TEST case study

Bakery and Chips production

Developed under the framework of Med TEST II

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

switchmed

The SwitchMed Programme is funded by the European Union

Bakery and Chips production

SECTOR	Food
SUBSECTOR:	Division 1: Bakery, Division 2: Chips
SIZE	380 Employees (Divisions 1 + 2)
PRODUCTS	Division 1 : Bread, pastries, cakes, kaak, ice cream, chocolate Division 2 : Potato chips, tortilla, pellets and extruded corn chips
MARKET	Local
CERTIFIED MANAGEMENT SYSTEMS	ISO 22000

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Company Key data

- The company was motivated to join MED TEST II to identify opportunities to increase resource efficiency and to reduce operational costs of production thus ensuring long-term environmental and economic sustainability of its operations.

- The company spends in excess of EURO 20 Million/year on resources input to its production lines of which EURO 2 Million is directed to meet an energy demand of ~ 26,500 MWhr. Consequence of this high energy use was high CO_2 emission no less than 8,600 t/y. Water demand neared 90,000 m³/year. These were the main drivers for joining the MED TEST II program with an objective to ensure the sustainability of company operations.

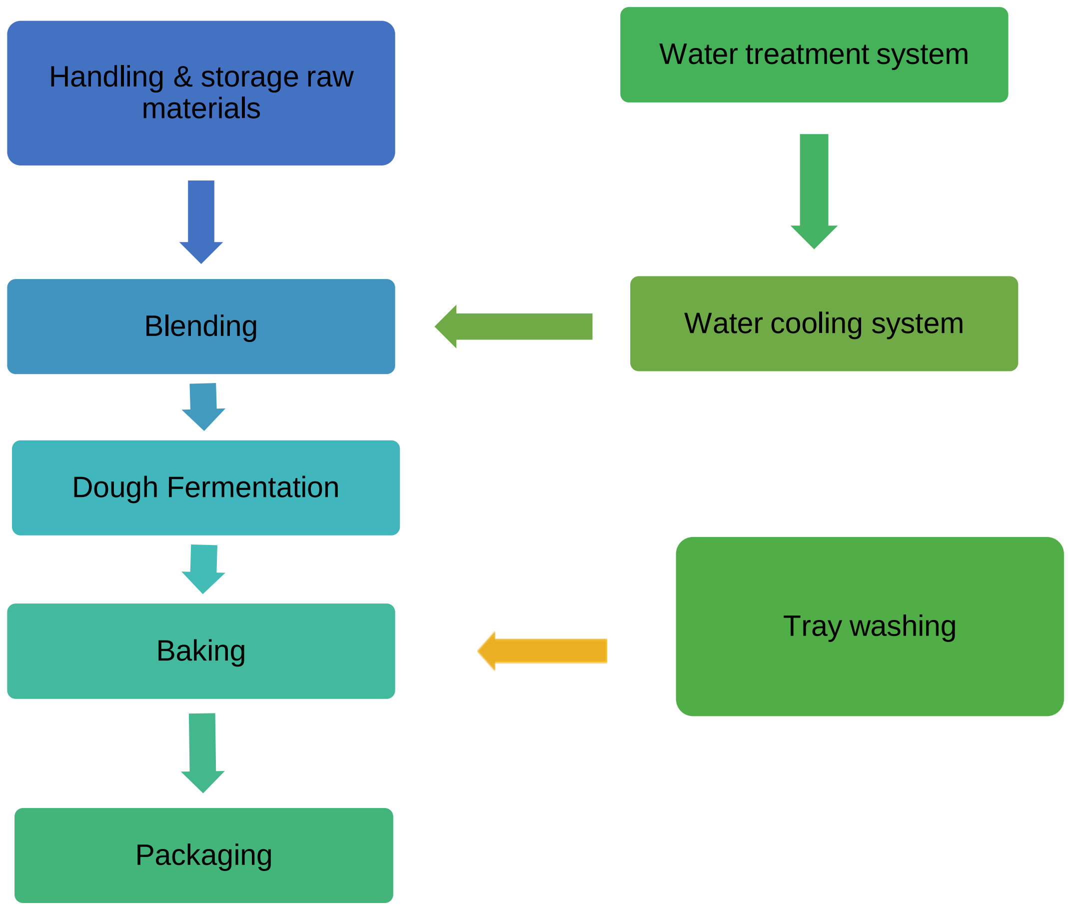
YEAR 2015	Unit	Value
Production division 1	Tonnes/year	**9,400**
Production division 2	Tonnes/year	**5,200**
Electricity consumption (1+2)	kWh/year	**2,000,000**
HFO consumption	NA	**NA**
Diesel consumption (1+2)	litre/year	**2,100,000**
LPG consumption	NA	**NA**
Water consumption (1+2)	m³/year	**50,000[1]**
CO_2 emission (1+2)	Tonnes/year	**8,600**
BOD5 (1+2)	Kg/year	**70,000**
COD (1+2)	Kg/year	**80,000**
Total cost of sales (1 + 2)	EUR/year	**36,969,028**
Total cost of physical inputs (Purchase value of raw materials, auxiliary materials, packaging energy and water) (1 + 2)	EUR/year	**24,160,134**
	% vs. cost of sales	**65%**
Estimated non-product output (1+2)	EUR/year	**4,470,632**
	% vs. cost of sales	**12%**

