TEST case study

Plastic Recycling company

Developed under the framework of Med TEST II

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

switchmed

The SwitchMed Programme is funded by the European Union

Plastic Recycling company

SECTOR	Chemical sector
SUBSECTOR:	Plastic recycling
SIZE	150 full time employees
PRODUCTS	Recycled PET (RPET), Recycled Polypropylene (RPP) & Recycled Polyethylene (RPE) Pellets with brand names QPET, QPE & QPP
MARKET	94% Export; USA & Canada, EEA, Turkey and KSA
CERTIFIED MANAGEMENT SYSTEMS	**Before participation in TEST:** • Quality (ISO9001); • EHS (ISO14001 OHSAS18001); • and food safety (ISO22000, FDA, EFSA, Health Canada) **After participation in TEST:** • ISO 14001: 2015 Certification for Environmental Management System.

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Company Key data

- Before Joining the project, the company was facing a few challenges related to the quality of feedstock, and excessive consumption of resources such as water.
- These in turn are reflected in higher conversion cost, so overcoming such big challenges would definitely lead to a better and efficient performance in both operations/financial aspects

YEAR 2015	Unit	Value
Production: Recycled PET pellets	Ton/an	**11,894**
Electricity consumption	kWh/an	**11,865,588**
Diesel Consumption	Litre/an	**199,727**
Water consumption	m^3/an	**65,018**
CO_2 emission	Ton/an	**6,345**
BOD_5	Kg/an	**N/A**
COD	Kg/an	**N/A**
Total cost of sales	Euro/an	**10,704,600**
Total cost of inputs (Purchase value of raw materials, auxiliary materials, packaging energy and water)	Euro/an	**3,434,735**
	% vs. cost of sales	**32%**
Estimated non-product output	Euro/an	**1,606,888**
	% vs. cost of sales	**15%**

Process overview/flowchart

INPUTS

- PET bottle bales, Process chemicals
- Water
- Energy (Electricity, Diesel)
- Operating chemicals (washing line, utilities)
- Packaging materials

Utilities

- Water Treatment plant
- Air compressors
- Waste Water Treatment plant
- Steam boiler

Process

Raw materials recieving & storage ↓ Grinding ↓ Washing ↓ Sorting ↓ Cleaning ↓ Flakes extrusion ↓ Filteration ↓ Crystallization ↓ SSP (Solid State Polycondensation) ↓

OUTPUTS

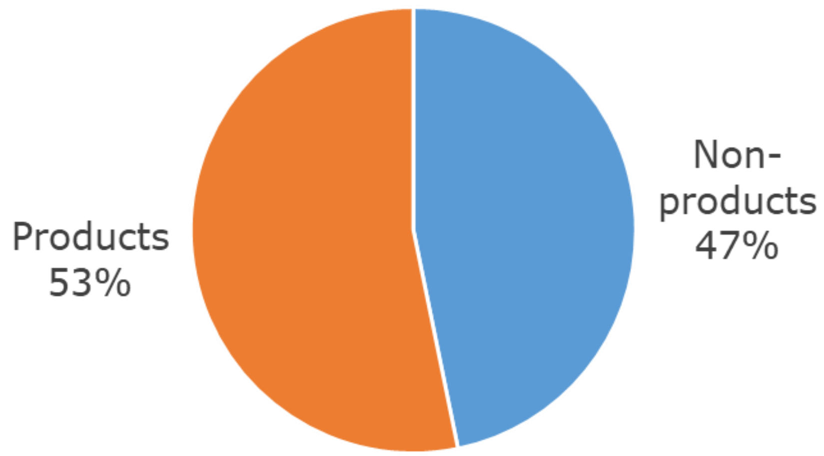
- PET pellets
- Byproducts (PO flakes, fines,...)
- Rejected bottles
- Wastewater
- Air emissions (CO_2, boiler, dust, odour)
- Solid waste (Cartoon Dust Mud)

