655	283	5.938
FOKIDA	27	21	8	4.157	6.000	1.197	1.830	15.288	2.974	18.262	21.289	1.816	23.106
KERKIRA	115	27	9	30.765	8.039	3.975	1.331	54.600	2.163	56.763	62.069	3.184	65.253
ZAKINTHOS	126	34	24	77.064	15.366	5.203	1.664	45.318	2.704	48.022	54.889	4.120	59.010
ITHAKI	9	0	0	696	100	44	499	2.184	811	2.995	3.538	326	3.864
KEFALLINIA	117	25	12	27.774	8.894	2.052	1.664	51.870	2.704	54.574	58.290	2.229	60.519
LEYKADA	89	9	2	25.757	2.000	1.532	0	26.754	0	26.754	28.286	919	29.205
ACHAIA	209	57	46	52.492	39.260	6.596	7.322	90.090	11.898	101.988	115.905	8.350	124.255
ETOLOAKARNANIA	135	56	16	37.313	20.090	5.532	2.496	63.336	4.056	67.392	75.420	4.817	80.236
ILIA	110	49	22	19.039	28.767	3.229	1.165	48.594	1.893	50.487	54.880	2.636	57.517
ARKADIA	57	55	26	11.009	14.433	2.439	4.659	31.668	7.571	39.239	46.338	4.259	50.597
ARGOLIDA	58	24	18	18.271	19.627	4.133	2.330	30.576	3.786	34.362	40.824	3.878	44.702
KORINTHIA	87	38	23	36.151	28.438	6.831	3.328	57.876	5.408	63.284	73.443	6.096	79.539
LAKONIA	85	34	13	21.534	13.933	3.470	1.997	31.122	3.245	34.367	39.833	3.280	43.113
MESSINIA	124	42	19	33.480	44.459	4.339	3.162	57.330	5.138	62.468	69.969	4.501	74.469

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
LESVOS	68	20	6	14.380	2.468	890	1.165	20.748	1.893	22.641	24.695	1.233	25.928
IKARIA	10	5	3	1.262	165	226	333	7.098	541	7.639	8.197	335	8.533
LIMNOS	10	6	0	2.179	622	260	333	6.552	541	7.093	7.685	356	8.041
SAMOS	27	18	6	3.730	2.650	536	666	9.828	1.082	10.910	12.111	721	12.832
CHIOS	66	23	12	15.409	9.306	1.911	2.163	27.846	3.515	31.361	35.435	2.445	37.880
SIROS	26	17	2	6.540	1.377	452	499	8.190	811	9.001	9.952	571	10.523
ANDROS	18	8	1	3.026	755	361	166	7.098	270	7.368	7.896	316	8.212
THIRA	103	26	10	38.368	6.477	4.016	1.165	39.312	1.893	41.205	46.385	3.108	49.494
KALIMNOS	41	17	4	8.251	2.464	851	0	14.196	0	14.196	15.047	511	15.557
KARPATHOS	20	6	2	4.601	2.383	306	333	6.552	541	7.093	7.732	383	8.115
KEA-KITHNOS	18	1	2	3.622	496	1.094	166	7.644	270	7.914	9.175	757	9.932
KOS	47	8	5	27.193	4.093	1.568	166	22.386	270	22.656	24.391	1.041	25.432
MILOS	35	8	4	7.040	5.290	793	499	13.104	811	13.915	15.208	775	15.983
MIKONOS	21	11	0	12.678	2.958	424	0	3.276	0	3.276	3.700	254	3.954
NAXOS	59	39	5	17.084	8.229	1.997	499	29.484	811	30.295	32.792	1.498	34.290
PAROS	58	37	6	16.786	5.679	2.214	1.165	36.036	1.893	37.929	41.307	2.027	43.334
RODOS	93	24	6	20.541	19.637	2.713	499	51.324	811	52.135	55.347	1.927	57.274
TINOS	15	2	0	4.074	1.936	515	499	7.098	811	7.909	8.924	609	9.533
IRAKLIO	258	64	40	81.787	34.352	11.475	3.661	116.298	5.949	122.247	137.383	9.082	146.465
LASITHI	61	18	13	13.497	9.968	2.259	1.331	31.122	2.163	33.285	36.875	2.154	39.029
RETHIMNO	86	17	12	48.197	8.938	4.706	2.163	52.962	3.515	56.477	63.346	4.121	67.468
CHANIA	125	22	27	49.237	13.649	5.740	499	61.698	811	62.509	68.748	3.743	72.491
TOTAL	**4.930**	**1.835**	**1.154**	**1.685.326**	**1.090.910**	**266.519**	**192.026**	**2.691.780**	**312.042**	**3.003.822**	**3.462.366**	**275.127**	**3.737.492**

Table A3.4: CDW quantities managed through PROs, per regional unit (2017) (units in tones)