[1]This was an estimate back in 2015, the company did not know at that time how much water was used.
After the installation of water meters in June 2016, it appeared that actual consumption for the 12 month July 2016 - June 2017 was 89,695 m³ a difference of 79%!!!
The production over these two periods was nearly the same.

Process overview/flowchart (Division 1)

INPUTS

Water
Wheat, sugar, eggs, baking soda, powder milk, salt, olive oil, emulsifiers, spices, flavour, additives,.......
Electricity, diesel
Lubricants
Spare parts
Filters
Detergents
Sanitation implements,
Refrigerants
Carton packaging
Plastic packaging



MAIN OUTPUTS

Bakery Products

Effluent from tray washing,

Air emissions (combustion gases and particles, dust, odour)

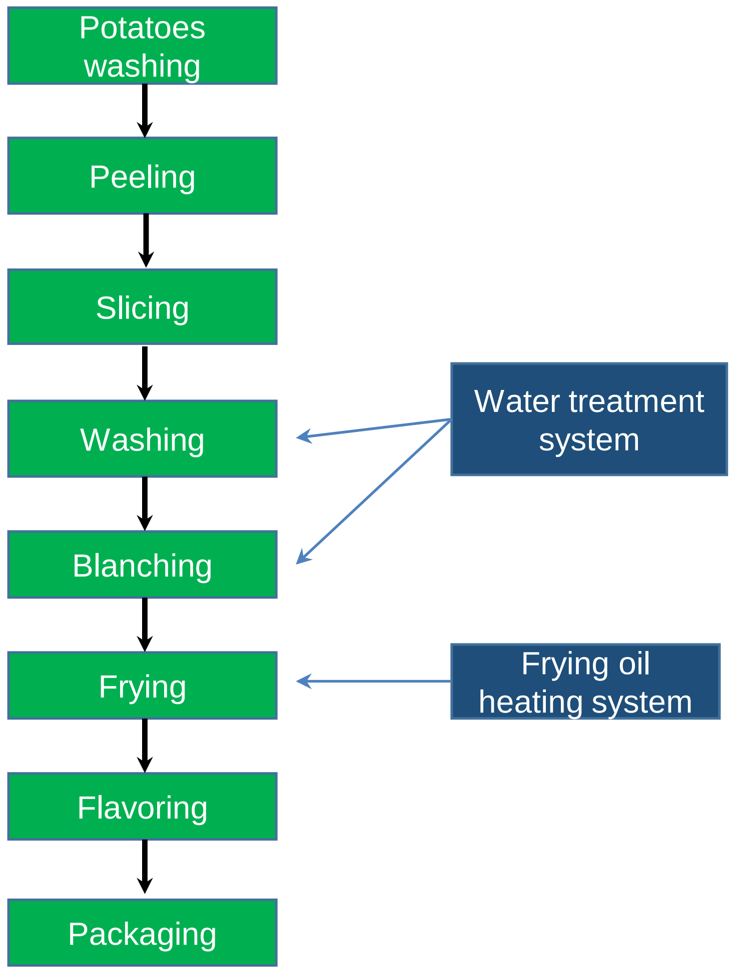
Solid waste including off specs, expired/returns from clients

Process overview/flowchart (Division 2)

INPUTS

Water
Potatoes, Semi finished potato pellets, corn powder, vinegar, salt, flavors, Spices.
Cooking oil.
Electricity, diesel fuel
Thermal oil
Lubricants
Spare parts
Filters
Detergents
Sanitation implements
Refrigerants
Carton packaging
Plastic packaging