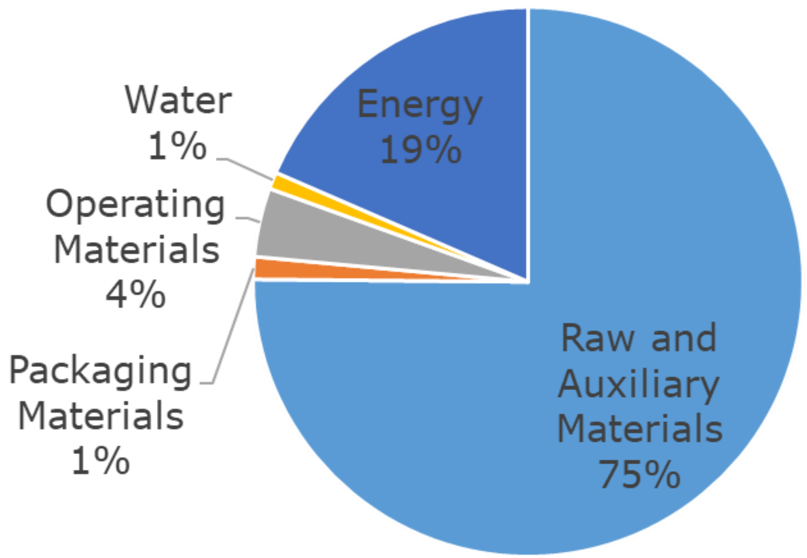
Benchmarking

Benchmark type	Unit	Company records (2015)	International Best practice
Electricity	KWh_{elec}/ Ton_{PET}	997.61	850-900
Thermal energy	KWh_{heat}/ Ton_{PET}	195.29	150
Water	m^3/ Ton_{PET}	5.47	1.5
Resources, raw material	$Ton_{raw\ material}$/ Ton_{PET}	1.56	1.177

Comparing the company level KPI to international best practice was very useful to highlight the large gap in water consumption at the company compared to the international benchmark. Other flows are also slightly higher than the benchmark, but the gap in water is extremely high.

Non-Product Output costs





Approximately 47% of the purchased value in 2015 was lost due to product losses in manufacturing, energy, waste water and waste generation. This high percentage of loss was only quantified after the MFCA exercise.

By breakdown of the NPO amongst different flows, the company realised that the main source of losses was due to the losses in raw material. Before the TEST, the company wanted to address Energy and water losses (which account for only 20% of the loss).

Priority flows

Priority flows were selected to be:

1 – Raw and Auxiliary material

2 – Water

3 – Energy

This selection and prioritization was based on:

- NPOs cost analysis
- Potential for improvement (deviation from international benchmarks)

Information system - MFCA

- The company had an Enterprise Resource Planning (ERP) monitoring system already in place. That ERP system facilitated the speedy data collection on company level for the I/O analysis. However, some data was overseen from the system such as the solid and hazardous waste.
- The MFCA revealed that the main losses result from raw material losses, and the share of water losses is negligible, representing 1% of the NPO.
- Some flows were not monitored within the company existing system. Those were mainly the losses of raw material in the form of dust and mud, which were normally estimated.

Information system - MFCA

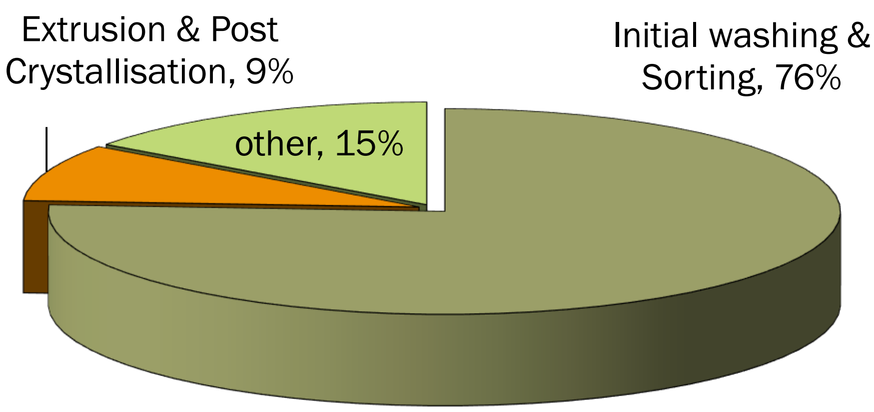
- One of the main challenges faced with the MFCA assessment relates to the definition of flows within the company. In some meetings, it was noted that the definition of rejects was not common amongst different parties. Some considered the rejects as the material that is sold or discarded of as solid waste, while others considered the rejects as the material that is removed from the main production step (although they are reprocessed to produce by-products).

