WASTE CONTROL

Waste Management Options for Greenhouse Gases Emissions Control - LIFE09 ENV/GR/000294






LAYMAN'S REPORT

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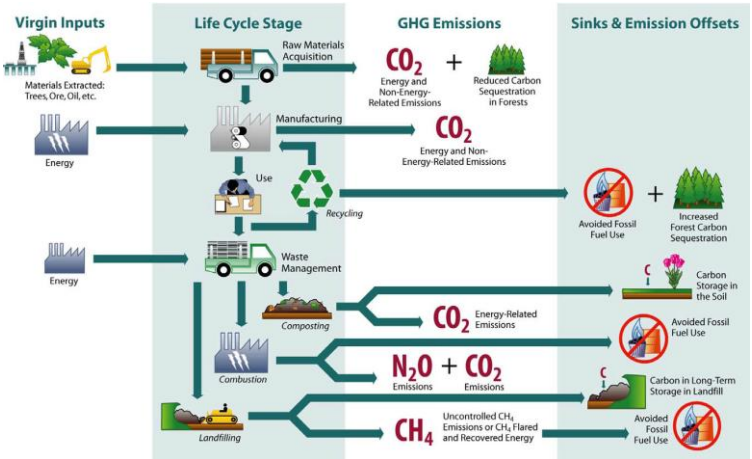
PROJECT SCOPE AND OBJECTIVES

Climate change is a major global concern for modern society. Since the pre-industrial era, atmospheric concentrations of carbon dioxide (CO_2) have increased by 35%, while methane (CH_4) concentrations have more than doubled. There is scientific consensus that the observed increase in global average temperatures since the mid 20th century is due to the increase in concentrations of such greenhouse gases (GHG) produced by human activity, primarily the combustion of fossil fuels such as coal, oil and natural gas. [1]

The European Union (EU) has long been committed to international efforts to tackle climate change. At European level a comprehensive package of policy measures to reduce Greenhouse Gas (GHG) emissions has been initiated, in 2000, through the European Climate Change Programme (ECCP). Each of the EU Member States (MS) has also put in place its own domestic actions that build on the ECCP measures or complement them. [2]

GHG can be produced at each stage of a product's life cycle: from raw material extraction, transport, manufacturing, use and final treatment or disposal of materials. By relating this life cycle to the waste hierarchy, we can see how each level of the hierarchy impacts on climate change.

Waste management (WM) generates CO_2 and CH_4, which are both GHG. The impact of WM on the global warming equivalence of European GHG emissions comes mostly from CH_4 released as biodegradable wastes decay under the airless (anaerobic) conditions in landfills.



Greenhouse Gas Sources and Sinks Associated with the Material Life Cycle, US EPA 2006

[1] ISWA White Paper: Waste and Climate Change, 2009

[2] European Climate Change Programme: http://ec.europa.eu/clima/policies/eccp/index_en.htm

According to the EC, about a third of anthropogenic emissions of CH_4 in the EU can be attributed to this source. The global direct GHG emissions resulting from WM activities are around 1,3Gt CO_2 eq. or approximately 3 – 5% of the total anthropogenic emissions in 2005.[3] In Greece, ~80% of the waste goes to landfills, thus creating a major problem in methane emissions management and control.

Combating climate change is a top priority of the EU policy. In the EU region, municipal waste management activities alone could potentially account for 18% of the 2012 Kyoto GHG reduction target set for the original 15 EU Member States.

There is currently credible evidence that, taking into account associated avoided emissions, the waste sector can completely change this picture. On regional and city scales, the waste sector has the opportunity to change from a net emitter into a net reducer of GHG emissions. Through careful selection and use of existing waste management systems and technologies, many regions and cities can work to achieve an internationally significant reduction of GHG emissions.

The waste management sector offers proven, practical and cost effective technologies which can contribute to GHG mitigation. When adapted and deployed according to local traditions and needs, they can help secure significant global GHG emissions savings. Solutions might include waste prevention, recycling and reuse, biological treatment with land use of products, energy recovery and engineered landfilling.