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
ATTICA	13.621	68.878	353.702							436.201	67%
RODOPI				7.857	280					8.138	36%
DRAMA				6.312	11.052					17.364	83%
EVROS				15.490	1.415					16.905	95%
THASOS										0	0%
KAVALA				8.851	2.886					11.737	39%
XANTHI				426	3.748					4.174	10%
THESSALONIKI				105.504			12.599			118.103	82%
IMATHIA				1.792						1.792	6%
KILKIS										0	0%
PELLA				2.118						2.118	5%
PIERIA				14						14	0%
SERRES				16.927			558			17.486	40%
CHALKIDIKI				120.621					28.304	148.925	124%
LOZANI										0	0%
GRAVENA										0	0%
KASTORIA				433						433	4%
FLORINA										0	0%
IOANNINA										0	0%
ARTA										0	0%
THERSPROTIA										0	0%
PREVEZA										0	0%
LARISSA						447				447	0%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
KARDITSA										0	0%
MAGNISIA						76				76	0%
SPORADES										0	0%
TRIAKALLA										0	0%
FTHIOTIDA										0	0%
VIOTIA			2.853							2.853	8%
EVIA			16.221							16.221	14%
EVRITANIA										0	0%
FOKIDA										0	0%
KERKIRA						36.806				36.806	50%
ZAKINTHOS										0	0%
ITHAKI										0	0%
KEFALLINIA						0				0	0%
LEYKADA										0	0%
ACHAIA										0	0%
ETOLOAKARNANIA										0	0%
ILIA										0	0%
ARKADIA										0	0%
ARGOLIDA										0	0%
KORINTHIA										0	0%
LAKONIA						4.349				4.349	7%
MESSINIA						23.198				23.198	26%
LESVOS				5.790						5.790	13%
IKARIA										0	0%
LIMNOS										0	0%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
SAMOS										0	0%
CHIOS										0	0%
SIROS						55.260				55.260	335%
ANDROS						4.230				4.230	39%
THIRA						5.459				5.459	8%
KALIMNOS										0	0%
KARPATHOS										0	0%
KEA-KITHNOS						177				177	2%
KOS										0	0%
MILOS						10.911				10.911	47%
MIKONOS										0	0%
NAXOS						5.208				5.208	13%
PAROS						8.206				8.206	21%
RODOS										0	0%
TINOS										0	0%
IRAKLIO					1.695					1.695	1%
LASITHI								4.129		4.129	9%
RETHIMNO										0	0%
CHANIA				1.241						1.241	1%
TOTAL	**13.621**	**68.878**	**372.776**	**293.377**	**21.076**	**154.326**	**13.157**	**4.129**	**28.304**	**969.645**	26%

Table A3.5: Construction activity and assumptions for CDW calculation based on ELSTAT data (2018)

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
ATTICA	768	263	450	454.841	229.300	65.678	74.880	419.328	121.680	541.008	681.566	84.335	765.900
RODOPI	43	12	14	12.918	1.782	1.411	2.330	23.478	3.786	27.264	31.004	2.244	33.249
DRAMA	38	17	6	11.637	10.713	2.146	998	20.748	1.622	22.370	25.514	1.886	27.401
EVROS	34	19	12	6.749	6.169	1.240	1.997	18.564	3.245	21.809	25.046	1.942	26.988
THASOS	21	0	0	10.672	90	1.033	0	11.466	0	11.466	12.499	620	13.119
KAVALA	33	9	7	12.131	3.240	1.476	1.165	18.018	1.893	19.911	22.551	1.584	24.135
XANTHI	43	17	18	18.397	9.757	2.703	2.995	23.478	4.867	28.345	34.043	3.419	37.462
THESSALONIKI	220	61	54	132.160	139.998	26.127	8.986	120.120	14.602	134.722	169.834	21.068	190.902
IMATHIA	47	27	10	24.767	13.123	3.637	1.664	25.662	2.704	28.366	33.667	3.181	36.848
KILKIS	25	11	3	17.284	6.335	2.267	499	13.650	811	14.461	17.228	1.660	18.888
PELLA	51	16	13	13.541	12.649	2.514	2.163	27.846	3.515	31.361	36.039	2.806	38.845
PIERIA	82	37	13	33.926	37.163	6.825	2.163	44.772	3.515	48.287	57.275	5.393	62.668
SERRES	72	59	24	17.719	17.988	3.428	3.994	39.312	6.490	45.802	53.223	4.453	57.676
CHALKIDIKI	241	27	19	80.044	11.825	8.819	3.162	131.586	5.138	136.724	148.705	7.189	155.893
LOZANI	51	7	12	11.958	12.655	2.363	1.997	27.846	3.245	31.091	35.450	2.616	38.066
GRAVENA	7	2	2	4.610	191	461	333	3.822	541	4.363	5.156	476	5.633
KASTORIA	20	5	4	5.778	2.699	814	666	10.920	1.082	12.002	13.481	888	14.369
FLORINA	23	2	3	12.198	7.711	1.911	499	12.558	811	13.369	15.780	1.446	17.226
IOANNINA	71	31	21	44.646	25.694	6.753	3.494	38.766	5.678	44.444	54.691	6.148	60.840
ARTA	20	8	2	15.868	6.842	2.180	333	10.920	541	11.461	13.974	1.508	15.482
THERSPROTIA	49	24	7	14.902	18.667	3.223	1.165	26.754	1.893	28.647	33.034	2.632	35.667
PREVEZA	57	18	6	20.061	11.359	3.016	998	31.122	1.622	32.744	36.759	2.409	39.168

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
LARISSA	112	53	32	54.964	48.986	9.979	5.325	61.152	8.653	69.805	85.109	9.182	94.291
KARDITSA	26	18	6	8.951	5.276	1.366	998	14.196	1.622	15.818	18.183	1.419	19.601
MAGNISIA	88	60	35	22.154	26.512	4.672	5.824	48.048	9.464	57.512	68.008	6.298	74.305
SPORADES	44	11	4	10.588	2.298	1.237	666	24.024	1.082	25.106	27.008	1.142	28.150
TRIAKALLA	55	49	10	19.190	19.653	3.729	1.664	30.030	2.704	32.734	38.127	3.236	41.363
FTHIOTIDA	90	54	7	19.364	27.513	4.500	1.165	49.140	1.893	51.033	56.698	3.399	60.097
VIOTIA	49	43	13	28.479	49.030	7.441	2.163	26.754	3.515	30.269	39.873	5.762	45.636
EVIA	158	68	15	32.069	35.272	6.465	2.496	86.268	4.056	90.324	99.285	5.376	104.661
EVRITANIA	13	6	2	1.558	1.001	246	333	7.098	541	7.639	8.217	347	8.564
FOKIDA	46	9	9	9.777	5.753	1.491	1.498	25.116	2.434	27.550	30.538	1.793	32.331
KERKIRA	149	24	13	47.655	10.785	5.610	2.163	81.354	3.515	84.869	92.643	4.664	97.307
ZAKINTHOS	164	45	26	90.882	30.817	11.683	4.326	89.544	7.030	96.574	112.584	9.606	122.190
ITHAKI	4	1	2	443	20	44	333	2.184	541	2.725	3.102	226	3.328
KEFALLINIA	140	35	15	30.746	5.886	3.517	2.496	76.440	4.056	80.496	86.509	3.608	90.116
LEYKADA	126	9	5	50.864	3.947	5.262	832	68.796	1.352	70.148	76.242	3.656	79.898
ACHAIA	164	62	60	46.576	27.456	7.107	9.984	89.544	16.224	105.768	122.859	10.255	133.114
ETOLOAKARNANIA	139	51	15	32.320	18.176	4.848	2.496	75.894	4.056	79.950	87.294	4.406	91.700
ILIA	133	38	20	26.667	26.177	5.073	3.328	72.618	5.408	78.026	86.427	5.041	91.468
ARKADIA	54	40	25	14.567	9.299	2.291	4.160	29.484	6.760	36.244	42.695	3.871	46.566
ARGOLIDA	67	28	27	19.782	17.605	3.589	4.493	36.582	7.301	43.883	51.965	4.849	56.814
KORINTHIA	98	41	17	39.750	24.804	6.197	2.829	53.508	4.597	58.105	67.131	5.416	72.546
LAKONIA	73	40	10	20.589	12.679	3.194	1.664	39.858	2.704	42.562	47.420	2.915	50.334
MESSINIA	168	44	16	52.816	20.894	7.076	2.662	91.728	4.326	96.054	105.793	5.843	111.636

