Environment, Climate Change and Low Carbon Economy Programme

'Environment Programme'

European Economic Area (EEA) Financial Mechanism 2014-2021

Structure of the Interim nº 7 / Final Report

01/07/2023 a 31/12/2024

09_CALL#1/SGS#X – REAP - Recycling and Reimbursement of Aluminum and PET Packaging - pilot system

Accordingly, with the Articles 25.2.j) and 29.4 of the 'Applicants Guide for Financing of Projects Supported by Environment, Climate Change and Low Carbon Economy Programme'

https://www.eeagrants.gov.pt/media/2994/applicants-guide-for-financing-eea-grants_environment-projects_28112019.pdf

INDICE

INTRODUCTION

This report is part of the set of reports from the REAP Program - Recycling and Reimbursement of Aluminum and PET Packaging - pilot system, and is intended for:

a) describe in detail the progression of work for each program activity;
b) demonstrate the activities and their impact.

DETAILED DESCRIPTION OF ACTIVITIES

The activity was designed with the purpose of significantly expanding the dissemination and participation of students, as well as other members of the academic community and partners, aiming to significantly increase the number of packages deposited in the collection machines.

To achieve this ambitious goal, we have undertaken a multi-faceted approach, implementing a series of strategic activities. This included the integration of the project in several events promoted by the University, where we sought to engage and raise awareness in the community about the importance of recycling and active participation in this environmental initiative.

In addition to publicity actions, our team was also dedicated to dealing with administrative issues crucial to the continuity and effectiveness of the project. This involved managing payment requests, ensuring financial resources to sustain operational activities, and requesting an extension of the project deadline, a strategic measure that was granted to us, extending our efforts for these last 3 months, which are covered in this report.

The extension allowed us to consolidate and expand our awareness and packaging collection initiatives, reinforcing our commitment to sustainability and environmental awareness. As we move forward, we feel the academic community's increasing commitment to continuing to improve and diversify engagement and sustainability strategies.

We recognize that the success of this project will depend not only on the quantitative increase in packaging collected, but also on building a culture of environmental responsibility and active participation throughout the university community. We are confident that, with perseverance and continued collaboration, we will achieve our goals and leave a lasting impact on the sustainability landscape within our institution.

ACTIVITY 0 – MANAGEMENT

STATUS: concluded In December of 2023 | **EXECUTION RATE:** 100%

We strategically adjust the processes on the various campuses where the collection machines are located, so that, after the financing ends, the project can continue generating transformations in the culture of sustainability and the circular economy.

Adjustments were made to the execution of the project to take into account its extension, meaning that all activities that had changes in execution time could be better worked on. It also focused on the approval of the budget adjustment by the SGA in relation to the project activities.

The consortium meeting and technical visit were held at the headquarters of Infinitum SA (Norway), with the aim of technology transfer and preparation of the University team for the changes in recycling legislation that will occur in Portugal in 2024.

ACTIVITY 1 - DEFINITION OF THE PILOT STUDY
STATUS: concluded in January of 2021 | **EXECUTION RATE:** 100%

ACTIVITY 2 – PILOT IMPLEMENTATION
STATUS: concluded in March of 2022 | **EXECUTION RATE:** 100%

ACTIVITY 3 - MONITORING AND EVALUATION OF PILOT IMPLEMENTATION
STATUS: concluded in December of 2023 | **EXECUTION RATE:** 100%

This is one of the activities that was carried out constantly during the project and that will go beyond the scope of the project, that is, it will continue to be worked on after completion, being absorbed by the University's technical management services. To this end, learning was shared and adjustments were made to fit within the team, thus generating a consolidation of the culture of sustainability within its services, which is an added value that REAP brought to the academic environment.

Monitoring and collection data can be analysed at the end of the report and in the Excel document attached to this report, where you can see the project's progression month by month.

The collection of quantitative data allowed the assessment of pilot effectiveness and calculation of operating and performance indicators, on a temporal basis.

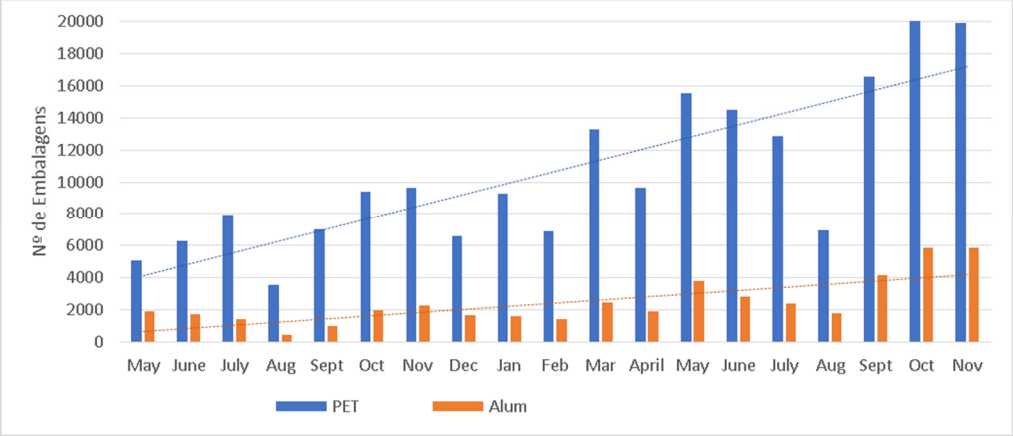


Figure 1 - Packaging deposited between April 2022 and November 2023.

Figure 1 shows the evolution of the quantity of packaging deposited during the pilot period, with a growing trend towards adherence to the project, between April 2022 and November 2023, with more PET packaging being deposited than cans. aluminum.

For the same period of time, Figure 2 shows the fraction of packaging deposited in the six RVM machines, relative to a total of 200 thousand units of PET and 47 thousand units of aluminum cans

Figure 3 presents the estimated ratio of packaging deposited to packaging sold on UA campuses, based on packaging sold in 2019, being higher for PET packaging (51%) than aluminum packaging (49%).

Project monitoring data made it possible to estimate some indicators relating to the operation of the six RVM machines, see Figure 4.

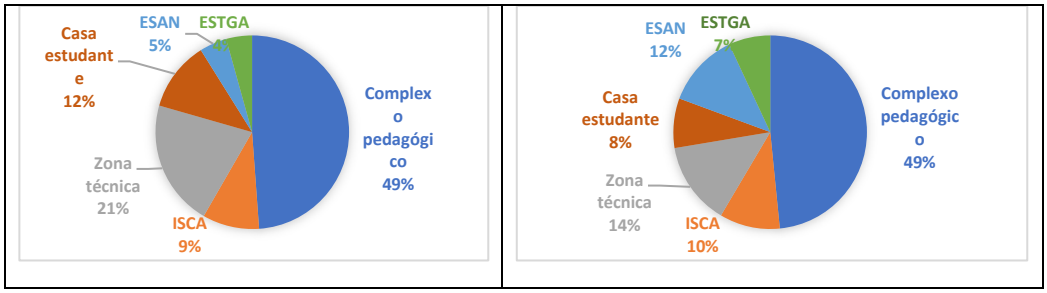


Figure 2 – Fraction of packaging deposited in the six RVM machines, between April 2022 and November 2023.

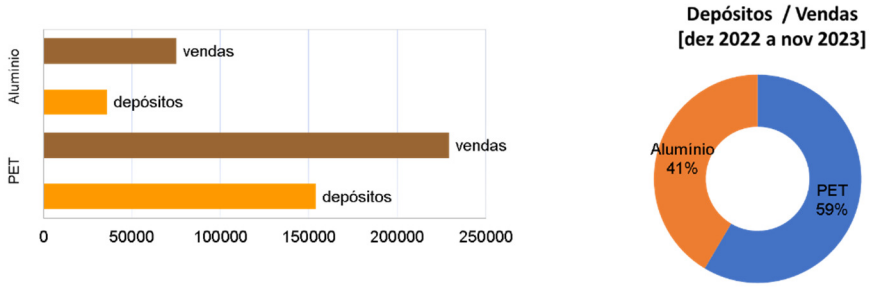


Figure 3 – Estimated ratio of packaging deposited to packaging sold on UA campuses, using 2019 as a reference.