Information system - Metering

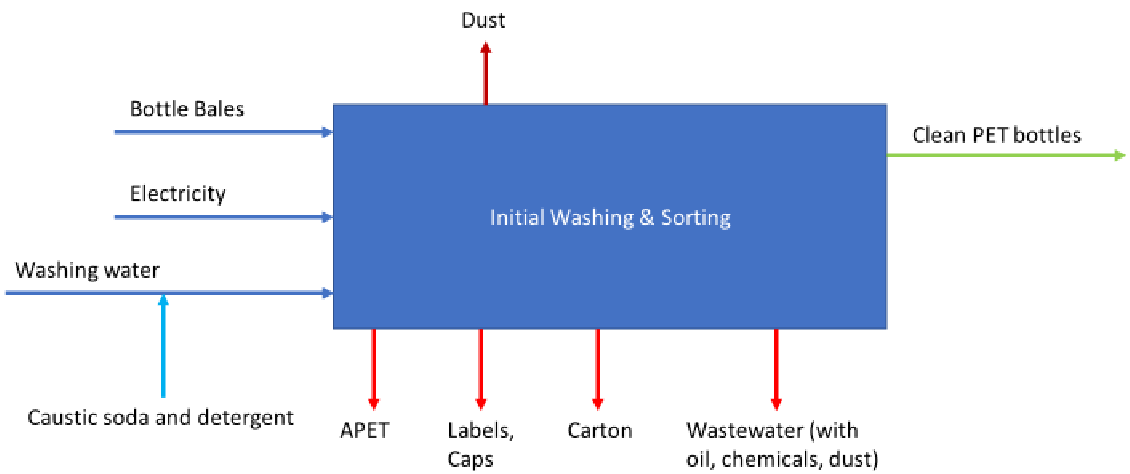
- The company metering system was sufficient to record all the losses, and products. The only issue with that metering system was the non-unified recording intervals. Some records are on annual basis (Solid waste), utilities consumption are on monthly basis (electricity, water, and fuel), while records related to material were per batch basis.
- One of the confusing records for the company team was the records for wastewater flow, which exceeded the records of water intake! **This issue was explained after conducting the water and material balance.**
- The TEST team was recommended to keep frequent records for all important parameters

Raw Material - Focus areas and cause analysis

- Mapping of Raw material losses was done over two stages, first to identify the process where the majority of the losses occur using the Environmental cost breakdown tab in the MFCA sheet to define the focus area. Then a material balance over that focus area was conducted using the records from the company on the type and quantity of loss (qualitative and quantitative analysis), to identify the causes for that loss.



Raw Material - Focus areas and cause analysis



Increase in WW flow to intake water flow

Item	Weight		Percentage of Input
Input			
Bottle bales	18,594	Ton	100%
NPO			
APET	1,294	Ton	7%
Labels, Caps	1,133	Ton	6%
Carton	243	Ton	1%
Waste and water (remains in raw bottles)	1,500	Ton	8%
Mud in wastewater	1,250	Ton	7%
Output			
Washed PET bottles	1,3174	Ton	71%