In this context, the WASTE-C-CONTROL project, titled “Waste Management Options for Greenhouse Gases Emissions Control” was proposed for co-funding to the EC LIFE+2009 program. The project’s overall goal was to contribute to the global effort to combat climate change, through the assessment and proposal of new waste management options and practices at local level.

The WASTE-C-CONTROL Software Tool enables Waste Management Authorities and other stakeholders to substantially reduce GHG emissions resulting from their WM activities. The tool provides "decision support" for the optimization of WM practices, in terms of GHG emissions and financial data, through a simulation environment where an existing or desired regional / local waste management system can be designed by the user. The innovative idea is the incorporation of an optimization function through which the tool will calculate the optimal values for the decision variables using Mathematical Programming (MP). Moreover, a demo version of the tool was made available through the realization of the WASTE-C-CONTROL iOS application.

The results of the tool facilitated the identification of procedures for the development of Local Action Plans, which aim to reduce GHG emissions from WM activities at local level. Each Action Plan sets specific quantitative goals for GHG emissions reductions, specifies the means to attain them, as well as the relevant investments that need to take place and the timing of these investments. The implementation of specific short-term actions and measures took place between January and September 2013.

[3] IPCC Climate Change 2007: Chapter 10. Waste Management in Climate Change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007

PROJECT AREA

The WASTE-C-CONTROL project was implemented from October 2010 until September 2013 in Greece, in the Region of Eastern Macedonia & Thrace (population 608.000, 2011), the Region of Western Macedonia (population 301.500, 2011) and the Regional Union of Chania, Crete (population 156.500, 2011). The Coordinating Beneficiary was the environmental consulting firm EPEM S.A.

The project's Associated Beneficiaries, DIAAMATH (WM Authority of Eastern Macedonia and Thrace), DIADYMA (WM System of Western Macedonia) and DEDISA (Trans-Municipal Enterprise of SWM of Chania), are the active WM Authorities in these regions of Greece.

METHODOLOGY IMPLEMENTED

The implemented methodology, in accordance with the project Actions, comprised of the following.

1. Collection of data and development of a database on waste management technologies

   Formulation of data collection questionnaires. Literature review and site visits. Communication with key players in the solid waste management sector in Greece and the EU. Data collection. Development of a database on WM technologies and data entry. Preliminary disaggregation of waste technologies in their main technical components.

2. Disaggregation of WM technologies and design of the WASTE-C-CONTROL Software Tool

   Final disaggregation of waste technologies. Determination of categories of process technologies and potential combinations. Module operation modeling. Formulation of the list of required procedures to be performed by the tool. Identification of user requirements.

3. WASTE-C-CONTROL Software Tool development

   Development of the tool's user interface. Process modeling. Development of mathematical programming algorithms to be incorporated to the tool. WASTE-C-CONTROL Software Tool development. Tool testing. Tool assessment. Training of the WM Authorities' personnel on the use of the tool. Realization of the WASTE-C-CONTROL iOS application for mobiles and tablets (also serving as the Tool's demo version).

4. Development of Local Action Plans (LAP) in the 3 Regional Waste Management Authorities, for reducing GHG emissions from the solid waste sector

   Collection of local data. Projection of generated solid waste quantities up to 2025. "Guidance Document on Best Management Practices" for landfill operators and regulators. Elaboration of "Reference Case" with respect to local WM. Development of a LAP for each administrative region and presentations in open events.

5. Implementation of the Local Action Plans

   Use of the tool's "best practices" and exchange of experiences. Elaboration of necessary studies and preparatory actions for the implementation of SWM practices and measures. Establishment of a Monitoring Team to overview the implementation of each LAP, Monitoring Plans and Practical Guidelines for the implementation of the measures proposed in the LAPs.

6. Communication and dissemination

   Website development and regular update. Notice boards at strategic places accessible to the public. Formulation and distribution of dissemination material. Informative meetings with local associations and NGOs. Dissemination of the project's results to newspapers, TV and radio. Presentations of project's activities and results in conferences and workshops in Greece and the EU. Final workshop in Athens. Layman's report. After LIFE Communication Plan.