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
LESVOS	58	23	11	11.982	5.265	1.656	1.830	31.668	2.974	34.642	38.129	2.092	40.220
IKARIA	7	4	1	970	227	115	166	3.822	270	4.092	4.374	169	4.542
LIMNOS	24	4	10	4.148	2.017	592	1.664	13.104	2.704	15.808	18.064	1.354	19.417
SAMOS	34	13	12	5.751	2.246	768	1.997	18.564	3.245	21.809	24.573	1.659	26.232
CHIOS	35	22	26	8.827	8.577	1.671	4.326	19.110	7.030	26.140	32.138	3.598	35.736
SIROS	23	16	3	5.918	2.068	767	499	12.558	811	13.369	14.635	760	15.395
ANDROS	14	9	0	1.847	2.654	432	0	7.644	0	7.644	8.076	259	8.335
THIRA	126	30	5	75.603	6.904	7.921	832	68.796	1.352	70.148	78.901	5.252	84.152
KALIMNOS	54	16	1	10.137	3.494	1.309	166	29.484	270	29.754	31.229	885	32.114
KARPATHOS	23	4	2	7.874	1.701	919	333	12.558	541	13.099	14.351	751	15.102
KEA-KITHNOS	18	2	0	8.836	586	905	0	9.828	0	9.828	10.733	543	11.275
KOS	41	8	3	15.011	24.098	3.754	499	22.386	811	23.197	27.451	2.552	30.003
MILOS	27	8	2	7.126	924	773	333	14.742	541	15.283	16.388	663	17.052
MIKONOS	98	18	5	47.235	14.812	5.957	832	53.508	1.352	54.860	61.649	4.073	65.722
NAXOS	83	32	3	36.600	7.300	4.214	499	45.318	811	46.129	50.843	2.828	53.671
PAROS	98	39	9	27.104	9.711	3.534	1.498	53.508	2.434	55.942	60.973	3.019	63.993
RODOS	88	16	10	26.273	7.895	3.280	1.664	48.048	2.704	50.752	55.696	2.966	58.663
TINOS	51	11	0	14.502	4.289	1.804	0	27.846	0	27.846	29.650	1.082	30.732
IRAKLIO	253	69	28	91.263	42.481	12.839	4.659	138.138	7.571	145.709	163.208	10.499	173.707
LASITHI	72	12	15	22.629	4.804	2.634	2.496	39.312	4.056	43.368	48.498	3.078	51.575
RETHIMNO	135	22	5	60.323	11.177	6.864	832	73.710	1.352	75.062	82.758	4.618	87.376
CHANIA	147	26	19	60.549	21.436	7.871	3.162	80.262	5.138	85.400	96.432	6.619	103.051
TOTAL	**5.685**	**1.905**	**1.254**	**2.208.066**	**1.200.455**	**327.218**	**208.666**	**3.104.010**	**339.082**	**3.443.092**	**3.978.975**	**321.530**	**4.300.505**

Table A3.6: CDW quantities managed through PROs, per regional unit (2018) (units in tones)

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
ATTICA	16.176	162.341	1.123.398							1.301.915	170%
RODOPI				7.420	6.788					14.208	43%
DRAMA				4.048	25.676					29.724	108%
EVROS				30.636	2.044					32.679	121%
THASOS										0	0%
KAVALA				5.846	36.589					42.435	176%
XANTHI				17.914	506					18.420	49%
THESSALONIKI				197.576			15.519			213.095	112%
IMATHIA				7.330						7.330	20%
KILKIS										0	0%
PELLA				3.529						3.529	9%
PIERIA				4.683						4.683	7%
SERRES				51.035			3.627			54.662	95%
CHALKIDIKI				21.747					4.575	26.322	17%
LOZANI										0	0%
GRAVENA										0	0%
KASTORIA				7.840	6.925					14.765	103%
FLORINA				10.593						10.593	61%
IOANNINA										0	0%
ARTA										0	0%
THERSPROTIA										0	0%
PREVEZA										0	0%
LARISSA				137.085		14.683				151.768	161%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
KARDITSA										0	0%
MAGNISIA			43.169			3.988				47.157	63%
SPORADES										0	0%
TRIAKALLA										0	0%
FTHIOTIDA										0	0%
VIOTIA			8.554							8.554	19%
EVIA			64.115							64.115	61%
EVRITANIA										0	0%
FOKIDA										0	0%
KERKIRA						6.872				6.872	7%
ZAKINTHOS										0	0%
ITHAKI										0	0%
KEFALLINIA										0	0%
LEYKADA										0	0%
ACHAIA				2.219						2.219	2%
ETOLOAKARNANIA										0	0%
ILIA										0	0%
ARKADIA										0	0%
ARGOLIDA										0	0%
KORINTHIA										0	0%
LAKONIA						121.618				121.618	242%
MESSINIA						38.694				38.694	40%
LESVOS				62.105						62.105	179%
IKARIA										0	0%
LIMNOS										0	0%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
SAMOS										0	0%
CHIOS										0	0%
SIROS						26.620				26.620	199%
ANDROS						1.118				1.118	15%
THIRA						5.596				5.596	8%
KALIMNOS										0	0%
KARPATHOS										0	0%
KEA-KITHNOS						3.113				3.113	32%
KOS										0	0%
MILOS						6.600				6.600	43%
MIKONOS						4.526				4.526	8%
NAXOS						12.648				12.648	27%
PAROS						10.665				10.665	19%
RODOS										0	0%
TINOS										0	0%
IRAKLIO					7.487					7.487	5%
LASITHI								7.856		7.856	18%
RETHIMNO										0	0%
CHANIA				45.411						45.411	53%
TOTAL	**16.176**	**162.341**	**1.239.236**	**617.017**	**86.014**	**256.741**	**19.145**	**7.856**	**4.575**	**2.409.102**	56%