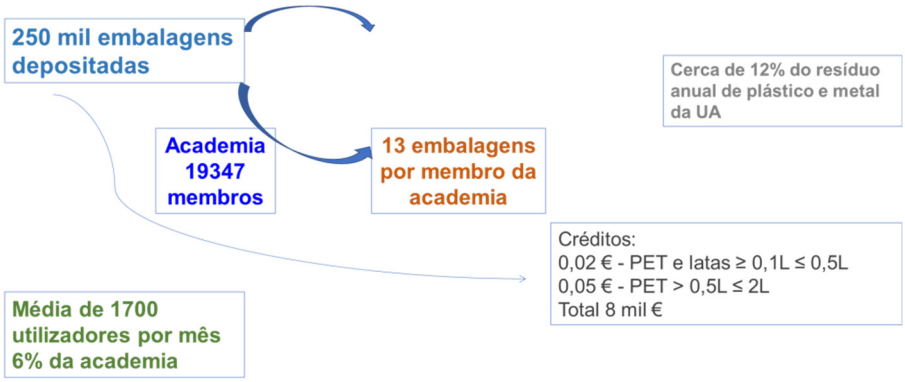


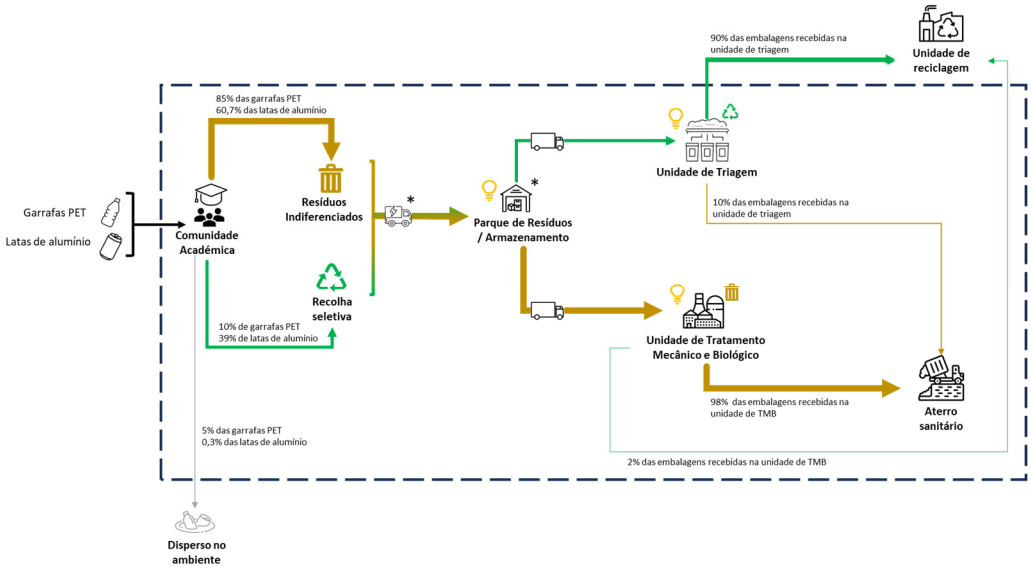
Figure 4 – Indicators relating to pilot operation.

Assessment of the pilot from the point of view of its environmental sustainability, through a life cycle analysis.

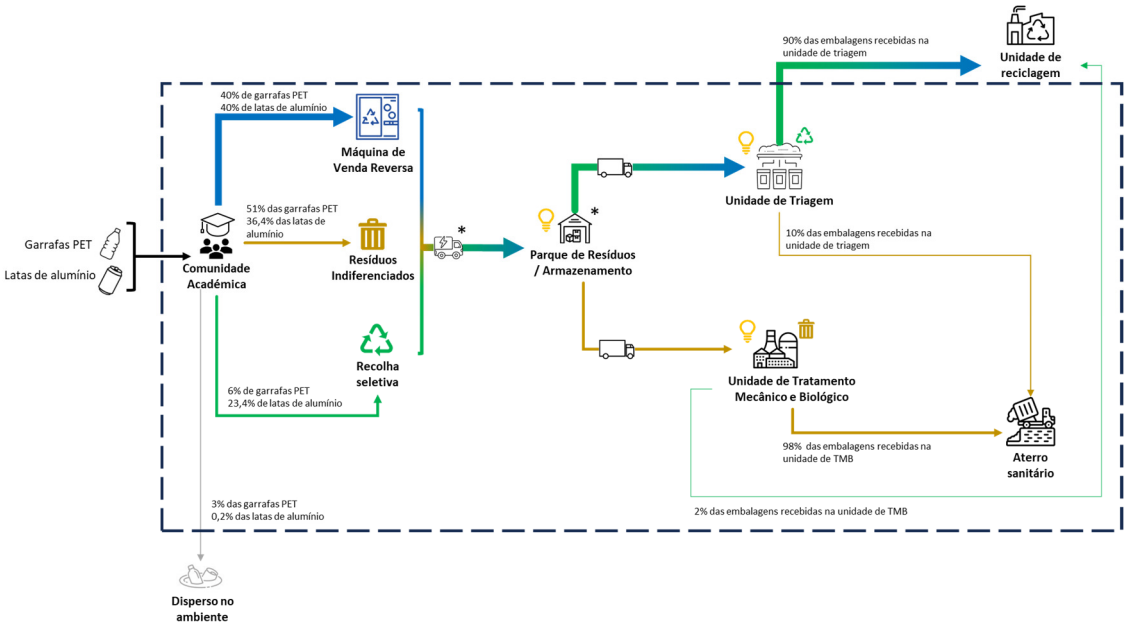
The environmental assessment targeted the management of PET packaging and aluminum cans and had as its functional unit phase considered: 1 ton of PET or aluminum beverage packaging waste sent for recycling.

Two scenarios were considered: Scenario 1 or Base scenario and Scenario 2, with implementation of a Deposit and Refund System (SDR), with analysis for two return rates, 40% and 80%.

Figures 5 and 6 represent the management models considered for Scenario 1 and Scenario 2.



Figures 5 - Management models considered for Scenario 1.



Figures 6 - Management models considered for Scenario 2.

The methodology followed in Life Cycle Analysis is shown in Figure 7 and the results can be found in Figures 8 and 9.

Recursos
Normas ISO 14040:2006 e ISO 14044:2006
Software ***OpenLCA*** (versão 1.10)
Base de dados ***Ecoinvent*** (versão 3.9.1 – Cutoff LCI).

Inventário de Ciclo de Vida (ICV)
Modelo *gate-to-gate*

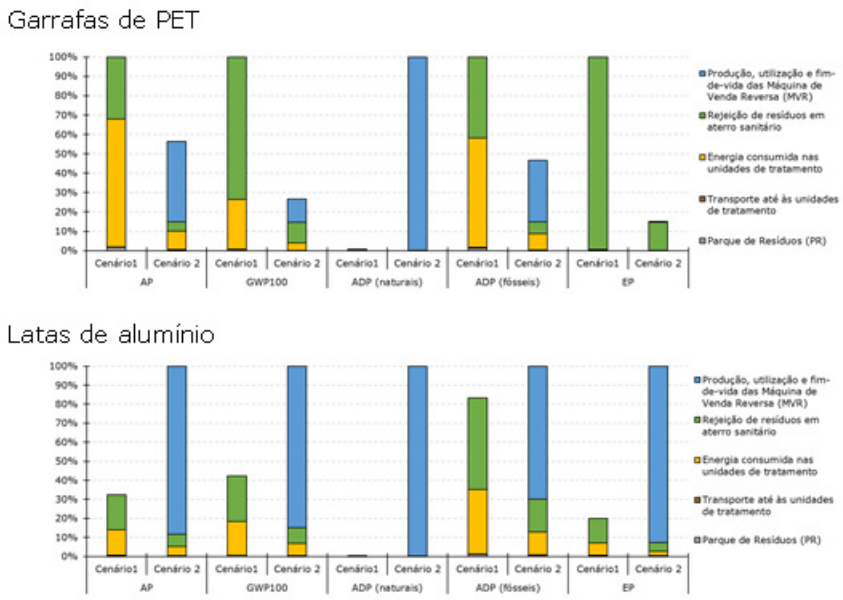
Avaliação de Impacto de Ciclo de Vida (AICV)
Metodologia **CML** (*baseline* – versão 4.4, janeiro 2015)
Categorias de impacto:

- **Potencial de acidificação** (AP)
- **Potencial de aquecimento global** (GWP 100)
- **Potencial de esgotamento de recursos abióticos naturais** (ADP (naturais))
- **Potencial de esgotamento de recursos abióticos fósseis** (ADP (fósseis))
- **Potencial de eutrofização** (EP).

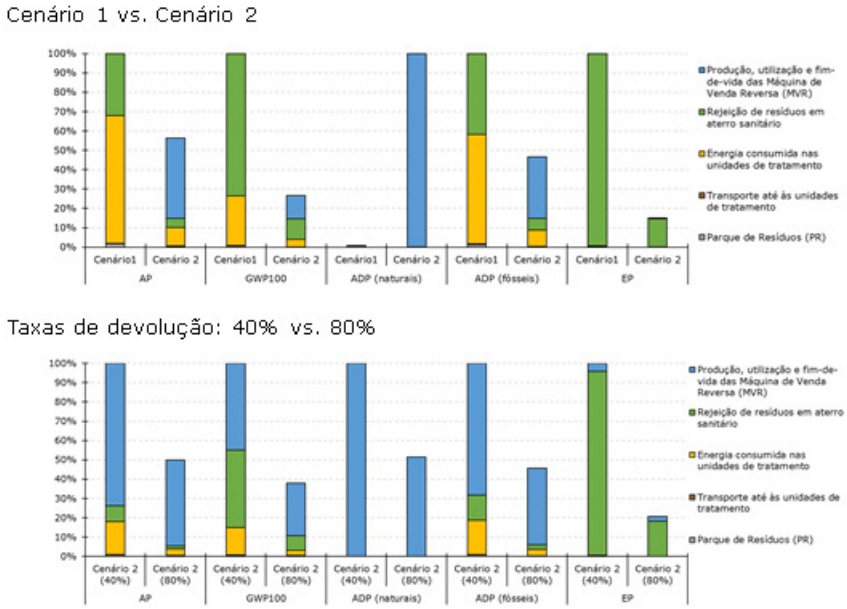
A análise não incluiu:
- A produção e distribuição das embalagens de bebida de PET e de alumínio.
- O processo de reciclagem das embalagens de bebidas.
- A produção e fim de vida de equipamentos das unidades de tratamento.

A análise considera:
6 Máquinas de Venda Reversa (MVR)
- Vida útil: 10 anos
- Fim de vida: desmantelamento, separação e valorização material

Figures 7 – Summary of the life cycle analysis methodology.



Figures 8 – Summary of the life cycle analysis methodology.



Figures 9 – Summary of the life cycle analysis methodology

These allow us to conclude that:

- The implementation of SDR reduces, for PET and aluminum beverage packaging, the production of packaging waste requiring treatment (sorting units and TMB) and landfill disposal.
- The increased impact associated with the production and use of RVM machines highlights the importance of regular use of the equipment and the importance of adequate maintenance and cleaning.
- Improving the environmental performance of this system is possible by increasing the return rate. The deposition rate is a social aspect, for which it is essential to invest in the academy's environmental awareness and continue the implementation/operationalization of the system.