RESULTS ACHIEVED

The WASTE-C-CONTROL project results consist of tools, plans and awareness material. The project's major outcome is the WASTE-C-CONTROL **Software Tool**, which enables Waste Management Authorities and other stakeholders to substantially reduce GHG emissions resulting from their WM activities. The tool provides "**decision support**" for the **optimization of WM practices, in terms of GHG emissions and financial data** through a simulation environment, where an existing or desired regional / local waste management system can be designed by the user.

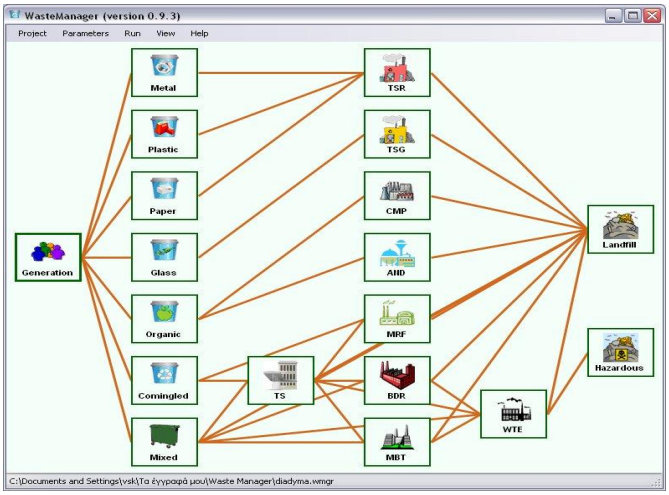


Figure 1: conceptual map of the Tool MSW system

The **innovative idea** is the incorporation of an optimization function through which the tool will calculate the optimal values for the decision variables using Mathematical Programming (MP).

Moreover, the WASTE-C-CONTROL **iOS Application** (for mobiles and tablets) was developed that also serves as the Tool's demo. [4]

The results of the Tool facilitated the identification of procedures for the development of **Local Action Plans** (LAP), which aim to reduce GHG emissions from WM activities at local level. Each Action Plan placed specific quantitative goals for GHG emissions reductions, specified the means to attain them, as well as the relevant investments that need to take place and the timing of these investments. Within the pilot implementation of the LAP short-term measures, GHG emission reductions at local and sectoral level were achieved.

According to the WASTE-C-Control Tool results, the **anticipated GHG emissions reductions** from the LAP implementation (**20-year period**) in the project areas are:

- Region of Eastern Macedonia & Thrace: 1.600 kt CO_2 eq (65%)
- Region of Western Macedonia: 192 kt CO_2 eq (36%)
- Regional Union of Chania, Crete: 75 kt CO_2 eq (18%)

Finally, extensive dissemination activities on "Waste Management and Climate Change" took place and public awareness events were organized with great success.

PROJECT BENEFIT AND IMPACT

The WASTE-C-CONTROL Software Tool was applied in 3 "real-world" case studies (the Region of Eastern Macedonia & Thrace, the Region of Western Macedonia and the Regional Union of Chania), in order to assist local decision-makers (the 3 project's Associated Beneficiaries, which are also the local responsible Waste Management Authorities) in developing Local Action Plans (LAPs) for reducing GHG emissions from the solid waste sector.

The three Regional WM Authorities collected data on the quantities and composition of solid wastes generated in their area. Data collection covered all the stages of WM, starting from collection bins to transportation and processing / disposal. A projection of generated solid waste quantities up to the year 2025 was performed based on population figures and improvement / change of life standards.

Figure 2: the MBT plant and the sanitary landfill in Chania

Three "Reference Cases" (one for each administrative region) with respect to local waste management were elaborated, on the basis of the projected solid waste quantities. The relevant

[4] Developed by D-WASTE: http://www.d-waste.com/mobile-applications/waste-c-control-tool

systems were “drawn” within the WASTE-C-CONTROL Software Tool environment and the operational, economic and environmental parameters required by the Tool were completed. GHG emissions and the rest environmental burdens for the present and the “Reference Cases”, as well as the expected changes of GHG emissions and the rest indices of environmental performance, up to the year 2025, were calculated.