Natural Potato Chips (NPC)



MAIN OUTPUTS

Potato chips Products

Effluent from washing, blanching,

Air emissions (Combustion gases and particles, dust, odour)

Solid waste (Peelings, off specs, returns from clients)

Benchmarking

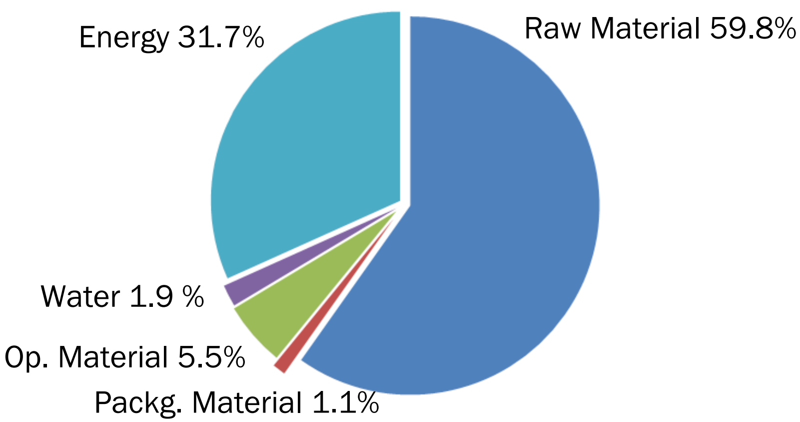
Table 1: Key Performance Indicators for operations

Benchmark type	Unit	Company	Best practice	Boundaries
Returned products	% of production	7.5%	2%	Division 1
Energy (Electricity + heat)	kWhr/kg Arabic bread	1.0[2]	0.25[1]	Division 1 Arabic bread department
Energy (Electricity + heat)	kWhr/kg Natural potato chips	3.5[2]	2.8[1]	Division 2 NPC production line
Water	Liter/kg Natural potato chips	24[2]	16[1]	Division 2 NPC production line
BOD_5	mg/l waste water Natural potato chips	5,500[2]	1,000[1]	Division 2 NPC production line

[1] *Based on estimated efficiencies that could be achieved through state of the art equipment and best practices*
[2] *Based on readings during years 2016 – 2017 and not on MFCA data of year 2015*

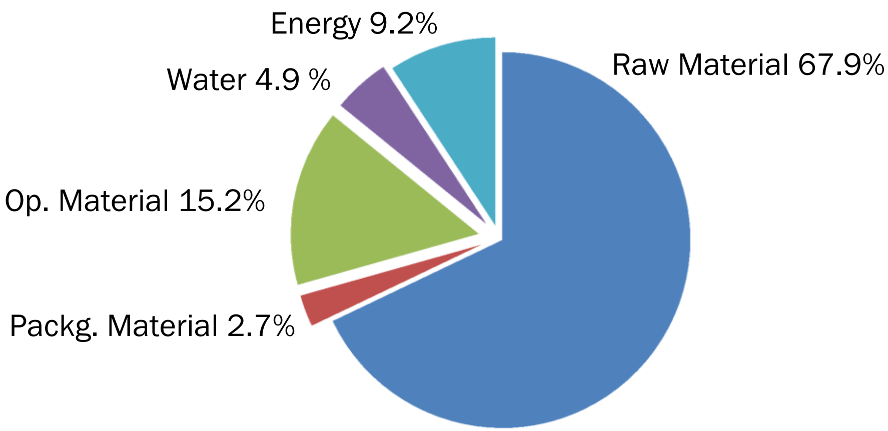
Non-Product output costs

Division 1 NPO breakdown



In monetary terms, NPOs including materials, water and energy amount to EUR 2,878,907 or 13% of total production costs.

Division 2 NPO breakdown



In monetary terms, NPOs including materials, water and energy amount to EUR 1,591,725 or 11.2% of total production costs.

Priority flows

Priority flows are: raw materials, energy and water. The criteria for selection are as shown below. Cost as NPO is an issue for raw material and energy while for water it is the relative scarcity of that resource knowing that its scarcity does not reflect on its cost in the country unless one buys water from the market. The company draws water from an underground well on its premises.