ACTIVITY 4 - INNOVATION IN PET RECYCLING

STATUS: concluded in September of 2023 | **EXECUTION RATE:** 100%

Activity 4 of the REAP project presents itself as an innovative activity in the reuse and valorization of PET bottles collected by the collection systems spread across UA Campi and ESAN. The strategy for valuing collected post-consumer bottles focused on two distinct aspects:

i) Production of PET bottles with high incorporation of recycled PET (rPET)

ii) Production of filaments with high incorporation of rPET for 3D printing

The preparation of rPET flakes followed a mechanical recycling approach, without any addition of chemical agents, in order to guarantee the direct reuse of PET bottles, without compromising the sustainability of the process. Briefly, obtaining rPET flakes went through several stages, namely: (1) separation of bottles by brand; (2) removing the covers; (3) washing bottles with water to disinfect and remove the label; (4) removing the glue from the label with acetone; (4) drying and; (5) mechanical recycling. The execution of the various steps is quite time-consuming, thus affecting the amount of rPET produced. Step (1) is fundamental, since bottles with different amounts of rPET are available on the market, with 0%, 25% and 30% being the most common amounts. In this sense, different nomenclatures were defined according to

the amount of rPET initially present in the rPET flakes: flakes coming from bottles with 0% rPET (rPET0R), flakes coming from bottles with 25% rPET (rPET25R) and flakes coming from bottles with 30% rPET (rPET30R). The non-spherical geometry of the flakes is limiting during the feeding phase of industrial equipment.

For strategy i), different formulations containing different concentrations of rPET were initially prepared. The formulations tested are described in Table 1.

Table 1. Composition of the formulations (vPET – virgin PET).

Formulations	vPET % (w/w)	$rPET_{0r}$ % (w/w)	$rPET_{25r}$ % (w/w)	$rPET_{30r}$ % (w/w)
100vPET	100	0	0	0
$50rPET_{0r}$	50	50	0	0
$50rPET_{25r}$	50	0	50	0
$50rPET_{30r}$	50	0	0	50
$75rPET_{25r}$	25	0	75	0

After preparing the mixtures, they were studied and the injection molding (IM) conditions suitable for the production of preforms were defined. The optimal conditions are listed in Table 2.

Table 2. MI conditions (Kraus Maffei 80T injection molding machine).

Parâmetros de MI	vPET e rPETs
Perfil de temperatura (℃)	295 – 290 – 285 – 275 – 265
Pressão de injeção (bar)	110
Velocidade de injeção (mm/s)	35
Contra-pressão (bar)	10
Temperatura do molde (℃)	20
Tempo de arrefecimento (s)	10

Next, the blow molding (MS) conditions of the injected preforms were also studied and defined (see Table 3).

Table 3. MS Conditions

Parâmetros de MS	vPET e rPETs
Perfil de temperatura (℃)	0 – 0 – 20 – 35 – 35 – 110
Temperatura do forno (℃)	60
Pressão de sopro (bar)	20
Tempo de sopro (s)	1,2

In Figure 1 it is possible to see examples of bottles blown with different amounts of rPET, using the conditions defined in Table 3.

A qualitative and comparative analysis was carried out between the various bottles, evaluating different parameters, as illustrated in Table 4.

It is visible from Table 4 that the formulation that presented the best performance and evaluation after the MS process was 75rPET25r. This formulation will then be evaluated by CESAM regarding its performance as packaging, namely regarding its chemical, mechanical and structural behavior, in accordance with the guidelines for food packaging.

In the case of strategy ii), filaments containing 100% rPET were developed. Before the filament extrusion process, the thermal behavior of vPET and recycled materials was evaluated using differential scanning

calorimetry (DSC) analysis. Figure 2 presents the DSC curves obtained, where it is possible to observe that the melting temperature does not change and the crystallization temperature is slightly anticipated for recyclates from different origins. The extrusion conditions for filaments containing 100% recycled content can be found in Table 5. It is also possible to view the surface of the extruded filaments.

Figure 1. Image of bottles obtained with different amounts of rPET.

Table 4. Comparative analysis between bottles with different rPET contents.

Parâmetros	vPET	50rPET$_{0r}$	50rPET$_{25r}$	50rPET$_{30r}$	75rPET$_{25r}$
Transparência	✓	✓	✓	✓	✓
Brilho	✓	✓	✓	✓	✓
Uniformidade da espessura da parede	✓	✓	✓	✓	✓
Vitrificação	✓	+/-	✓	+/-	✓
Número de garrafas descartadas	✓	↑	✓	↑	✓

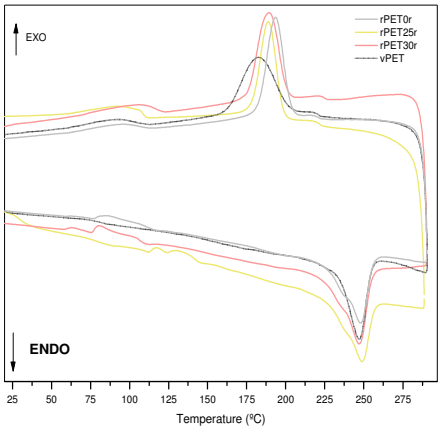
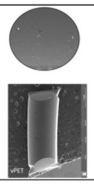


Figure 2. DSC curves of vPET and rPET flakes from bottles with different amounts of rPET.

Table 5. Extrusion conditions for producing filaments with 100% recycled content.

Filament	vPET	$rPET_{0r}$	$rPET_{25r}$	$rPET_{30r}$
T1 (°C)	258	266	264	264
T2 (°C)	250	255	255	250
T3 (°C)	255	255	255	255
T4 (°C)	263	260	260	260
Screw speed (rpm)	5.0 – 5.2	3.8 – 4.0	3.8 – 4.0	4.8 – 5.0
Image				
Filament thickness (µm)	1.75±0.1	1.75±0.2	1.75±0.35	1.75±0.1
Image				

A complementary study was also carried out to evaluate the reprocessing limit (number of cycles) of vPET filaments. This study concludes that vPET filaments could only be reprocessed once, without compromising their performance. The addition of another reprocessing cycle results in the degradation of the PET chains, impacting both the rheological and thermal properties, and, consequently, the mechanical properties. The main results of this study are summarized in Figures 3 – 5 and Tables 6 – 8 (1 reprocessing cycle: vPET_1C; 2 reprocessing cycles: vPET_2C)

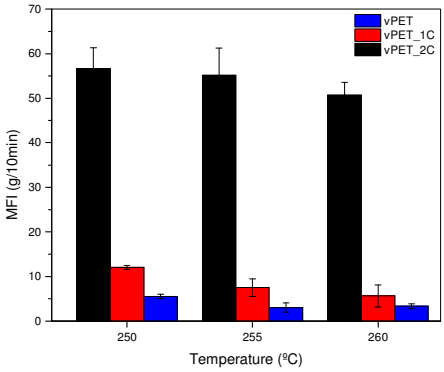


Figure 3. Fluidity Index (MFI) results.

Table 6. Extrusion conditions for producing vPET filaments after different reprocessing cycles.

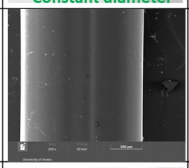
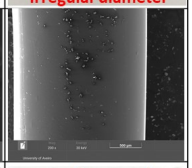
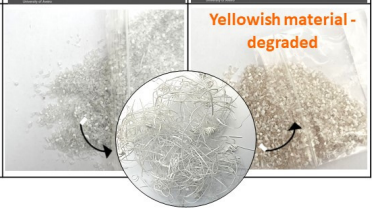
Extrusion parameters	vPET_1C	vPET_2C
T1	258	243
T2	250	242
T3	255	240
T4	263	250
Screw speed (rpm)	5.0 – 5.2	9.8 – 10.0
Cooling fan speed (%)	50	90
Filament (diameter: 1.75 ± 0.05 mm)		
Filament surface (SEM image)		
Grinding filament		

Figure 4. DSC curves of vPET filaments after different reprocessing cycles.

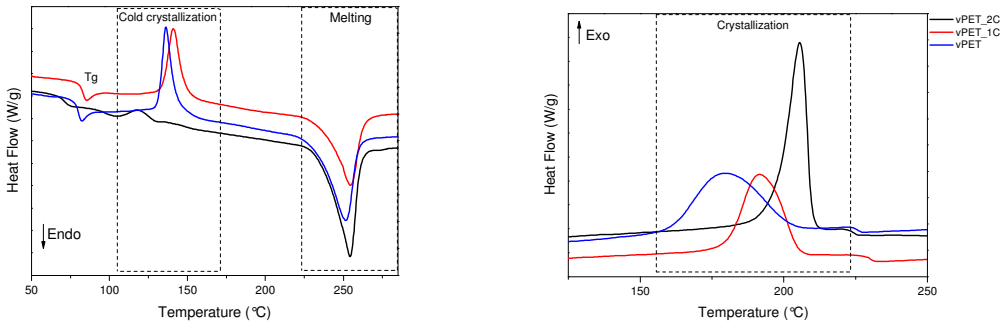


Table 7. DSC parameters (Tg: glass transition temperature; Tm: melting temperature; Tcc: cold crystallization temperature; Tc: crystallization temperature).