Highlights from the Material balance

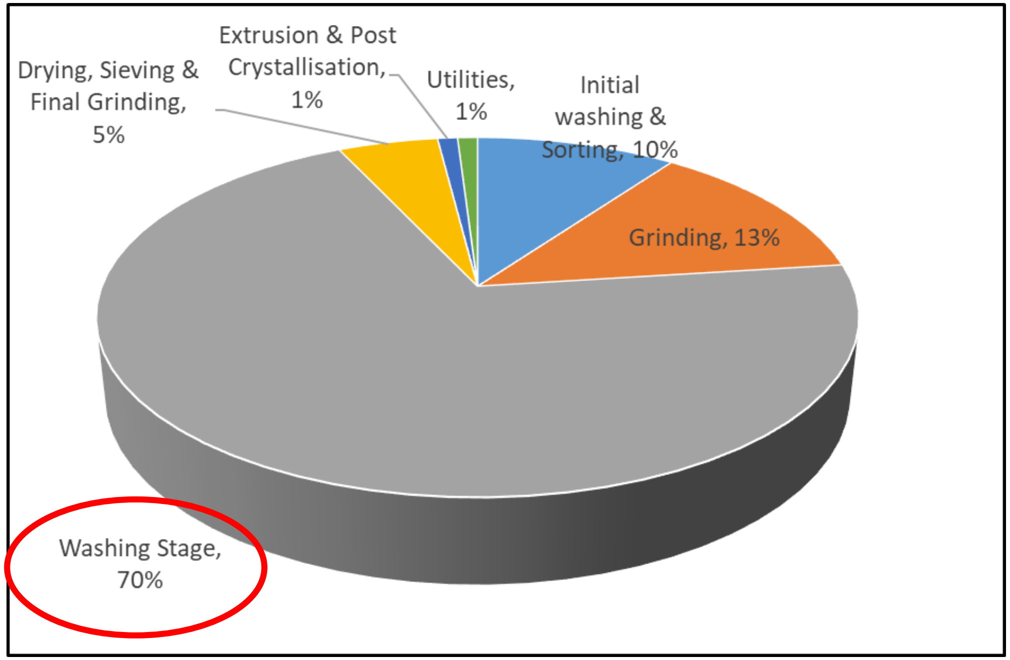
- The increase in the recorded wastewater flow to the intake water flow was explained after conducting the material balance. There are 1,250 tons of mud incoming with the raw material, that is washed out with the water, and ends up to the wastewater. Therefore, the wastewater flow meter (which is installed before the wastewater treatment plant) shall read 1,250 m^3/year over the water flow meter.
- As the losses of raw material are related to the quality of raw material rather than a specific process, the focus area is not considering a specific process. It addresses the categories of rejects, and the detailed analysis will investigate elimination of those rejects as early as possible.

Causes of inefficient use of Raw and auxiliary materials

- High sand and dust contamination in the bottle bales.
- High percentage of oil bottles in the bales. The bales used by the company are from local waste traders, which contains more than 50% of edible oil bottles. This leads to increase in water and chemical consumption.
- Unoptimized settings for sorting machines, resulting in the reject of good bottles
- Removal of caps, and labels is done in later stages of the processing

Water - Focus areas and cause analysis

- Water mapping was conducted through allocating a percentage of water use to each cost center in the Environmental cost breakdown tab of the MFCA sheet.
- The main consumer of water was in the washing stage, where it accounts for 70% of the consumption. This is due to the need to thoroughly clean the input bottles from dust, mud, and oil.



Causes of inefficient use of Water

- The low grade raw material (with high dust, oil bottles, and mud) require additional water consumption in washing stages.
- Contamination of returns from washing water with oil from the bottles hinders the reuse of washing water in closed loop, thus increasing the water consumption. There is a filter already installed to clean the washing water returns, but is not in operation.

Causes of inefficient use of Energy

- Increase of the temperature set point in the upgrading line over the recommended settings.
- Through the investigations and measurements, all large motors were noted to be of high efficiency, recently installed equipment. The only identified issue was the low utilization of the production line, as it was operating at 60% of its installed capacity due to unavailability of raw material. This results in increase of specific energy consumption.

Example of option generation and feasibility analysis

- Priority flow: Raw Material, Focus area: Initial washing and sorting.
  - **Problem: High sand and dust contamination in the bottle bales.**
    - Option 1: Install a sieving device to remove the sand and dust ahead of the washing line inlet.