Table A3.7: Construction activity and assumptions for CDW calculation based on ELSTAT data (2018)

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
ATTICA	1.016	300	614	709.394	246.345	91.751	102.170	554.736	166.026	720.762	914.682	116.352	1.031.034
RODOPI	71	37	16	15.657	6.353	2.113	2.662	38.766	4.326	43.092	47.868	2.865	50.733
DRAMA	22	21	12	16.175	17.431	3.226	1.997	12.012	3.245	15.257	20.480	3.134	23.614
EVROS	39	34	8	9.799	11.510	2.046	1.331	21.294	2.163	23.457	26.834	2.026	28.860
THASOS	66	5	3	28.135	2.448	2.936	499	36.036	811	36.847	40.282	2.061	42.343
KAVALA	176	28	16	56.973	19.980	7.387	2.662	96.096	4.326	100.422	110.472	6.030	116.502
XANTHI	35	11	16	10.560	4.995	1.493	2.662	19.110	4.326	23.436	27.592	2.493	30.085
THESSALONIKI	231	88	70	124.541	90.651	20.658	11.648	126.126	18.928	145.054	177.360	19.384	196.744
IMATHIA	44	46	14	17.071	13.725	2.956	2.330	24.024	3.786	27.810	33.096	3.172	36.267
KILKIS	14	14	2	4.340	14.848	1.842	333	7.644	541	8.185	10.360	1.305	11.665
PELLA	48	31	6	40.574	10.891	4.941	998	26.208	1.622	27.830	33.769	3.563	37.333
PIERIA	85	46	14	27.693	39.392	6.440	2.330	46.410	3.786	50.196	58.965	5.262	64.227
SERRES	62	33	9	18.258	22.617	3.924	1.498	33.852	2.434	36.286	41.707	3.253	44.960
CHALKIDIKI	277	45	18	90.614	25.263	11.124	2.995	151.242	4.867	156.109	170.229	8.472	178.700
LOZANI	54	22	7	21.197	13.496	3.331	1.165	29.484	1.893	31.377	35.872	2.697	38.569
GRAVENA	7	5	0	1.157	408	150	0	3.822	0	3.822	3.972	90	4.062
KASTORIA	6	1	2	1.439	14.556	1.536	333	3.276	541	3.817	5.685	1.121	6.806
FLORINA	11	1	0	2.632	4.554	690	0	6.006	0	6.006	6.696	414	7.110
IOANNINA	92	38	27	56.755	30.243	8.352	4.493	50.232	7.301	57.533	70.377	7.707	78.084
ARTA	23	11	7	12.351	3.805	1.551	1.165	12.558	1.893	14.451	17.167	1.629	18.796
THERSPROTIA	65	19	4	22.829	13.516	3.489	666	35.490	1.082	36.572	40.726	2.493	43.219

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
PREVEZA	51	8	7	15.923	7.648	2.263	1.165	27.846	1.893	29.739	33.166	2.057	35.223
LARISSA	134	68	29	56.162	64.512	11.585	4.826	73.164	7.842	81.006	97.416	9.846	107.262
KARDITSA	27	15	2	15.138	7.928	2.214	333	14.742	541	15.283	17.830	1.528	19.358
MAGNISIA	71	41	42	23.891	14.760	3.710	6.989	38.766	11.357	50.123	60.822	6.420	67.242
SPORADES	23	12	6	10.227	1.795	1.154	998	12.558	1.622	14.180	16.333	1.292	17.624
TRIAKALLA	60	45	11	28.118	15.952	4.231	1.830	32.760	2.974	35.734	41.796	3.637	45.432
FTHIOTIDA	71	28	10	17.823	18.809	3.517	1.664	38.766	2.704	41.470	46.651	3.108	49.759
VIOTIA	40	28	15	18.898	33.164	4.998	2.496	21.840	4.056	25.896	33.390	4.496	37.886
EVIA	132	52	20	31.491	14.554	4.420	3.328	72.072	5.408	77.480	85.228	4.649	89.877
EVRITANIA	14	5	2	2.469	1.067	339	333	7.644	541	8.185	8.857	403	9.260
FOKIDA	21	17	7	2.954	5.428	805	1.165	11.466	1.893	13.359	15.328	1.182	16.510
KERKIRA	156	36	13	45.750	13.170	5.656	2.163	85.176	3.515	88.691	96.511	4.692	101.202
ZAKINTHOS	154	48	28	54.464	16.182	6.782	4.659	84.084	7.571	91.655	103.096	6.865	109.961
ITHAKI	1	0	0	102	0	10	0	546	0	546	556	6	562
KEFALLINIA	168	45	18	31.015	13.971	4.319	2.995	91.728	4.867	96.595	103.909	4.388	108.297
LEYKADA	139	12	4	40.853	4.980	4.400	666	75.894	1.082	76.976	82.041	3.039	85.081
ACHAIA	145	83	37	39.222	39.290	7.537	6.157	79.170	10.005	89.175	102.869	8.216	111.085
ETOLOAKARNANIA	122	47	14	36.725	30.560	6.459	2.330	66.612	3.786	70.398	79.187	5.273	84.460
ILIA	64	27	17	21.234	9.480	2.949	2.829	34.944	4.597	39.541	45.318	3.466	48.785
ARKADIA	39	35	9	7.943	9.603	1.684	1.498	21.294	2.434	23.728	26.910	1.909	28.819
ARGOLIDA	58	23	18	17.389	14.788	3.089	2.995	31.668	4.867	36.535	42.619	3.651	46.270
KORINTHIA	78	49	35	31.635	22.384	5.186	5.824	42.588	9.464	52.052	63.062	6.606	69.668
LAKONIA	63	35	15	12.892	11.512	2.343	2.496	34.398	4.056	38.454	43.293	2.903	46.196