Different actions were proposed in order to reduce GHG emissions from waste management processes, including landfill (maximize landfill gas collection, promote landfill gas to energy), recycling (develop new recycling opportunities, increase recycling rates), composting (optimization of aerobic conditions, increase compost production) etc. The three project Associated Beneficiaries, who are also the local decision-makers, initially determined certain potential changes / improvements that they wanted to explore and they used the Tool in order to evaluate all these interventions. Then, they also explored specific environmental goals and what changes to the system are needed in order to attain them.

Based on the obtained results and by taking into account other studies on local waste management, as well as the **existing Regional Waste Management Plans (Master Plans) and the provisions of the existing legislation**, three Local Action Plans for reducing GHG emissions from the solid waste sector were elaborated. The LAPs set specific quantitative goals for GHG emissions reductions; specified the means to attain them and presented the relevant needed investments. Furthermore, they contained an appropriate Monitoring Programme.

It is obvious that the implementation of all the LAP’s proposed measures (alternative SWM technologies, prevention techniques and efforts etc) goes far beyond the scope, the time frame and the available resources of the WASTE-C-CONTROL LIFE+ project. However, even the “pilot implementation” of the LAP towards this direction, offered opportunities to significantly reduce the carbon footprint of SWM activities, to the whole life cycle of waste. The following options were considered:

- New production and consumption patterns of products, where reuse and recycling will be the main characteristics
- More efficient energy use in collection and transportation activities
- More efficient energy recovery and less carbon emissions where energy recovery takes place
- Less energy intent waste management practices

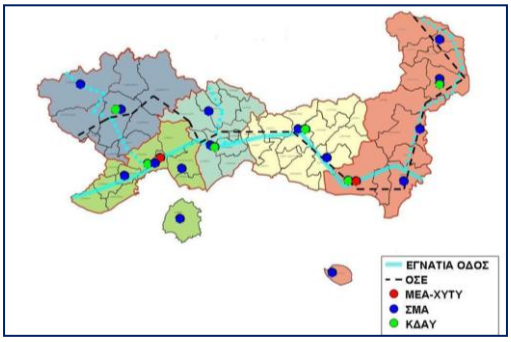
The implementation of specific LAP measures was carried out according to **Practical Guidelines and the Monitoring Plan** that was elaborated. Short, mid and long-term measures were proposed, as they are described in the LAPs. For each measure, a “roadmap” was formulated, starting with necessary preparatory activities, which were important in order to set up properly the operating environment for each measure.

During the “pilot operation”, proper maintenance procedures were followed according to the LAP’s **Monitoring Plan**, which was developed in order to ensure that measures are working properly and delivering the GHG emissions reductions foreseen. The implementation of measures was closely followed by the LAP’s Monitoring Team, which was established at the early stages of this action.

The pilot demonstration part of the WASTE-C-CONTROL Program was carried out for 1 year (until the end of September 2013), with the implementation of the specific actions and measures that are briefly presented below.

Implementation of the LAP in the Region of Eastern Macedonia and Thrace

The LAP for the Region of Eastern Macedonia & Thrace included the implementation of the following actions and measures:



- **Short-term** (until the end of 2013). Maximum utilization of Transfer Stations (TS) and enhancement of waste packaging recycling:
  - ✓ ST1- Production of practical guidelines for waste - transfer stations
  - ✓ ST2- Information and public awareness of the Region's citizens
  - ✓ ST3- Supply of recycling equipment
  - ✓ ST4- Sitting of recycling bins in the Region's West Sector (cities of Drama & Xanthi)
  - ✓ ST5- Pilot monitoring of three (3) waste streams of municipal solid waste produced at household level (organic putrescibles to home composting, recyclable material to package recycling, other garbage to final disposal)
  - ✓ ST6- Improving the management of landfill gas