Amostra	T_g (°C)	T_m (°C)	T_{cc} (°C)	T_c (°C)	X_c (%)
vPET	78.7 ± 2.1	251.6 ± 0.2	136.3 ± 0.1	179.5 ± 0.1	56.5 ± 0.7
vPET_1C	79.6 ± 1.8	254.6 ± 0.3	141.0 ± 0.1	191.4 ± 0.3	61.6 ± 0.9
vPET_2C	71.2 ± 3.3	254.3 ± 0.3	117.7 ± 0.2	205.5 ± 0.5	71.3 ± 2.2

Table 8. Tensile mechanical properties (TS: tensile strength; SB: elongation at break: YM: Young's modulus).[1] values from the technical sheet

Samples	TS (MPa)	SB (%)	YM (GPa)
vPET[1]	70 – 75	65 – 75	2.76 – 3.10
vPET_1C	47.8 ± 4.6	12.1 ± 0.7	0.65 ± 0.05
vPET_2C	52.4 ± 2.1	10.1 ± 1.0	0.71 ± 0.09

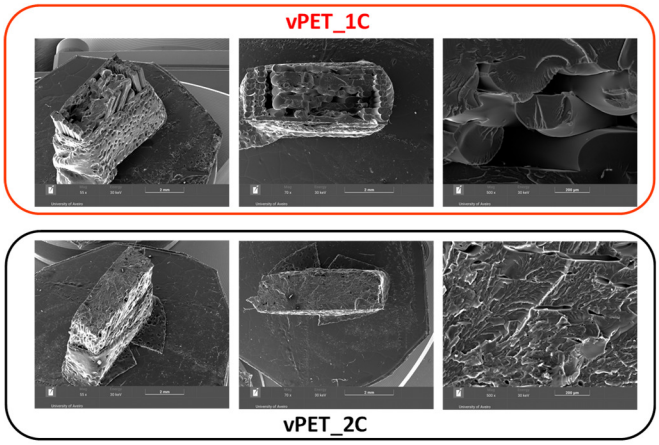


Figure 5. SEM images of the fracture surface of the tensile specimens.

Some examples of parts printed with filaments developed within the scope of the REAP project can be seen in Figure 6.

Figure 6. Examples of printed parts.

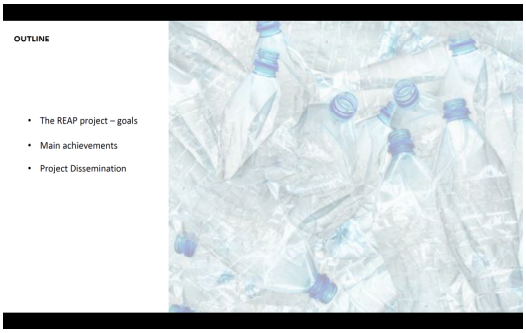
During the project's closing event, research conclusions regarding the quality of recycled PET were presented. Completing the technical demonstration of its quality and closing the activity in question with technological developments and technology transfer between University units and strategic partners.

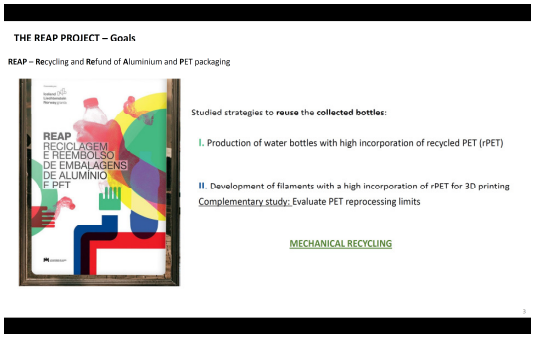
Several works were also presented before and by the year 2024 they will be defended and presented at several conferences in the materials area.

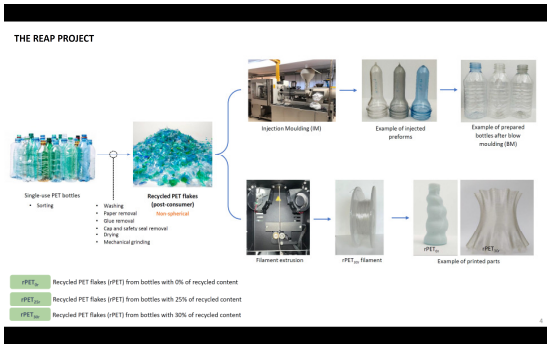
Researchers presentation

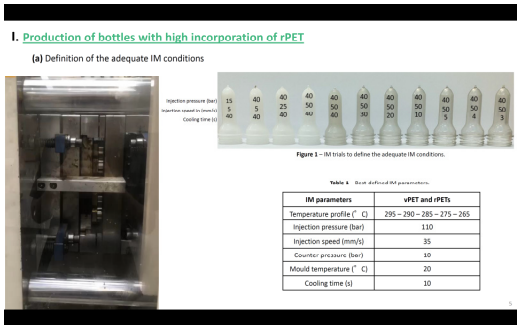
Research results presentation:

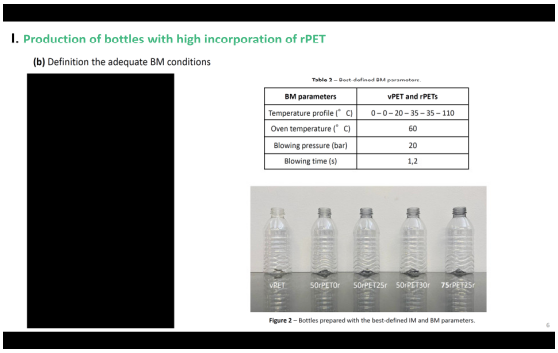

REAP- Recycling and refund of aluminum and PET packaging

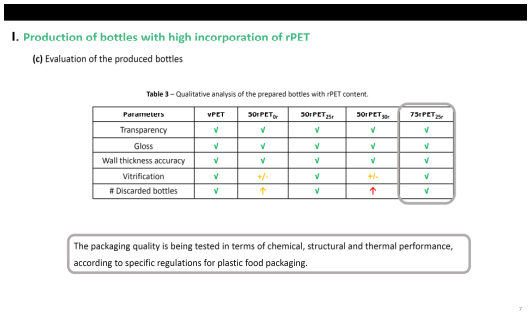

OUTLINE
• The REAP project – goals
• Main achievements
• Project Dissemination

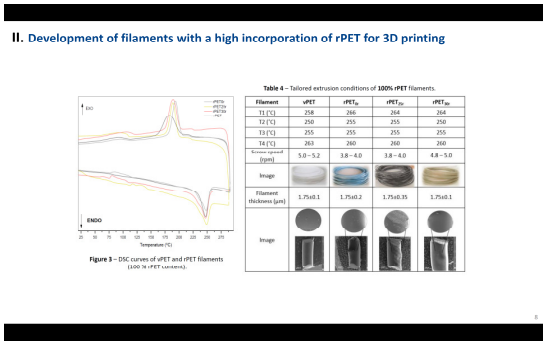

THE REAP PROJECT – Goals
REAP – Recycling and Refund of Aluminium and PET packaging
Studied strategies to reuse the collected bottles:
I. Production of water bottles with high incorporation of recycled PET (rPET)
II. Development of filaments with a high incorporation of rPET for 3D printing
Complementary study: Evaluate PET reprocessing limits
MECHANICAL RECYCLING

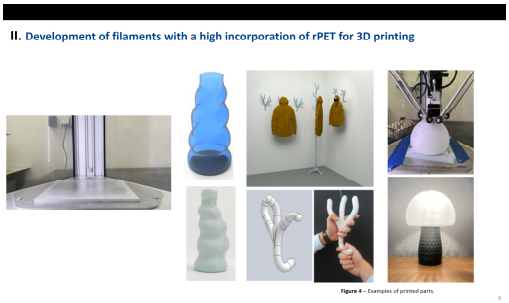

THE REAP PROJECT
Injection Moulding (IM)
Example of injected preforms
Example of prepared bottles after blow moulding (BM)
Single-use PET bottles
Recycled PET flakes (post-consumer)
Filament extrusion
Example of printed parts
Recycled PET flakes (rPET) from bottles with 0% of recycled content
Recycled PET flakes (rPET) from bottles with 25% of recycled content
Recycled PET flakes (rPET) from bottles with 30% of recycled content

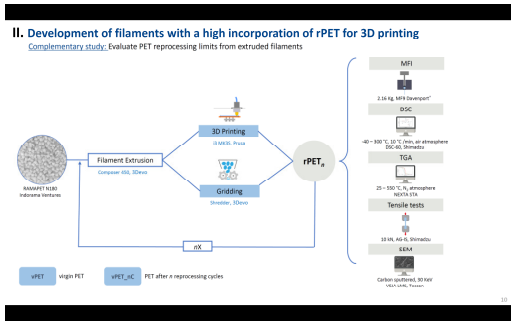

I. Production of bottles with high incorporation of rPET
(a) Definition of the adequate IM conditions
Figure 1 – IM trials to define the adequate IM conditions.
IM parameters | vPET and rPETs
Temperature profile (°C) | 295 – 290 – 285 – 275 – 265
Injection pressure (bar) | 110
Injection speed (mm/s) | 35
Counter pressure (bar) | 10
Mould temperature (°C) | 20
Cooling time (s) | 10

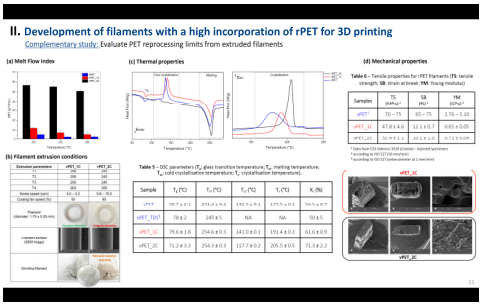

I. Production of bottles with high incorporation of rPET
(b) Definition the adequate BM conditions
BM parameters | vPET and rPETs
Temperature profile (°C) | 0 – 0 – 20 – 35 – 35 – 110
Oven temperature (°C) | 60
Blowing pressure (bar) | 20
Blowing time (s) | 1,2
vPET
50rPET0r
50rPET25r
50rPET30r
75rPET25r
Figure 2 – Bottles prepared with the best-defined IM and BM parameters.