Regional Unit	New Construction	Extensions	Demolitions	Surface of new Construction	Surface of Additions	CW	DW	EW (C)	EW (D)	EW (total)	ECDW PR	CDW PU	Total
MESSINIA	166	32	18	43.661	16.990	5.822	2.995	90.636	4.867	95.503	104.321	5.291	109.612
LESVOS	64	11	15	15.090	4.268	1.858	2.496	34.944	4.056	39.000	43.354	2.613	45.967
IKARIA	9	6	1	1.825	773	249	166	4.914	270	5.184	5.600	249	5.850
LIMNOS	21	3	10	6.561	1.049	731	1.664	11.466	2.704	14.170	16.565	1.437	18.001
SAMOS	29	9	5	9.362	2.820	1.169	832	15.834	1.352	17.186	19.187	1.201	20.388
CHIOS	40	20	12	8.924	7.755	1.601	1.997	21.840	3.245	25.085	28.683	2.159	30.842
SIROS	16	16	6	4.249	2.169	616	998	8.736	1.622	10.358	11.973	969	12.942
ANDROS	12	10	5	2.945	1.774	453	832	6.552	1.352	7.904	9.189	771	9.960
THIRA	119	42	6	50.634	18.682	6.654	998	64.974	1.622	66.596	74.249	4.592	78.841
KALIMNOS	29	12	4	5.460	1.180	637	666	15.834	1.082	16.916	18.219	782	19.000
KARPATHOS	16	3	3	3.854	241	393	499	8.736	811	9.547	10.440	535	10.975
KEA-KITHNOS	16	2	1	4.227	1.584	558	166	8.736	270	9.006	9.731	435	10.165
KOS	45	13	6	25.721	26.870	5.049	998	24.570	1.622	26.192	32.240	3.628	35.868
MILOS	44	22	6	11.893	8.467	1.955	998	24.024	1.622	25.646	28.599	1.772	30.371
MIKONOS	94	14	11	59.807	14.303	7.115	1.830	51.324	2.974	54.298	63.243	5.367	68.610
NAXOS	93	42	7	40.041	5.632	4.385	1.165	50.778	1.893	52.671	58.220	3.330	61.550
PAROS	133	21	10	40.643	8.192	4.688	1.664	72.618	2.704	75.322	81.674	3.811	85.485
RODOS	97	22	7	29.727	15.512	4.343	1.165	52.962	1.893	54.855	60.363	3.305	63.667
TINOS	2	0	1	1.204	100	125	166	1.092	270	1.362	1.654	175	1.829
IRAKLIO	272	64	42	108.284	43.205	14.543	6.989	148.512	11.357	159.869	181.401	12.919	194.320
LASITHI	79	16	8	23.751	6.397	2.894	1.331	43.134	2.163	45.297	49.523	2.535	52.058
RETHIMNO	133	16	8	81.777	16.888	9.472	1.331	72.618	2.163	74.781	85.584	6.482	92.066
CHANIA	240	43	23	93.964	16.699	10.624	3.827	131.040	6.219	137.259	151.710	8.671	160.381
TOTAL	6.044	2.034	1.439	2.524.066	1.200.114	357.521	239.450	3.300.024	389.106	3.689.130	4.286.100	358.183	4.644.283

Table A3.8: CDW quantities managed through PROs, per regional unit (2019) (units in tones)

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
ATTICA	34.998	413.573	1.734.089	0						2.182.661	211,70%
RODOPI				4.229	8.570					12.799	25,23%
DRAMA				2.573	7.870					10.443	44,23%
EVROS				16.592	2.316					18.908	65,52%
THASOS										0	0,00%
KAVALA				10.764	15.080					25.844	22,18%
XANTHI				13.294	11.733					25.027	83,19%
THESSALONIKI				289.367	87.984		40.107			417.458	212,18%
IMATHIA				462	1.543		65			2.070	5,71%
KILKIS					4.705					4.705	40,34%
PELLA				5.871	1.983		24.466			32.320	86,57%
PIERIA				6.248	684		56			6.988	10,88%
SERRES				13.073	7.657		14.759			35.489	78,94%
CHALKIDIKI				117.752			27.330		5.000	150.082	83,99%
LOZANI				12.450						12.450	32,28%
GRAVENA										0	0,00%
KASTORIA				4.150	20.636					24.787	364,18%
FLORINA				7.922	692					8.613	121,15%
IOANNINA				12.492						12.492	16,00%
ARTA										0	0,00%
THERSPROTIA										0	0,00%
PREVEZA										0	0,00%
LARISSA				190.033	8.761	48.609				247.403	230,65%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
KARDITSA										0	0,00%
MAGNISIA			22.117			13.254				35.371	52,60%
SPORADES										0	0,00%
TRIAKALLA					2.034					2.034	4,48%
FTHIOTIDA										0	0,00%
VIOTIA			29.764							29.764	78,56%
EVIA			125.304							125.304	139,42%
EVRITANIA										0	0,00%
FOKIDA			10.949	25.706						36.655	222,02%
KERKIRA						23.550				23.550	23,27%
ZAKINTHOS				2.364						2.364	2,15%
ITHAKI										0	0,00%
KEFALLINIA				14.736						14.736	13,61%
LEYKADA										0	0,00%
ACHAIA			17.327	22.275						39.602	35,65%
ETOLOAKARNANIA				7.728						7.728	9,15%
ILIA										0	0,00%
ARKADIA			230							230	0,80%
ARGOLIDA										0	0,00%
KORINTHIA			536							536	0,77%
LAKONIA						319.200				319.200	690,97%
MESSINIA						37.509				37.509	34,22%
LESVOS				68.155						68.155	148,27%
IKARIA										0	0,00%
LIMNOS					1.440					1.440	8,00%