Figure 3: LAP short term measures in the Region of Eastern Macedonia & Thrace

Moreover, the following actions and measures are foreseen in the LAP:

- **Medium-term** (until 2015). Increasing levels of waste packaging recycling, covering the entire area of the Region with the use of the "blue bin", in as many municipalities as possible. Also, an examination of implementing actions for the treatment of the organic fraction of municipal solid waste (composting) and ensuring and enhancing sanitary landfill, e.g. by better management of biogas from landfills:
  - ✓ MT1- Operation of Drama Material Recycling Facility (MRF) and Xanthi MRF
  - ✓ MT2- Sanitary Landfill extension in Komotini, Xanthi and Kavala
  - ✓ MT3- Supply of solid waste pretreatment and composting equipment of MSW

- **Long-term** (2017-2020). Development and operation of the Integrated Waste Management Unit (IWMU) for the mechanical and biological treatment of mixed municipal solid waste in the Waste Processing Unit (WPU):
  - ✓ LT1- Construction of Integrated Waste Management Unit (IWMU) of the Eastern Sector of the Region (Alexandroupolis)
  - ✓ LT2- Construction of IWMU of the Western Sector of the Region (Chrysoupolis – Kavala)

Implementation of the Local Action Plan in the Region of Western Macedonia

The LAP for the Region of Western Macedonia included the implementation of the following actions and measures:

- **Short-term** (until the end of 2013):
  - ✓ ST1- Expanding of the recycling program (separation at source system)
  - ✓ ST2- Improvement of transfer system
  - ✓ ST3- Control of landfill gas / Supply of bio-filters
  - ✓ ST4- Drivers education – training

Figure 4: LAP short term measures in the Region of Western Macedonia

Moreover, the following actions and measures are foreseen in the LAP:

Medium-term (until 2015):

- ✓ MT1- Develop a recycling program for organics (separated at source system) / Supply bins for recycling organic waste

- ✓ MT2- Implementation of mechanical and biological treatment / Construction and operation of mechanical & biological treatment plan
- ✓ MT3- Information campaign and training for employees in the municipal cleaning department
- ✓ MT4- Information campaign for employees in the Regional department of environment
- ✓ MT5 / LT1- Information campaign and awareness raising for organic recycling

The Practical Guidelines describe the necessary preparatory activities, the implementation phases the output indicators, the duration of the actions, the penetration targets and the expected results. The preparatory activities for each measure included:

- Feasibility study or report according to the tendering procedure
- Preparing official requests for financing
- Preparation of tender documents (according with Regulation 1251/2011)
- Approval of tender documents by the Decision Board

Implementation of the Local Action Plan in the Regional Union of Chania, Crete

The LAP for the Regional Union of Chania, Crete, included the implementation of the following actions and measures:

- **Short-term** (until the end of 2013):
  - ✓ ST1- Control / Monitor Biogas
  - ✓ ST2- Co-composting
  - ✓ ST3- Eco-driving
  - ✓ ST4- Information / awareness raising activities
  - ✓ ST5- Promoting organic collection of large-scale producers: working with large scale units (e.g. hotels, military) in which the organic waste is collected in separate containers, thus diverting large amounts of biodegradable fraction from landfills, while enhancing the production of compost material

Figure 5: LAP short term measures in the Regional Union of Chania, Crete

The following actions are described in the LAP and consist of the mid and long-term measures that will be implemented in the Regional Union of Chania in the following years:

- ✓ Support and expansion of source separation of recyclables
- ✓ Biowaste collection and utilization
- ✓ Maintenance / conversion of equipment vehicles
- ✓ Upgrade the Mechanical Recycling and Composting plant
- ✓ Construction of a Transfer Station

Dissemination activities

Dissemination and public awareness in "waste management and climate change" issues consisted of an activity that was implemented until the end of the project, according to the proposed work plan, and included:

- Development and regular update of the project's website
- Dissemination of the project's progress to press and TV
- Dissemination of the project's through participation in conferences, workshops, schools etc