    Not possible as the bales are compacted, and the sieving device will not be effective.

    - Option 2: Ask the raw material suppliers to supply the bales free from sand and dust.

    Due to low supply in the market, the existing suppliers refused this idea.

    - Option 3: Seek other raw material sources to assure reduced sand and dust contamination.

    This idea would require seeking other raw material suppliers providing higher grade material, creating competition to existing suppliers of raw material. Eventually the local suppliers will have to go to option 2 to maintain their market share.

Example of option generation and feasibility analysis

- Priority flow: Raw Material, Focus area: Initial washing and sorting.
  - **Problem: High percentage of oil bottles in the bales.**
    - Option 1: Discard all oil bottles from the initial sorting stage.

      Not feasible as the company is already operating with shortage of supply.

    - Option 2: Ask the raw material suppliers to supply the bales with less oil bottles.

      Due to low supply in the market, the existing suppliers refused this idea.

    - Option 3: Seek other raw material sources to assure reduced sand and dust contamination.

      This idea would require seeking other raw material suppliers providing higher grade material, creating competition to existing suppliers of raw material. Eventually the local suppliers will have to go to option 2 to maintain their market share.

    - Option 4: Check with technology suppliers on alternatives to clean the oil from the bottles

      As it is not common to have high % of oil bottles, technology suppliers will work on a tailored solution. Retained for further investigation

Saving Catalogue – identified projects

Raw material

1 Better quality secondary raw material

2 Check efficiency of delabeler/labels separator

3 Reset the bottle sorters

4 Evaluate installation of a automatic bottle sorting machine on the resort of the rejects from machine 1 and 2.

5 Contact with bales supplier to eliminate cartons sheet, and supply material free of dust and sand

6 Adjust air flow of vertical air stream separator

7 Check the size of the sieve screen

8 Install a resort channel on the flakes sorter

Water

9 Restart the vacuum filter when processing high grade bales bottles

10 Improve the separation of oil from the process water

Energy

11 Adjust the HAD, PDU process temperature and put the vacuum pump of the degassing in function .

Sample of identified measures on Raw Material: Improve separation of rejects before processing

Description of the solution	The design of the washing line contains several points for label removal, including the pre-washing stage, Ballistic separator, and the wet grinder. This means that the labels will pass through several processes before being removed, adding to water and energy consumption, and limiting the throughput of the production line. Solution is to purchase and install a trommel (to remove stones, sand and small particles), bottle de-labeller (to remove the labels ahead of the feeding conveyor), and an air shifter (to further remove the labels). This will have a positive impact on the production line throughput.
Economic benefits	Saving will be around 1% additional throughput equivalent to 170 tons of additional productivity. The profit gain from the increased productivity is equivalent to 153,000 Euros/year
Environmental benefits	Reduction of 170 tons/year of disposed solid waste
Capital investments	100,000 Euro was the cost of the new installations from Chinese origin. Payback is 0.65 years
Other barriers	None.

Sample of identified measures on Water: Restart vacuum filter

Description of the solution	The washing water for the flakes is contaminated with glue, sand, dust and oil. The company has a vacuum filter which is responsible for cleaning the water from the washing stage to be suitable for reuse. Due to the high level of oil contamination of the input material, that filter malfunctioned, and was switched off to avoid stoppages. In the same time, the washing water effluent was totally drained as there is no filtration. When the company operates with high grade raw material, it can put the filter back into operation, and thus reuse the washing water with little make-up.
Economic benefits	The estimated savings from this action was calculated to be 10,000 m3/year (15% of the baseline), with a production of 10,494 ton/year, this results in a saving of approx. 1 m3/ton product. Cost savings is equivalent to 2,850 Euro/year
Environmental benefits	Reduction in water consumption by 1 m3/ton ~ 10,000 m3/year (15% of baseline) Reduction of wastewater generated by 1 m3/ton~ 10,000 m3/year
Capital investments	No cost option Payback is immediate
Other barriers	Implementation is constrained by the availability of high grade raw material