Regional Unit	ΑΕΚΚ ΑΤΤΙΚΗΣ	ΣΕΔΠΕΚΑΤ	ΣΑΝΚΕ	ΑΝΑΚΕΜ	ΑΝΑΒΕ	ΑΑΝΕΛ	ΨΑΡΡΑΣ	ΔΙΑΣ	ΚΤΕΝΙΔΗΣ - ΚΟΥΦΙΔΗΣ	TOTAL	%
SAMOS										0	0,00%
CHIOS				12.069						12.069	39,13%
SIROS						41.175				41.175	318,16%
ANDROS						2.327				2.327	23,37%
THIRA						12.884				12.884	16,34%
KALIMNOS										0	0,00%
KARPATHOS										0	0,00%
KEA-KITHNOS			200			3.595				3.795	37,33%
KOS										0	0,00%
MILOS						14.683				14.683	48,34%
MIKONOS						82.886				82.886	120,81%
NAXOS					207	8.742				8.949	14,54%
PAROS						16.171				16.171	18,92%
RODOS										0	0,00%
TINOS										0	0,00%
IRAKLIO					17.469					17.469	8,99%
LASITHI				11.418				2.538		13.956	26,81%
RETHIMNO										0	0,00%
CHANIA				426.506						426.506	265,93%
TOTAL	**34.998**	**413.573**	**1.940.516**	**1.298.230**	**201.364**	**624.586**	**106.783**	**2.538**	**5.000**	**4.627.590**	100%

CW: Construction Waste
DW: Demolition Waste
EW (C): Excavation Waste – Construction
EW (D): Excavation Waste – Demolition
EW = EW (C) + EW (D)
CDW PR: CDW Private Works
CDW PU: CDW Public Works

Annex 4: Photos

LIST OF PHOTOS

Photo 4A.1: Selective Demolition

Photo 4A.2: Open-type Reversible Truck

Photo 4A.3: Skip loader – type truck for skip containers

Photo 4A.4: Hook – Lift type truck for container roll-type

Photo 4A.5: Quarry rehabilitation/restoration

Photo 4A.6: Spent Abandoned Quarry

Photo 4A.7: Inert Waste Landfill

Annex 5: List of PROs

Table 5A.1: List of PROs

PRO	ADRESS	Tel/E-mail/Website
ANABE P.C. (ΑΝΑΚΥΚΛΩΣΗ ΑΔΡΑΝΩΝ ΒΟΡΕΙΟΥ ΕΛΛΑΔΟΣ)	Thessaloniki industrial area, Block 49, 57022 Sindos	2310795968 kaisidis@otenet.gr www.anabe.gr
AANEL P.C (ΑΝΑΚΥΚΛΩΣΗ ΑΔΡΑΝΩΝ ΝΟΤΙΟΥ ΕΛΛΑΔΟΣ)	1 Isminis @ Leonida str, 15344 Gerakas	2106047497 info@aanel.gr www.aanel.gr
ANAKEM P.C. (ΑΝΑΚΥΚΛΩΣΗ ΑΕΚΚ ΚΕΝΤΡΙΚΗΣ ΜΑΚΕΔΟΝΙΑΣ)	1 G. Frantzi str, 54655 Thessaloniki	2310595085 info@anakem.gr www.anakem.gr
AEKK ATTIKIS P.C (ΑΝΑΚΥΚΛΩΣΗ ΑΕΚΚ ΑΤΤΙΚΗΣ)	11 A. Prifti & G. Profi str, 19400 Koropi	2106026165 aekkattikis@gmail.com www.aekkattikis.gr
DIAS P.C (ΑΠΟΣΤΟΛΑΚΗΣ ΕΜΜ. & ΣΙΑ Ο.Ε.)	Kastelli area, 72100 Agios Nikolaos Crete	2841022096 www.dias-aekk.gr
I. KTENIDIS – I. KOUFIDIS P.C (Ι. ΚΟΥΦΙΔΗΣ - Ι. ΚΤΕΝΙΔΗΣ & ΣΙΑ Ο.Ε. - ΣΥΣΤΗΜΑ ΣΥΛΛΟΓΙΚΗΣ ΕΝΑΛΛΑΚΤΙΚΗΣ ΔΙΑΧΕΙΡΙΣΗΣ ΧΑΛΚΙΔΙΚΗΣ Ο.Ε.)	12 Thessalonikis str, 63200 N. Moudania	2373023010
PSARRAS P.C. (ΨΑΡΡΑΣ ΕΝΑΛΛΑΚΤΙΚΗ ΔΙΑΧΕΙΡΙΣΗ Α.Μ.Κ.Ε.)	8 Kallipateiras str, 56224 Evosmos Thessaloniki	2310587760
SANKE LTD (ΣΥΣΤΗΜΑ ΑΝΑΚΥΚΛΩΣΗΣ ΚΕΝΤΡΙΚΗΣ ΕΛΛΑΔΑΣ Ε.Π.Ε.)	8 Iatridou str, 34100 Chalkis	2221400738 info@sanke.gr www.sanke.gr
SEDPEKAT P.C. (ΕΝΑΛΛΑΚΤΙΚΗ ΔΙΑΧΕΙΡΙΣΗ ΠΡΟΪΟΝΤΩΝ ΕΚΣΚΑΦΩΝ, ΚΑΤΕΔΑΦΙΣΕΩΝ Α.Ε.)	92 Agnoston Iroon str, 14231 Nea Ionia Attica	2130238752 info@sedpekat.gr www.sedpekat.gr