Figure 6: WASTE-C-CONTROL dissemination activities

COST-BENEFIT DISCUSSION OF THE RESULTS (ECONOMIC AND ENVIRONMENTAL BENEFITS)

According to the International Solid Waste Association (ISWA) White Paper on "Waste and Climate Change" (2009), **waste policies and regulations can be strong national drivers to reduce GHG emissions**:

- Progress in reducing GHG emissions in the EU between 1990 and 2007 was made through policy and regulations based on the Waste Hierarchy. The legislative framework included specific targets and directives regarding packaging waste and diversion of organic waste from landfill.
- In the US, landfill methane emissions decreased by 11% between 1990 and 2007 due to increased landfill gas recovery resulting from economic incentives, policies, and regulations.
- In developing countries, it is important to focus on waste policies and regulations which are practical and sustainable. Initiatives from one country cannot be exported to another without taking into account local waste composition and quantities, infrastructure, preferences, economic resources, and climate.

The WASTE-C-CONTROL project was proposed in 2009 and falls under the thematic area "Environmental Policy & Governance" with "Waste Management & Climate Change" being the principal objectives.

According to the latest national inventory report for GHG emissions submitted to the UNFCCC [5], the waste sector in Greece is responsible for the generation of 155,5 kt CH4 in 2011. Out of these, 36,5% (56,7 kt CH_4) derives from solid waste disposal on land (managed), 55% of these (85,7 kt CH_4) comes from uncontrolled sites (unmanaged), while 8,5% (13,1 kt CH_4) derives from sludge treatment.

The need for GHG reductions in Greece is more than urgent and must be delivered as soon as possible, in order to expand the time framework available for broader changes. This is where the SWM technologies can have a very important role because they are proven successful and they can immediately deliver significant GHG reduction from SWM activities. Of course, the thorough implementation of such measures was far beyond the scope, the time frame and the available resources of the WASTE-C-CONTROL program, but even the development and the initial / "pilot" implementation of the Local Action Plan measures towards this direction, offered opportunities to significantly reduce the carbon footprint of SWM activities, to the whole life cycle of waste.

From the project's outcomes, it became obvious that **waste management may be proved an effective tool to reduce GHG emissions**. The project assessed the entire range of the current SWM practices, taking into account all the different social, financial and technical parameters. The result of these efforts will be the gradual integration of SWM with resource management, in regional and national scales.

In the above framework, the project has a **positive impact on issues related to waste management and climate change mitigation policies**, even though the full potential of GHG emissions reduction identified is not (and could not be) delivered yet. The limited availability of capital resources (given the economic recession in Greece), as well as delays in the procurement process, are among the parameters affecting the emissions reductions already achieved.

Apart from the above mentioned environmental benefits, the implementation of the LAP developed in the context of the WASTE-C-CONTROL project is expected to have **economic and social benefits**. Significant savings will result from the foreseen WM measures, including recycling (develop new recycling opportunities, increase recycling rates), composting (optimization of aerobic conditions, increase compost production) landfill (maximize landfill gas collection, promote landfill gas to energy) etc, that will also extend the lifetime of the existing sanitary landfills. Furthermore, indirect economic benefits are expected, through the participation of the private sector (in the services and construction sectors) in the implementation of the measures, as additional income would be generated.

Other positive impacts that are related to the **long-term capacity of the Regional WM Authorities for the assessment of "waste management and climate change" mitigation actions** include:

(a) The developed database and the three "Reference Cases" (for the 3 administrative regions), that provides a base for setting targets and for the assessment of the effectiveness of related policies and measures.

(b) The developed tools that built capacity within the Regional WM Authorities in issues related to GHG emissions inventory and projections. The application of these tools can provide the basis for any future integrated assessment of climate change mitigation actions.

[5] Greek Ministry of Environment, Energy and Climate Change: Climate change emissions inventory, 2013

(c) The Local Action Plans (and the associated Monitoring Plans), especially when considered their formal adoptions by Regional Authorities, on the one hand indicates the commitment of local authorities for reducing emissions and on the other hand provides a guidance on how to achieve the target set.