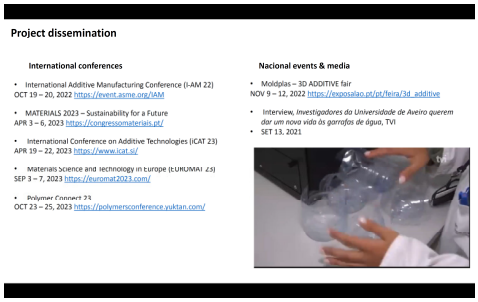

I. Production of bottles with high incorporation of rPET
(c) Evaluation of the produced bottles
Table 3 – Qualitative analysis of the prepared bottles with rPET content.
Parameters | vPET | 50rPET0r | 50rPET25r | 50rPET30r | 75rPET25r
Transparency | √ | √ | √ | √ | √
Gloss | √ | √ | √ | √ | √
Wall thickness accuracy | √ | √ | √ | √ | √
Vitrification | √ | +/- | √ | +/- | √
Discarded bottles | √ | ↑ | √ | ↑ | √
The packaging quality is being tested in terms of chemical, structural and thermal performance, according to specific regulations for plastic food packaging.


II. Development of filaments with a high incorporation of rPET for 3D printing
Table 4 – Tailored extrusion conditions of 100% rPET filaments.
Filament | vPET | rPET0r | rPET25r | rPET30r
T1 (°C) | 258 | 266 | 264 | 264
T2 (°C) | 250 | 255 | 255 | 250
T3 (°C) | 255 | 255 | 255 | 255
T4 (°C) | 263 | 260 | 260 | 260
Screw speed (rpm) | 5.0 – 5.2 | 3.8 – 4.0 | 3.8 – 4.0 | 4.8 – 5.0
Image
Filament thickness (µm) | 1.75±0.1 | 1.75±0.2 | 1.75±0.35 | 1.75±0.1
Image
ENDO
Figure 3 – DSC curves of vPET and rPET filaments





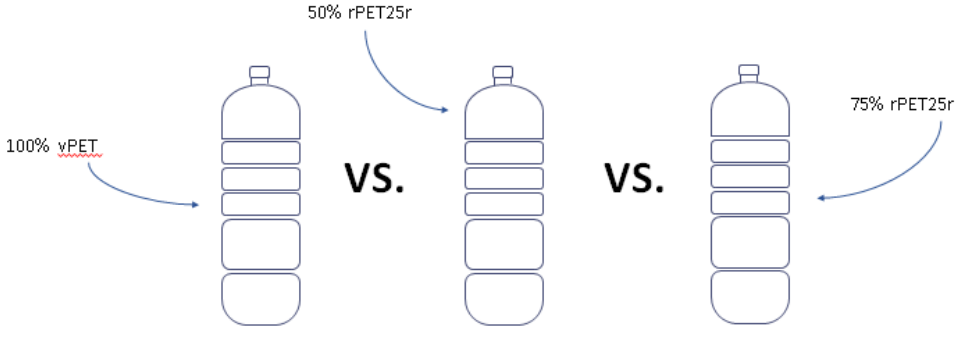




ACTIVITY 5 - DEMONSTRATION OF THE QUALITY OF RECYCLED PET

STATUS: concluded in December of 2023 | **EXECUTION RATE:** 100%

The demonstration of the quality of products obtained with recycled PET (rPET), bottle-to-bottle, within the scope of the project, considered the scheme for the tested samples in Figure 10.



As garrafas foram produzidas na Escola Superior Aveiro- Norte, Universidade de Aveiro.

Figures 10 – Products obtained by incorporating recycled PET, bottle-to-bottle.

The study was based on chemical, structural and thermal analyses.

The chemical analysis was based on the determination of Bisphenol A and Terephthalic Acid, applying:

- Global migration tests, in accordance with European Standard 1186-1;
- Specific migration tests according to European Standard 13130-2,13130-13.

In global migration tests, given the global migration limit of 10 mg/kg, all samples are below the detection limit (≃ 0.1 mg/kg).

In the specific migration tests, by ion chromatography, the presence of bisphenol A or terephthalic acid was not detected in any of the rPET fractions and for two different simulants.

It was concluded that no significant changes were detected in the quality of bottles produced with 50%rPET and 75% rPET in the first recycling cycle.

The structural analysis was carried out by FTIR analysis on bottles produced in the project (50%rPET and 75%PET) and commercial bottles (0%rPET), Figure 11.

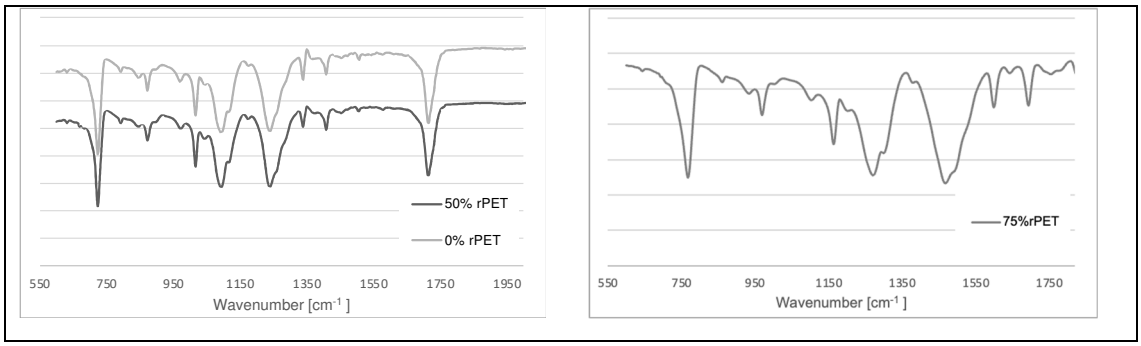


Figure 11 - FTIR analysis comparison on commercial bottles 0% rPET, bottles 50% rPET and 75% rPET, produced within the scope of the REAP project.

Thermal analysis was carried out using thermogravimetric analysis (TGA) of the same samples, to evaluate the mass variation according to the temperature variation, Figure 12.

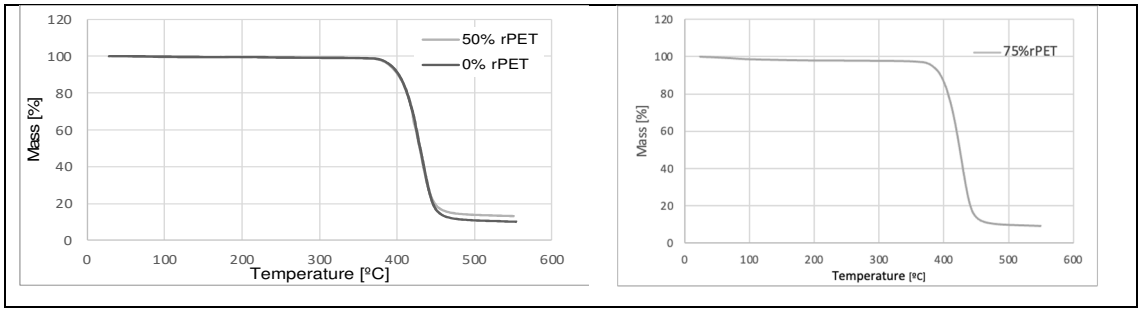


Figure 12 - Comparison of TGA analysis on commercial 0% rPET bottles, 50% rPET and 75% rPET bottles, produced within the scope of the REAP project

These two analyzes were carried out for comparison, with the aim of evaluating the possible change in structure/chemical modification of PET when adding recycled PET.

No significant changes were detected in the quality of bottles produced with 50%rPET and 75%rPET in the first recycling cycle, compared to 0%rPET bottles.

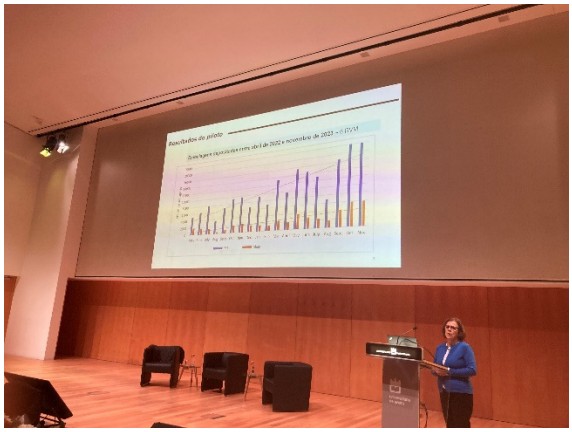
No significant changes were detected in the quality of bottles produced with 50%rPET and 75%rPET in the first recycling cycle.

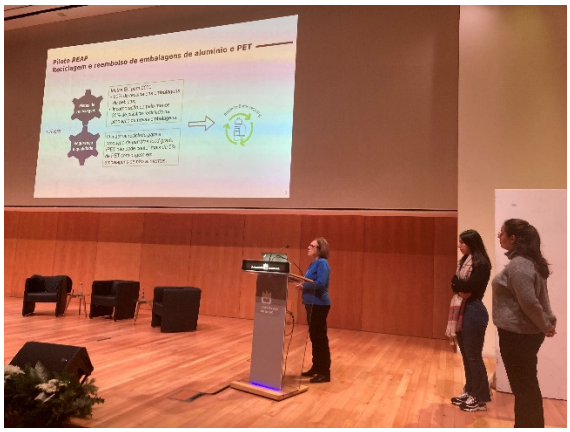
The results highlight the importance of selective collection and the recycling method bottle-to-bottle.

During the project's closing event, research conclusions regarding the quality of recycled PET were presented. Completing the technical demonstration of its quality and closing the activity in question with technological developments and technology transfer between University units and strategic partners.

Several works were also presented before and by the year 2024 they will be defended and presented at several conferences in the materials area.