Annex 6: Geographical Coverage of PROs (Map)

ANNEX 7_MAP.pdf

Annex 7: Kick Off Meeting Presentation

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Annex 8: Selected Best Practices

Best Practices for CDW Logistics

Belgian example of a C&D waste tracking (Tracimat)
Tracimat is a non-profit, independent demolition management organization recognized by the Belgian public authorities that issue a "certificate of selective demolition" for a specific C&D material that has been collected selectively at the demolition site and subsequently gone through a tracing system. The demolition certificate shows the processor whether the C&D material can be accepted as "low environmental risk material" which means that the purchaser (recycling plant) can be quite sure that the C&D material meets the quality standards for processing at the recycling plant. Therefore the “low environmental risk material” can be processed separately from” the high environmental risk material”. Because of the unknown origin and/or the unknown quality the “high environmental risk material” must be controlled more stringently than the “low environmental risk material” so the processing will be more expensive. All this will boost trust in the demolishing contractors and the recycled product, resulting in improved and more widespread marketing of recycled C&D materials. In the future, other demolition waste management organizations could be recognized by the relevant public authorities. Tracimat does not issue a certificate of selective demolition until the waste has gone through the traceability system. The tracing process starts with the preparation of a demolition inventory and waste management plan prepared by an expert prior to the selective demolition and dismantling work. To guarantee the quality of the demolition inventory and waste management plan, they must be prepared according to a specific procedure. Tracimat will check the quality of the demolition inventory and waste management plan and issue a declaration on its conformity. Tracimat checks whether both the hazardous waste and the non-hazardous waste that complicates the recycling of the specific demolition C&D material, have been selectively and properly disposed of. Tracimat initially focused on the stony fraction, which in terms of weight by far represents the greatest portion of the construction and demolition waste and will deal with other C&D materials at a later stage. The 'eenheidsreglement' is a certification regulation for recycled aggregates that consist of an internal control and an external control by an accredited certification organization. 'Clean input gives clean output' is the general motto of this policy. It also explains the distinction between streams with a Low Environmental Risk Profile (LERP) and streams with a High Environmental Risk Profile (HERP). In fact the Tracimat-system is one way for the crusher to accept debris as LERP, beside other possibilities. So the 'eenheidsreglement' stands on its own and is a management system and certification regulation for recycled aggregates. Tracimat is a type of tracing system for debris derived from selective demolition. ***Source: EU Construction & Demolition Waste Management Protocol, 2016***

Best Practices for Demolition Process & QAP

Dutch certification scheme for demolition processes (BRL SVMS 007)

In the Netherlands, most contractors are certified by the demolition process scheme **BRL SVMS-007** which is controlled by third parties and the Council of Accreditation. The certified demolition process follows four steps:

Step 1 Pre-demolition audit: The demolition contractor carries out an advanced inspection of the demolition project and an inventory of the materials (hazardous and non-hazardous) to get insight into the nature, quantity and any contamination of the extracted demolition materials. An inventory is made of the risks to occupational safety and safety risks to the surroundings.

Step 2 Waste management plan: A waste management plan is drawn up that includes a description of the method of selective demolition and environmentally-friendly demolition, processing and removal of released material flows, safety measures that have to be taken and implementation requirements of the customer.

Step 3 Execution: The execution of the demolition occurs in accordance with the waste management plan. Experts in the area of safety and environmentally-friendly demolition are involved and certified demolition contractors work with approved equipment. The demolition contractor must ensure that the demolition location is safe and well organized and that the released material flows do not contaminate the soil and the surroundings.

Step 4 Final report: The delivery of the project takes place in consultation with the involved parties. A final report of the released demolition materials is drawn up by the demolition contractor, and it is supplied to the customer upon request.

*Source**: EU Construction & Demolition Waste Management Protocol, 2016***

QUALIRECYCLE BTP, a French audit tool designed for C&D waste management companies

The voluntary French Management and Audit Scheme, QUALIRECYCLE BTP, is a management scheme developed by Syndicat des Recycleurs du BTP (SR BTP) for waste management companies to evaluate, report and improve their performance in the compliance, environment and safety fields and show their commitment to recovering issues.
The framework of the scheme contains 5 sections with mandatory and recommended parameters to assess the level of:

- Governance and transparency
- Regulatory compliance
- Monitoring of the environmental effects of the activity
- Safety of people and work conditions
- Performance in terms of sorting and recovering rates.

The label is delivered by the follow-up committee of the Syndicat des Recycleurs du BTP (professional organization linked to the French construction association), after a labelling audit carried out by an independent consultant.
*Source: **EU Construction & Demolition Waste Management Protocol, 2016***

Northern Ireland Environmental Agency – Quality Protocol

This Quality Protocol was funded by Defra, the Welsh Government and the Northern Ireland Environment Agency (NIEA) as a business resource efficiency activity. It was developed by the Environment Agency and WRAP (Waste & Resources Action Programme) in consultation with Defra, the Welsh Government, industry and other regulatory stakeholders. The Quality Protocol is applicable in England, Wales and Northern Ireland. It sets out the end of waste criteria for the production and use of aggregates from inert waste.