TRANSFERABILITY OF PROJECT RESULTS

Several tools have been developed, both in the USA and the EU, on waste management LCA, providing general estimations on GHG emissions. However, the WASTE-C-CONTROL Software Tool provides **a state of the art solution** to the urgent need to revise and improve data sets (Life Cycle Inventories). In addition, the Tool consists of a valuable instrument for the assessment and improvement of regional / local WM options, enabling Waste Management Authorities and other stakeholders to substantially reduce GHG emissions resulting from their WM activities.

The tool provides "**decision support**" for the optimization of WM practices, in terms of GHG emissions and financial data through a simulation environment, where an existing or desired regional / local waste management system can be designed by the user. The **innovative idea** is the incorporation of an optimization function through which the tool will calculate the optimal values for the decision variables using Mathematical Programming (MP). Moreover, the WASTE-C-CONTROL **iOS Application** (for mobiles and tablets) was developed that also serves as the Tool's demo.

The developed Software Tool includes **mathematical algorithms** in order to allow the user to identify which changes to the waste management system should be made in order to reach as close as possible a specific **environmental goal**, e.g. reduce GHG emissions by x% compared to the existing situation, also incorporating **cost optimization**. This is also an **innovative feature compared to existing tools**, which at most allow for a "what-if" assessment of waste management technologies and not for an optimization process incorporating a number of user-defined goals and constraints.

The results of the tool facilitated the identification of procedures for the development of **Local Action Plans** (LAP), which aim to reduce GHG emissions from WM activities at local level. Each Action Plan placed specific quantitative goals for GHG emissions reductions, specified the means to attain them, as well as the relevant investments that need to take place and the timing of these investments. Within the pilot implementation of the LAP short-term measures, GHG emission reductions at local and sectoral level were achieved.

As there are no similar programs at local level elsewhere in Greece, the project can be considered to be a **pilot** for the application of the Software Tool and the accompanying methodologies that were developed. The GHG emission reduction measures (application of new / alternative waste management options), as part of the Local Action Plan, addressed all the waste management sector in the three Administrative Regions and, thus, their implementation constitutes a **first full-scale application**.

The description of the methodological framework developed in the technical reports prepared and the tools developed for applying this framework (all available in the project web-site) allows for the **transferability** of the process to other local WM Authorities. The multi-parametric structure of the tools enables their replicability to other stakeholders, as long as a minimum set of data / information is available.

The true environmental value of a LIFE+ Program depends on whether it will succeed to mobilize human and financial resources, so that its activities are sustainable and can deliver environmental benefits, after the project is finished, with the active participation of local communities. The WASTE-C-CONTROL project developed **effective dissemination approaches** to the local waste management authorities and municipalities and took full advantage of local media and educational establishments.

Finally, it should be stressed out that the nature of the WASTE-C-CONTROL project's results have a **global dimension** and promote innovative waste management technologies aiming at GHG emissions mitigation. Also, the project served (e.g. through the project implemented measures, dissemination activities etc) as an **example to other Municipalities** to get involved on climate change mitigation issues in their jurisdiction. Such an involvement could have a positive impact in the overall implementation of the associated EU Directives in order to reach the targets set for Greece.

PROJECT DETAILS

Duration: 36 months (1/10/2010 – 30/9/2013)

Total budget: 1.430.195 EUR

EC co-funding: 697.483 EUR (49,50%)

Coordinating Beneficiary:	EPEM SA – Environmental Planning, Engineering and Management www.epem.gr
Associated Beneficiaries:	Waste Management Authority of Eastern Macedonia and Thrace S.A. (DIAAMATH) www.diaamath.gr
	Waste Management System of Western Macedonia S.A. (DIADYMA) www.diadyma.gr
	Trans-Municipal Enterprise of Solid Waste Management (DEDISA) www.dedisa.gr

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Further information is available on the WASTE-C-CONTROL website www.epem.gr/waste-c-control

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