Researchers presentation





Research results presentation:

Equipa do REAP do Departamento de Ambiente e Ordenamento

Ana Isabel Miranda – Docente
Ana Paula Gomes – Docente
Maria Isabel Nunes – Docente
Ana Alexandra Oliveira – Bolseira REAP
Jéssica Moura – Bolseira REAP
Vânia Castro – Bolseira REAP

Piloto REAP
Reciclagem e reembolso de embalagens de alumínio e PET

Drivers

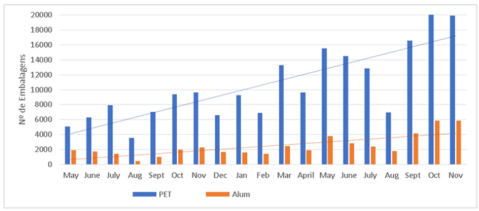
- Metas de reciclagem
- Segurança e qualidade

Metas EU para 2030:
- 90% de recolha das embalagens de bebidas;
- Incorporação de pelo menos 30% de plástico reciclado na produção de novas embalagens.

O material reciclado para a produção de garrafas *food-grade* rPET não pode conter mais de 5% de PET com origem em embalagens de não alimentos.

Resultados do *piloto*

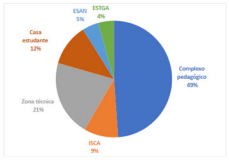
Embalagens depositadas entre abril de 2022 e novembro de 2023 – 6 RVM



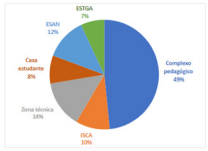
Resultados do *piloto*

Embalagens depositadas entre abril de 2022 e novembro de 2023

PET – total 200 mil unidades



Alumínio – total 47 mil unidades



Resultados do *piloto*

Embalagens depositadas entre abril de 2022 e novembro de 2023 – 6 RVM

250 mil embalagens depositadas

4,4 Mg

Cerca de 12% do resíduo anual de plástico e metal da UA

Academia 19347 membros

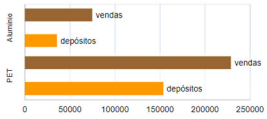
13 embalagens por membro da academia

Créditos:
0,02 € - PET e latas ≥ 0,1L ≤ 0,5L
0,05 € - PET > 0,5L ≤ 2L
Total 8 mil €

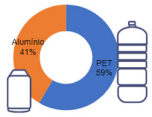
Média de 1700 utilizadores por mês

Resultados do *piloto*

Para a estimativa de vendas na UA no ano de referência 2019



Depósitos / Vendas [dez 2022 a nov 2023]



Avaliação ambiental

Ferramenta – análise de ciclo de vida

Metodologia

Embalagens de bebida em análise:
Garrafas de polietileno tereftalato (PET)
Latas de alumínio

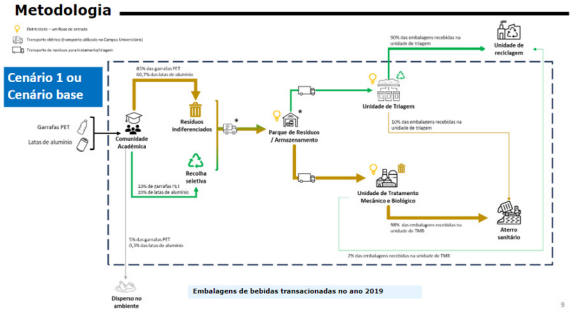
Unidade funcional considerada:
1 tonelada de resíduos de embalagem de bebidas de PET ou de alumínio encaminhadas para reciclagem.

Cenário 1 ou Cenário base

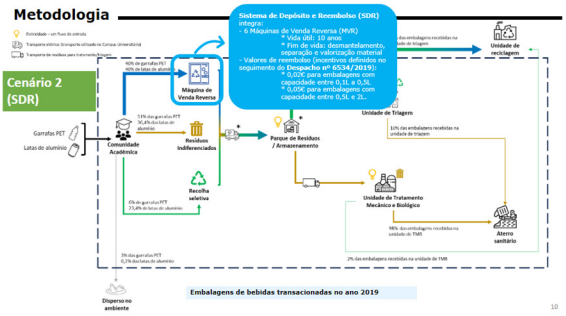
Cenário 2 (com implementação de SDR)

Taxas de devolução em análise de 40% e 80%

Metodologia



Metodologia



Metodologia

Recursos
Normas ISO 14040:2006 e ISO 14044:2006
Software OpenLCA (versão 1.10)
Base de dados Ecoinvent (versão 3.9.1 – Cutoff LCI).

Inventário de Ciclo de Vida (ICV)
Modelo *gate-to-gate*

Avaliação de Impacto de Ciclo de Vida (AICV)
Metodologia CML (*baseline* – versão 4.4, janeiro 2015)
Categorias de impacto:

- **Potencial de acidificação** (AP)
- **Potencial de aquecimento global** (GWP 100)
- **Potencial de esgotamento de recursos abióticos naturais** (ADP (naturais))
- **Potencial de esgotamento de recursos abióticos fósseis** (ADP (fósseis))
- **Potencial de eutrofização** (EP).

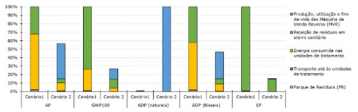
A análise não incluiu:
- A produção e distribuição das embalagens de bebida de PET e de alumínio.
- O processo de reciclagem das embalagens de bebidas.
- A produção e fim de vida de equipamentos das unidades de tratamento.

11

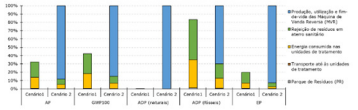
Resultados

Análise relativa dos cenários para embalagens de bebida de PET e de alumínio

Garrafas de PET



Latas de alumínio

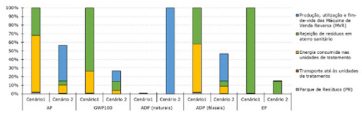


12

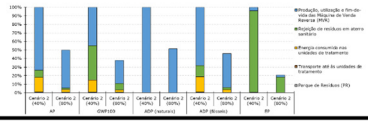
Resultados

Análise relativa da taxa de devolução para embalagens de bebida PET

Cenário 1 vs. Cenário 2



Taxas de devolução: 40% vs. 80%



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Conclusões

A implementação do SDR reduziu, para embalagens de bebida de PET e de alumínio, **a produção de resíduos** de embalagem **com necessidades de tratamento** (unidades de triagem e TMB) e a deposição em aterro.

O aumento de impacte associado à produção e utilização das máquinas de venda reversa (MVR), alerta para a importância da **utilização assídua dos equipamentos** e para a importância de **manutenção e limpeza adequada.**

Melhoria do desempenho ambiental deste sistema é possível com o aumento da taxa de devolução. A **taxa de deposição** é um **aspeto social**, para o qual é essencial o **investimento na sensibilização ambiental** da academia e **dar continuidade à implementação/operacionalização do sistema.**

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Avaliação da qualidade

De acordo com normas de qualidade para plásticos em contacto com alimentos

15

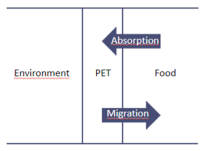
Metodologia

- Chemical Analyses
- Structural Analyses
- Thermal Analyses

16

Metodologia

- Chemical Analyses
- Structural Analyses
- Thermal Analyses



Testes de migração global
European Standard 1186-1

Testes de migração específica
European Standard 13130-2 13130-13

17

Metodologia

- Chemical Analyses
- Structural Analyses
- Thermal Analyses

Fourier transform infrared spectroscopy Analysis (FTIR)

18

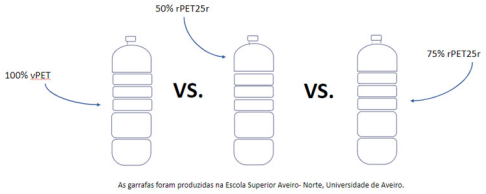
Metodologia

- Chemical Analyses
- Structural Analyses
- Thermal Analyses

Thermal gravimetric analysis (TGA)

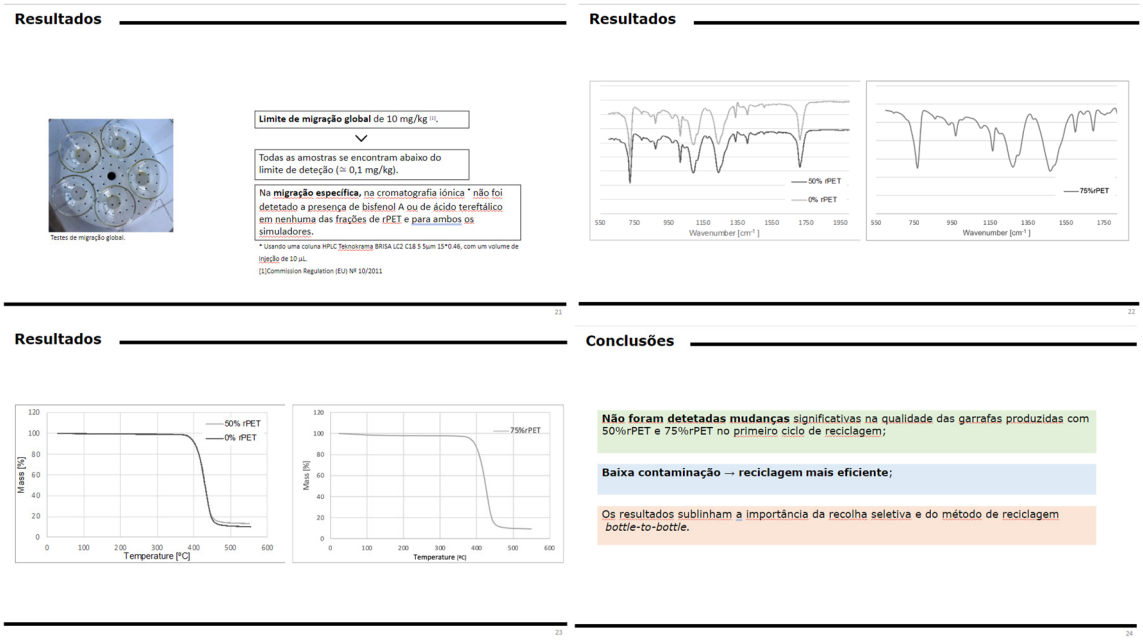
19

Materiais



As garrafas foram produzidas na Escola Superior Aveiro- Norte, Universidade de Aveiro.