Priority Flow	Selection criteria		
	NPO cost	Benchmarking	Environment
Raw Materials	YES	YES	-
Water	-	YES	YES
Energy	YES	YES	-

Benchmarking is a criteria for all three priority flows because it was possible to establish accurate KPI for energy and water to compare with best practice benchmarks while for raw material the MFCA has shown that return products exceeds by three times the industry benchmark. Operating material as NPO is much higher than water or energy in division 2 but was not selected as priority flow because it consists mainly of general maintenance items.

Information system - MFCA

- Key findings of MFCA exercise (reference to company accounting system)

1. Different kinds of material do not have separate accounts (Raw material, packaging, operational material, etc.)
2. Only cost information is included in accounts, weight is not considered
3. Production volume and many material inputs are not recorded by weight but rather by items (i.e: bags, cartons, box, ...)
4. Solid waste is not recorded by type (reject, return) and weight
5. Sales of off standard products are not recorded separately, weight is not recorded
6. No records kept of water consumption
7. No segregation of fuel use by type of equipment (boilers, ovens, generators)
8. Maintenance costs are not segregated between manpower and materials
9. No record of liquid waste in terms of quantity and quality including amount of pollution
10. No record of mass and water balance

Information system - MFCA

- Experience with Input – Output (I/O) analysis

1. Accounting staff appreciated the usefulness of the method even though it proved tedious to implement especially that much data is not available to perform an accurate analysis
2. Much estimation was involved because data was not available, at the start this did not help build confidence in the process
3. Accounting staff members are aware that I/O analysis is to be refined over several accounting cycles, therefore understand the need to adopt I/O analysis as a standard accounting practice in order to benefit from this method
4. Company already has a data base inventory management software (Oracle) but it needs adaptation to suit better MFCA data requirements

Information system - MFCA

- Recommendations

1. Repeat the I/O analysis on a yearly basis
2. Assign different account numbers to the different type of material
3. Record the weight of all types of materials
4. Record the weight of production output per type of product
5. Record the types of solid waste including weight and categorize by sources of waste (reject, return)
6. Record water use and liquid waste including amount of pollution (BOD5, COD)
7. Record quantities and sales of reject and return products as well as material for re-use or recycling

Information system - Metering

- At the outset of the project, the company was requested by the MED TEST team to install an information system. The end purpose of installing this information system at the start of the project was to achieve three objectives:
  1. Obtain reliable data to monitor the resource efficiency performance of its production lines and support utilities in order to propose feasible improvement measures
  2. Help the staff get an actual feel about resources use at their facility
  3. Start introducing the motto "you cannot manage what you do not measure" into the management practices of the company.

List of meters installed at the plant

Water meters	KWH meters	Hour meters*	Fuel meters	Total metering points
23	24	37	7	91

* Hour meters measure the hours of operation of the equipment, reflecting and indication of its productivity.

- An Excel spread sheet was developed in which the readings could be entered together with production output. Accordingly the KPIs shown in Table 1 of slide 7 were developed thanks to the data accumulated through the information system. Currently more than 2 years of data is available for the evaluation of improvement measures. Furthermore Physico-chemical analysis was carried out on the effluent from the plant and at specific discharge points in the plant.

Water focus area and cause analysis

Water balance

Water balance (m^3/yr) applicable for July 2016 – June 2017		
Description	Quantity	Percentage
Water treatment reject	**17,954**	**20.0%**
Bakery department	**28,395**	**31.6%**
Steam for ovens and proofer	*1,170*	*1.3%*
Trays and utensils washing	*14,969*	*16.7%*
Dough making	*12,256*	*13.6%*
Natural potato chips production line	**31,910**	**35.6%**
Potato tubers de-soiling and rinsing	*10,692*	11.7%
Peeling	*1,460*	1.8%
Slicing	*3,223*	3.5%
Washing & Blanching	*16,535*	18.3%
Other uses (Vehicles wash, house keeping, toilets,….)	**11,436**	**12.7%**
TOTAL	**89,695**	**100%**

Water focus area and cause analysis

Notes on Water balance:

- Basically four hotspots can be identified from water balance in three different areas

1. Water treatment plant (area 1)
2. Trays and Utensils washing in bakery department (area 2)
3. De-soiling/rinsing of NPC line (area 3)
4. Washing/blanching of NPC line (area 3)

Dough making consumes large water quantities of water but water is incorporated in semi product and no potential inefficiencies could be identified so it was not retained as a hotspot

“Other uses (Vehicles wash, house keeping, toilets,....)” even though they represent a sizeable percentage (12.7%) are not concentrated in production centers but rather supporting activities.