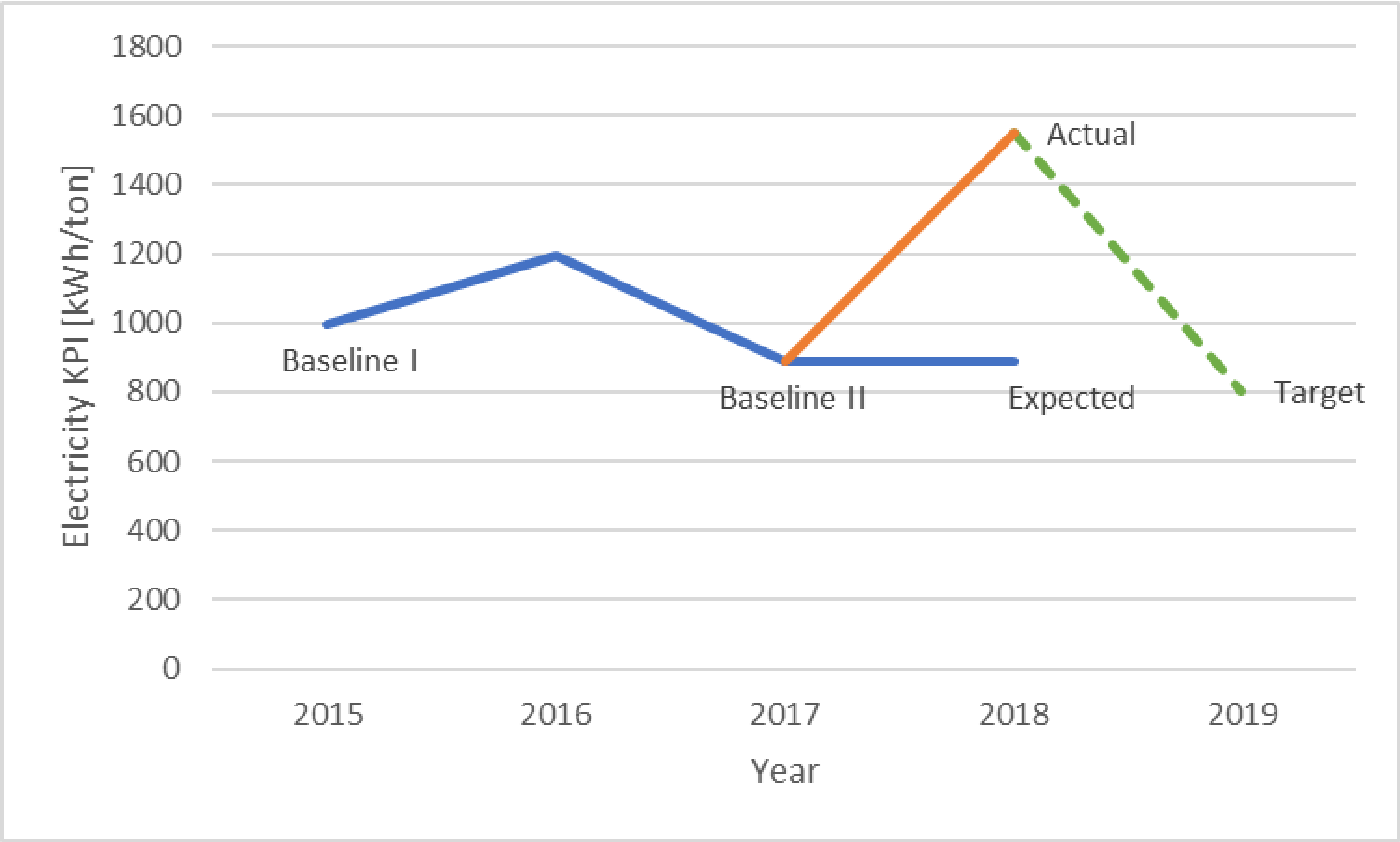
Sample of identified measures on Energy: Optimization of temperature settings