20



ACTIVITY 6 – PROJECT COMUNICATIONAL PLAN

STATUS: concluded in December of 2023 | **EXECUTION RATE:** 100%

Following the work previously carried out in activities 3 and 5 of the Project ("Monitoring and evaluating the implementation of the pilot" and "Demonstration of the quality of recycled products"), three communications were written, resulting in three presentations and a poster, presented in three scientific events, referred to below:

- CEST 2023 – 18th International Conference on Environmental Science & Technology

A scientific article was submitted to the CEST 2023 conference entitled "Reimbursement of aluminum and PET packaging project at a University Campus: a case study". This was accepted and presented at the conference held in Athens, Greece between August 30th and September 2nd, 2023. This article is published and accessible through https://doi.org/10.30955/gnc2023.00116. A poster was also created and displayed during the event's poster sessions.

- WASTES 2023: Solutions, Treatments and Opportunities - 6th International Conference

A scientific article was submitted to the WASTES 2023 conference, entitled "Quality assessment of PET bottles produced through bottle-to-bottle recycling" (Annex 3). This was accepted and presented at the conference held in Coimbra between the 6th and 8th of September 2023 where the project and the work carried out were presented. The article is compiled in the Book of Proceedings pp 299-301, ISSN 2183-0568

- 13th International Waste Technical Conference (13th JTIR) - under the theme “Singularities and Opportunities”

A scientific article was submitted to the 13th JTIR conference, entitled “ENVIRONMENTAL PERFORMANCE OF A DEPOSIT AND REFUND SYSTEM IN ACADEMIC CONTEXT. CASE STUDY: UNIVERSITY OF AVEIRO”. This was accepted and presented at the event that took place from 15 to 18 November 2023, in Bragança. The communication is referenced in the Summary Book. E-Book ISBN: 978-989-54301-4-7.

The results related with Activity 4 are listed below:

- Participation on International Conferences:
  - International Additive Manufacturing Conference (I-AM 22)
    OCT 19 – 20, 2022 https://event.asme.org/IAM
  - MATERIALS 2023 – Sustainability for a Future
    APR 3 – 6, 2023 https://congressomateriais.pt/
  - International Conference on Additive Technologies (iCAT 23)
    APR 19 – 22, 2023 https://www.icat.si/
  - Materials Science and Technology in Europe (EUROMAT 23)
    SEP 3 – 7, 2023 https://euromat2023.com/
  - Polymer Connect 23
    OCT 23 – 25, 2023 https://polymersconference.yuktan.com/
- Participation on National Conferences and press:
  - Moldplas – 3D ADDITIVE fair
    NOV 9 – 12, 2022 https://exposalao.pt/pt/feira/3d_additive
  - Interview, Investigadores da Universidade de Aveiro querem dar um nova vida às garrafas de água, TVI

SET 13, 2021

On December 18th, the closing event of the REAP project was held, where the packaging deposit and refund system was discussed. With the recent approval by the government of the legislation that defined the framework for the packaging Deposit and Refund System (SDR), we promoted a conference that brought together entities at the table to discuss the future system that should be implemented and come into operation in 2025.

The conference was moderated by journalist Carlos Vaz Marques and was part of the closing program of the REAP project. The initiative took place in the Renato Araújo Auditorium (Central Building of the Rectory), with free entry and was opened with the inauguration of "Reciclophonia", created especially for the UA, which gave life to materials found on the campuses, abandoned and unused, to promote music in an interactive way.

The conference was attended by Miguel Aranda da Silva, general director of SDR Portugal, the entity that should take over management of the system in the future, Ana Carrola (Portuguese Environment Agency), Pedro Gomes (General Secretariat for the Environment) and Tor Guttulsrud, financial director of Infinitum, a Norwegian company partnering with the UA for the project.

The project's closing event also served to publicize the results of the research projects and award prizes to the winners of the "Recicla & Ganha" competition, which awarded the students who deposited the most PET and aluminum packaging in reverse vending machines. (RVM) spread across campuses.

An artistic musical installation was planned and executed with the aim of creating an interactive orchestra that generates interactivity with people. It gave new life to materials that would be discarded by the University of Aveiro through recycling and constituted an invitation to create other works with creative reuse.

After a temporary stay at the entrance to the University Rectory, it was placed close to the student bar and study room 24 so that it had free access and could be shared among the community.

Presentation video link: https://www.youtube.com/watch?v=A7OWAzqfkD0




The Recicla e Ganha Awards were awarded to the students who collected the most aluminum and PET packaging within the scope of the project and we were successful with record participation and collection in the same months (September, October, November and December).

The repercussion in the media of the Reap's activities is presented below:


Diário de Aveiro

NOVO pingo doce AVEIRO

ROTUNDAS NO ACESSO À A1 EXIGIDAS PELOS MUNÍCIPES DA MEALHADA

Assembleia municipal vai remeter à Infraestruturas de Portugal um abaixo-assinado da população, no qual é reivindicada a substituição dos cruzamentos na Pedrulha e junto à portagem da autoestrada Página 28

INVASÃO DA UCRÂNIA
Famílias de soldados russos apelam ao fim da guerra
Página 21

Eólicas no mar geram receios na Ria de Aveiro
Ambiente | Pág

O Natal visto pelo Bispo de Aveiro
Opinião | Pág

Natal
Hoje, com o seu jornal, o especial Natal

Galitos em plano de destaque no Torneio Zonal de Juvenis
Natação | Pág

Turismo Centro de Portugal define estratégia de ação até 2030
Quatro eixos | Pág

Recolhidas 4,5 toneladas de embalagens na UA
As mais de 250.000 embalagens recicladas deram descontos nas cantinas e bares Página 5

Ouro 800 EMPRESTAMOS

NA COMPRA DE UMA VIATURA OFERTA CARTÃO COMBUSTÍVEL 150 €
SUPRACAR
OFERTA IPHONE 15 PARA COMPRAS SUPERIORES A 25.000€

Diário de Aveiro

Mais de 250.000 embalagens deram descontos na UA

Sustentabilidade Projeto de reciclagem permitiu recolher 4,5 toneladas de embalagens, «resultados valiosos no que respeita à disseminação de práticas sustentáveis», referiu Pedro Gomes, da Secretaria Geral do Ambiente

Carla Real (com Lusa)

Mais de 250.000 embalagens, cujo valor deu desconto em cartão usado nas cantinas, bares e papelarias, foram recolhidas na Universidade de Aveiro (UA), de acordo com o relatório final ontem divulgado.

O projeto-piloto REAP'Ale reciclagem e reembolso de embalagens de alumínio e PET), que começou em abril de 2022, permitiu recolher 250.700 embalagens, num total de 4,5 toneladas.

No âmbito deste projeto, foram instaladas, em vários espaços da universidade, máquinas de recolha, a que foi atribuído um valor, a descontar em cartão para consumir nas cantinas, bares e papelarias.

«Com este projeto conseguimos agregar 25 por cento de PET reciclado, sem adição de químicos, na produção de garrafas com qualidade para ir ao mercado consumidor», adiantou à Lusa um dos investigadores.

Além da recolha de embalagens, o projeto tem uma componente de investigação, cujos resultados foram apresentados numa conferência que decorreu ao longo do dia de ontem. Foram, ainda, entregues os prémios aos estudantes vencedores do concurso "Reciclo & Ganho".

A conferência deu lugar a novo sistema de recolha que entrará em funcionamento em 2025, por força da legislação que define o Sistema de Depósito e Reembolso de embalagens.

O projeto REAP foi aprovado para financiamento pelo Programa Ambiente, do mecanismo financeiro plurianual do Espaço Económico Europeu (EEA Grants). Pedro Gomes, em representação da Secretaria Geral do Ambiente, referiu que «este projeto representa muito do que são os EEA Grants», esperando «que continue a apresentar resultados tão bons e valiosos no que respeita à disseminação de práticas cada vez mais sustentáveis».

Para a sua implementação, a UA teve como parceiro a empresa norueguesa Infinitum, com experiência na implementação do sistema de recolha com reembolso na Noruega. Em sua representação esteve Tor Guttubrud, que falou no exemplo da Noruega no que respeita à reciclagem. «Se decidirmos a solução a cargo das indústrias, temos um problema; é mais eficiente tomar decisões a título individuais», defendeu. «Primeiro, temos que colectar e, só depois, pensar na reciclagem», acrescentou o responsável.

Alexandra Queirós, vice-reitora para as Políticas e para a Cultura e a Vida nos Campi, agradeceu a colaboração desta empresa no projeto. «A Infinitum tem dado um contributo muito importante, através da sua experiência, frisou, agradecendo, também, a toda a comunidade académica pelo envolvência e por «contribuir para a economia circular». «A sustentabilidade é, desde há já alguns anos, um princípio fundamental para a UA, tanto na dimensão social, como financeira e, naturalmente, ambiental, o nosso objetivo é a neutralidade carbónica, em sintonia com as políticas diretivas da União Europeia», acrescentou a vice-reitora.