*Source: **Northern Ireland Environmental Agency, 2013***

Best Practices for removing hazardous and other harmful materials

Recovinyl
Recovinyl is an initiative by the European PVC value-chain aimed at facilitating PVC waste collection and recycling under the Voluntary Commitments of Vinyl 2010 and now VinylPlus®. Established in 2003 by Vinyl 2010, PRE (European Recyclers Association) and EUPC (European Converters Association). Recovinyl's target is to stimulate and certify the recycling of 800,000 tonnes of PVC waste by 2020 as one of the challenges set in the VinylPlus Voluntary Commitment. VinylPlus has also recently committed to recycle and certify the use of at least 900,000 tonnes of PVC per year into new products by 2025, securing PVC's place at the heart of the Circular Economy. In 2018 alone, 734,568, tonnes of Recycled PVC waste were registered, a 16% increase from 2017. This number represents PVC recycling which were entirely recycled in Europe. Source: https://www.recovinyl.com/about-us

Austrian standard ÖNORM B3151
The present ÖNORM describes the measures needed for the planning and execution of the dismantling of buildings and specifies separation principles for the different materials in regard to recovery or disposal. The dismantling objective is to obtain mono-material mostly free of harmful substances and impurities. If ecologically appropriate, technically possible and not unreasonably cost-intensive, the waste products of the dismantling process shall be recovered. Harmful substances and impurities have to be examined and separated to obtain recyclable mono-fraction demolition materials. The present ÖNORM describes the dismantling in structural and civil engineering including line construction works and paved area. For dealing with asbestos-containing material ÖNORM M 9406 is implemented Source: https://shop.austrian-standards.at/action/en/public/details/532055/OENORM_B_3151_2014_12_01

Best Practices for recycled materials specifications

The Estonian Recycling Competence Centre

The Estonian Recycling Competence Centre (henceforth the Recycling Competence Centre) came as a result of an evolutionary process of knowledge and networking development projects planned and administered by the Estonian Waste Management Association (EWMA). The EWMA acts as an umbrella organization, representing the majority of enterprises engaging in waste management in Estonia, and especially the companies that focus on waste material recycling and recovery into useful products. The mission of EWMA is to stand for the common interests of the members and to develop waste management in Estonia directed by the general principles of sustainable development.

Waste management and recycling activities are increasingly becoming more and more sophisticated and technology intensive. In order for Estonia to become a competitive player in the future market development within the field of waste management and recycling, it is important that the local professional competence of waste recycling enterprises should be sufficiently developed and grow through research and innovation.

Furthermore, the products of recycling and recovery operations should meet certain quality standards and be certified in order to be competitive against natural materials and create added value within the waste recycling sector.

For dealing with the challenges identified above, the Estonian Recycling Competence Centre was founded in September 2013 as a non-profit organization with the aim to increase waste recycling in Estonia and to support waste recycling companies in producing high quality and certified materials from waste.

The activities of the Recycling Competence Centre are focused on development of different waste recycling projects (incl. international projects), trainings for all stakeholders in waste management/recycling and also sharing internationally the experiences of Estonian companies in waste recycling. Three waste product group categories have been identified as priority areas in the working programme of the Recycling Competence Centre. These are:

1. Production of compost

2. Production of recycled aggregates

3. Production of recovered fuels

The Recycling Competence Centre has established a foundation that would develop technical standards and proceed into waste products certification. A certification scheme has been developed for crushed concrete (primarily) and in the longer term it is envisaged that other CDW materials will be included as well. The certification of CDW materials will ensure high and common applied standards for crushed concrete to be used as aggregates for construction purposes. The certification will increase the visibility and confidence in use of this material instead of natural aggregates and it is expected to boost the image of recycled CDW while raising awareness about the quality of the recycled materials among the relevant actors in the construction and retail sector (of materials).

The Recycling Competence Centre's founders include the following companies: AS Kunda Nordic Cement, Ragn-Sells AS, the Estonian Environmental Services AS, AS Tallinna Waste Recycling Center and Landfill Väätsa AS.

Source: **Deloitte (2016). Resource Efficient Use of Mixed Wastes Case study: Estonian Recycling Competence Centre V2 – April 2016**

Best Practices for waste processing & treatment

Wood recycling into wood-based panels

Wood can be recycled into particle boards. In 2014, the European particle board industry in the EPF member countries consumed 18.5 million tonnes of wood raw material. The average share of recovered wood was 32%, the other raw material categories being processed round wood (29%) and industrial by-products (39%). Recovered wood continued to be used as the major raw material source in Belgium, Denmark, Italy and the United Kingdom. Austria, Germany, Spain and France also used important quantities of recovered wood for particle board manufacturing, reflecting the encompassing problem of wood availability. Other European countries still use primarily roundwood and industrial residues due to the lack of an efficient collecting system or thanks to less pressure from the incentivised bioenergy sector. The share of CDW in the recovered wood fraction used for panel production is currently rather low but rising with the improvement of appropriate source separation and collection from C&D sites.

Source: **European Panel Federation (EPF) and Europanels, www.europanels.org, 2016 in English**

Recycling and re-use of mineral wool

Mineral wool can be recycled into new mineral wool products and it can serve as raw material for bricks and ceiling tiles, for example. Mineral wool construction waste arises in very small quantities at construction or renovation sites. As mineral wool is flexible by nature, often rest material will be re-used on-site immediately to fill gaps for example, resulting in low quantities of remaining waste. Recycling of this clean waste stream is technically possible, but is a costly and infrastructure-driven process as for all stakeholders. Requirements for selective demolition and separation of waste streams are a pre-requisite, whereas after-sorting will often be necessary to guarantee sufficiently clean waste stream.

Today's release of mineral wool demolition waste is rather small but the quantities will increase in the future, as the buildings from the 1970's or 80's get old and the average renovation time is 30+ years. Collection and recycling of mineral wool demolition waste thus very much relies on demolition and sorting techniques as well as economic viability and regulatory frameworks. Mandatory separation, after-sorting obligations and training could improve this situation, although the small quantities (as well in weight) of mineral wool demolition waste remain a barrier for cost-effective solutions.

Information Sheet on Waste Handling of Mineral Wool Insulation:

http://www.eurima.org/uploads/ModuleXtender/Publications/151/Eurima_waste_handling_Info_Sheet_06_06_2016_final.pdf

Source: **European Insulation Manufacturers Association (EURIMA), 2016, http://www.eurima.org/ in English**