Description of the solution	The contamination removal process is achieved in both the Hot Air Drier and the Pre-Drying Unit through introducing hot air from the bottom of a tank, having the flakes falling from its top. This heats up the material and evaporates the contaminants. The temperature settings for the Hot Air Drier was at 120 degrees, while the Pre-Drying Unit was at 150 degrees. Reset the temperature for the Hot Air Drier and Pre-Drying Units to the supplier recommended values, that is 110-120 degrees for the Hot Air Drier, and 120-140 degrees for the Pre-Drying Units.
Economic benefits	The estimated savings from this action was calculated to be 600,000 kWh/year(5% of the baseline), with a production of 10,494 ton/year, this results in a saving of 57.2 kWh/ton product. Cost savings is equivalent to 23,100 Euro/year
Environmental benefits	Reduction in energy consumption by 57.2 kWh/ton ~ 600,000 kWh/year (5% of baseline) CO_2 reduction associated with the energy savings is equivalent to 288 ton/year
Capital investments	No cost option Payback is immediate
Other barriers	None.

Performance Monitoring

- Following the MED TEST II project implementation, the company's TEST team continued to use the methodology independently. After implementing the energy related measures, the electricity KPI decreased by 11% in 2017 from 2015 baseline.
- After some time of steady operation, the team noted an increase in the electricity KPI to exceed the original baseline as illustrated in the following figure. Applying the knowledge gained during the TEST training, company engineers successfully revealed the root cause of that increase, identifying two energy measures that would deliver significant results (target value in the following figure), improve product quality and further increase on the project gains.
- Both projects are channelled through an existing financing facility in the country.

Performance Monitoring



Results

Action	Investment euro	Savings euro /Yr.	PBP Years	Water and Raw Materials	Energy MwH	Environmental Impacts
Better quality of secondary raw material	None	310,275	Immediate	15,000 M^3 340 Tons	0 MwH	Total 548.3 tons CO2 1,180 tons of waste
Optimization of PET Washing Line bottle pre-treatment	185,000	444,338	0.42	640 Tons	0 MwH	
Optimization of PET Washing Line flakes production	173,000	206,350	0.84	42,000 M^3 200 Tons	930.4 MwH	
Adjusting the set points of the Solid State Polycondensation (SSP) production line	None	21,000	Immediate		600 MwH	
TOTAL	358,000 €	981,962 €	0.36	57,000 M^3 1,180 Tons	1530.4 MwH	

Action Plan - Sample

No	Objective	Title of the Action	Responsible	Budget (Euro)	Category	Target / indicator	Accepted	Discarded	Retained for study
1	Secondary raw material supply	Import better quality PET bottles bales from Europe	Procurement & Quality	-	No cost	To increase ratio of good quality PET bottles to 50%	x		
2	Optimization of PET washing line bottle pre-treatment	Check efficiency of de-labeler/labels separator	Production	100,000	Investment	Reduce the loss of material after bottle sorting by 1 %	x		
3		Reset the bottle sorters and set up new process parameters	Production	5,000	Medium cost	Reduce the loss of input material by 0.7%	x		
4		Install an automatic third bottle sorting machine	Management, Operations & Technical office teams	80,000	Investment	Save 1 % of the input material			x
5		Contact with bales supplier to eliminate cartons sheet	Procurement	0	No cost	Eliminate cartons waste		x	

Conclusions

- **7 out of 11 RECP opportunities implemented/under implementation/planned.**
- **Economic Savings 981,962 €/y with an average PBP of 0.36 year**
- **Total annual Water savings : 88%**
- **Total annual Energy savings : 11%**
- **Total annual Raw Material savings : 10%**
- **CO_2-emission reduction by 8.6%**
- **ISO14001 certification (2015 Version)**

- Improvment of information system and monitoring plan for timely identification of deterioration in performance
- Additional measures identified by the company team
- Enhanced sorting process created direct inhouse job opportunities
- Encouraging raw material suppliers to improve their collectiong and sorting process
- Initiate contact with local packaging company, as potential buyer of its products