Alexandra Queirós agradeceu o envolvimento da academia

'Reciclofonia' instalada na Reitoria

Alexandra Queirós congratulou-se com o facto de as cinco máquinas existentes, bem como a questão do reembolso, terem conseguido levar a comunidade académica a aderir a este projeto. «Foi, naturalmente, muito importante, e fomentou a importância da sustentabilidade ambiental na comunidade UAveiro, sabendo-se, relativamente aos bons resultados registados. «São importantes para a UA, na medida em que nos permitem trabalhar em novos projetos futuros», concluiu.

Antes da conferência, foi inaugurada, no átrio da Reitoria, a instalação sonora "Reciclofonia", da autoria do artista BiCoao Fernandes, criada especialmente para a UA, dando vida «a materiais encontrados nos campi, abandonados e sem uso, para promoverem música de forma infinitiva». ●

Jornal de Notícias 10 de dezembro de 2023

Mealhada quer rotundas no acesso à A1

Assembleia Municipal vai pedir à IP para substituir cruzamentos devido aos acidentes

SINISTRALIDADE A Assembleia Municipal da Mealhada vai remeter à Infraestruturas de Portugal (IP) um abaixo-assinado da população, através do qual é reivindicada a construção de duas rotundas, que venham substituir os cruzamentos existentes junto ao acesso à autoestrada do Norte (A1).

O documento foi entregue por um munícipe à Assembleia Municipal da Mealhada, sendo remetido esta semana à IP.

Do acordo com o munícipe Hélder Ferreira, há muito que a população da Pedrulha e de Casal Comba reivindica a construção da rotunda da Pedrulha e da rotunda junto à portagem, ambas no acesso à A1. Estas rotundas viriam substituir os cruzamentos ali existentes, nos quais se regista uma "elevada sinistralidade".

O munícipe pediu o contributo da Assembleia Municipal da Mealhada na resolução do problema, fazendo chegar o abaixo-assinado a diversas instâncias.

No que diz respeito à rotunda da Pedrulha, o presidente da Câmara, António Jorge Franco, admitiu que tem havido negociações com a IP.

"Espero que haja decisões céleres sobre a execução da rotunda", referiu.

Em relação à portagem, que já se encontra em território do concelho vizinho de Cantanhede, "está prevista a sua substituição por uma rotunda", no âmbito da empreitada de construção de uma adega privada nas imediações. ●

Cruzamento da Pedrulha fica a poucos metros da A1

Zona industrial de Formariz ampliada

PAREDES DE COURA A zona industrial de Formariz, em Paredes de Coura, está a ser alvo de obras de ampliação e requalificação de 2,2 milhões de euros cofinanciados em 1,5 milhões por fundos comunitários, foi ontem revelado pela Câmara. O investimento traduz-se na criação de novos lotes, novos arruamentos com ligação aos existentes e parques de estacionamento.

Vão ainda ser criados "novos lotes no interior do parque industrial, alguns dos quais para espaços verdes", informa o município. Com esta ampliação e requalificação, a Zona Industrial de Formariz vai "permitir a concentração das atividades industriais num único local". ●

BREVES

Coimbra pretende substituir iluminação pública

CONCURSO A Câmara de Coimbra aprovou ontem o lançamento de um concurso para um contrato de eficiência energética que prevê a substituição de toda a luminária convencional por tecnologia LED. Mais de 50% da iluminação pública do concelho ainda é luminária convencional (23 mil lâmpadas). A proposta passa por um contrato de concessão com uma empresa, que fica responsável pelo investimento (substituição de luminárias), recebendo uma parte da poupança prevista na fatura da luz.

Mais de 250 mil embalagens deram desconto em Aveiro

UNIVERSIDADE Mais de 250 mil embalagens, cujo valor deu desconto em cartão usado nas cantinas, bares e papelarias, foram recolhidas na Universidade de Aveiro, foi ontem divulgado. O projeto-piloto REAP de reciclagem e reembolso de embalagens de alumínio e PET, colocadas em máquinas espalhadas pelo campus, começou em 2022, permitiu recolher 250 700 embalagens, num total de 4,5 toneladas.

Festival de Jardins recebeu 11 propostas

PONTE DE LIMA O Festival de Jardins de Ponte de Lima, que vai decorrer entre maio e outubro de 2024, recebeu 11 propostas para o tema "O imaginário na arte dos jardins". Além de Portugal há propostas da Polónia, França, Brasil, Hungria, Dinamarca, Espanha, Alemanha, Suíça, Áustria, China e Inglaterra.

Barcelos muda de ano com música de baile e foguetes

FESTA Barcelos já tem programa para a entrada no novo ano. A autarquia informou ontem que 2024 vai entrar ao som de música de baile e de fogo de artifício, num espetáculo a acontecer em pleno Centro Histórico, junto ao Templo Bom Jesus da Cruz, com entrada livre e início marcado para as 22.30 horas. ●●

RESULTS ACHIEVED

The project results are presents in Tables 9 and 10.

Table 9 - Collection numbers – October; November; December 2023

	N.º Embalagens PET recolhidas	N.º Latas recolhidas	N.º de utilizadores (dados portal)	N.º Embalagens recolhidas	Peso em kg
Total out 2023	21520	5829	2194	23714	482,5
Total nov 2023	19955	5886	1825	21780	458,5
Total dez 2023	14522	3521	1241	15763	316,7
Total do período	55997	15236	5260	61257	1257,7

Table 10 - Project execution rate

Activity ID	Name of Activity	Executing entity	Indicator	Unit	Target	out/23	nov/23	dez/23	valor médio out23-dez2023	Execution rate out23-dez2023	Acumulated execution	Acumulated execution rate	Total recolhido (Kg)	Total recolhido (ton)
2	Pilot implementation - Priority area A	UA	Quantity of packages (PET and aluminium) sent for recycling per month	Kg/month	232	482,5	458,5	316,7	419,2	100%	225,1	97%	**4727,6**	**4,73**
			Quantity of Pet packaing sent for recycling per month	Kg/month	187	409,1	384,5	272,4	355,3	100%	195,1	100%		
			Quantity of aluminium packaging sent for recycling per month	Kg/month	44	73,4	74,0	44,3	63,9	100%	30,0	68%		
			RVM Users		-	2125	1854	1240	1739,8	-	1079,8	-		
			Quantity of packages sent for recycling per user (RVM users)	Kg/month	-	0,23	0,25	0,26	0,2	-	0,2	-		
			Quantity of packages sent for recycling per user (13400 students and non-students)	Kg/month	0,015	0,036	0,034	0,024	0,0	100%	0,0	100%		
											Project execution	**91%**		

FINANTIAL EXECUTION

The execution of the UA corresponds to 97.29% of the Promoter's budget (percentage without Indirect Costs). Considering the value of € 13,503.03 of expenditure contained in the excel file made available by the Partner, the execution of INFINITUM corresponds to 62.80% of the Partner's budget.

Therefore, under the above assumption and aggregating the UA data (email below), compared to the global budget, it will correspond to an execution of 96.42% (percentage without Indirect Costs).

Output / Activity Budget Heading	Custos de gestão / Management cost	Output / Atividade 1 /Output/Activity 1	Output / Atividade 2 / Output/Activity 2	Output / Atividade 3 /Output/Activity 3	Output / Atividade / Output/Activity 4	Output / Atividade / Output/Activity 5	Output / Atividade / Output/Activity 6	Custo total de despesas elegíveis / TOTAL ELIGIBLE BUDGET HEADING COSTS
Custos com recursos humanos afetos ao projeto / Cost of staff assigned to the project - Reg. Art. 8.3.1.a	108 632,28	29 236,24	35 210,38	112 657,10	64 109,15	56 514,11	115 005,85	521 365,12
Custos com transporte e ajudas de custo para deslocações de pessoal que participe no projeto / Travel and subsistence allowances for staff - Reg. Art. 8.3.1.b	-	-	-	-	-	-	25 568,68	25 568,68
Depreciation value for new or second hand equipment purchased - Reg. Art. 8.2.4	-	-	-	-	-	-	-	-
Custos com equipamentos novos ou em segunda mão, desde que sejam amortizados de acordo com as normas contabilísticas aplicáveis / Cost of new or second hand equipment - Reg. Art. 8.3.1.c & Art. 8.3.2	-	74 085,48	-	5 596,50	96 785,92	-	-	176 467,90
Purchase of land and real estate - Reg. Art. 8.3.1.d & Art. 8.6	-	-	-	-	-	-	-	-
Custos com consumíveis e outros fornecimentos / Costs of consumables and supplies - Reg. Art. 8.3.1.e	2 395,34	-	-	-	35 210,82	10 884,64	9 965,18	58 455,98
Custos com a aquisição de serviços a terceiros para a implementação do projeto / Costs entailed by other contracts awarded by PP for the purpose of carrying out the project - Reg. Art. 8.3.1.f	-	-	8 339,15	-	-	530,56	-	8 869,71
Despesas que resultem diretamente das obrigações impostas pelo contrato de projeto / Costs arising directly from requirements imposed by the project contract - Reg. Art. 8.3.1.g	21 217,50	-	-	-	-	-	-	21 217,50
Custos indiretos / INDIRECT COSTS - Reg. Art. 8.5								78 204,77
Total Custos Elegíveis / TOTAL ELIGIBLE COSTS	*132 245,12*	*103 321,72*	*43 549,53*	*118 253,60*	*196 105,89*	*67 929,31*	*150 539,71*	890 149,66

Projector Promotor

Name	Artur Silva
Date and Signature	Assinado por: **ARTUR MANUEL SOARES DA SILVA** Num. de Identificação: 06664931 Data: 2024.03.12 00:48:59+00'00' Certificado por: **Diário da República** Atributos certificados: **Vice-reitor para a investigação, inovação e formação de 3º ciclo e acreditação dos ciclos de estudos - Universidade de Aveiro** CARTÃO DE CIDADÃO
Position	Vice-Rector

Programme Operator – Secretary General for Environment

Name	Marco Rebelo
Date and Signature	
Position	Secretary General