Further analysis is needed to narrow down the process of identification of focus areas starting from the four hot spots identified above

Energy balance

Energy balance (KWhr/yr) applicable for July 2016 – June 2017						
	Electricity		**Diesel**		**Total**	
Description	Quantity	%	Quantity	%	Quantity	%
Bakery department	**1,640,497**	**27.5%**	**10,655,877**	**48.2%**	**12,296,374**	**43.8%**
Arabic Bread Tunnel Ovens	*51,855*	*0.9%*	*4,949,785*	*22.4%*	*5,001,640*	17.8%
French bread and confectionary ovens	*111,146*	*1.9%*	*5,346,037*	*24.2%*	*5,457,183*	19.4%
Refrigeration	*1,444,005*	*24.2%*	*0*	*0.0%*	*1,444,005*	5.1%
Trays washing	*33,491*	*0.6%*	*360,055*	*1.6%*	*393,546*	1.4%
Natural potato chips production line	**810,445**	**13.6%**	**4,623,367**	**20.9%**	**5,433,812**	**19.4%**
Natural Potato Chips	*162,735*	*2.7%*	*4,494,182*	*20.3%*	*4,656,917*	16.6%
Tortilla chips	*5,582*	*0.1%*	*129,185*	*0.6%*	*134,767*	0.5%
Extruded corn chips	*99,998*	*1.7%*	*0*	*0.0%*	*99,998*	0.4%
Pellets	*187,340*	*3.1%*	*0*	*0.0%*	*187,340*	0.7%
Packaging machines	*354,790*	*5.9%*	*0*	*0.0%*	*354,790*	1.3%
AIR COMPRESSORS	**465,255**	**7.8%**	**0**	**0.0%**	**465,255**	**1.7%**
WATER TREATMENT	**69,482**	**1.2%**	**0**	**0.0%**	**69,482**	**0.2%**
AIR CONDITIONING IN PRODUCTION AREAS	**1,875,450**	**31.4%**	**0**	**0.0%**	**1,875,450**	**6.7%**
OTHER ELECTRICAL LOADS (lighting, lifts, administration,....	**1,103,398**	**18.5%**	**0**	**0.0%**	**1,103,398**	**3.9%**
TOTAL 1 (WITHOUT GENERATORS FUEL CONSUMPTION)	**5,964,527**	**100.0%**	**15,279,245**	**69.1%**	**21,243,772**	**75.7%**
GENERATORS FUEL CONVERTED TO ELECTRICITY	**NA**	**0.0%**	**2,071,054**	**9.4%**	**2,071,054**	**7.4%**
GENERATORS FUEL CONVERTED TO WASTE HEAT	**NA**	**0.0%**	**4,749,071**	**21.5%**	**4,749,071**	**16.9%**
TOTAL 2 (WITH GENERATORS FUEL CONSUMPTION)	**5,964,527**	**100%**	**22,099,370**	**100%**	**28,063,897**	**100%**

Energy focus area and cause analysis

Notes on Energy balance

- Many industries in the country rely at least partially on electricity generators due to frequent black outs of varying duration. Consequently it is impossible to have a reliable reference baseline for NPOs and OPIs when the fuel for generators is included in final energy demand without further qualification.
- Consequently two aggregations are shown in the energy balance table, the first is for energy demand assuming 100% utility electricity while the second represents the actual case, and where the fuel is segregated into two components,

1. the first is the quantity of fuel burned assuming a 100% efficient genset, it is equivalent to electricity demand supplied by the utility at company gate
2. The second is considered to be burned in a 0% efficiency machine thus converted in totality to waste heat in case there is no heat recovery.

- Using this method the plant performance can be decoupled from the source of electricity supply thus the performance of a plant in the country could be assessed on a stable basis with respect to international benchmarks. The second component (waste heat) can be treated through heat recovery and brought back into the loop.
- In the case of this company, the generators supplied 2,071,054 KWhr during the period considered (July 2016 – June 2017) which represent 34.7% of total electricity supply and 7.4% of final energy demand while at the same time the generators consumed 24.3% of final energy entering the plant.

Energy focus areas and cause analysis

Notes on Energy balance

- Basically six hotspots can be identified from Energy balance in six different areas

1. Arabic bread production department (area 1)
2. French bread production department (area 2)
3. Refrigeration (area 3)
4. Natural Potato Chips line (area 4)
5. Air conditioning in production areas (area 5)
6. Diesel generators (area 6)

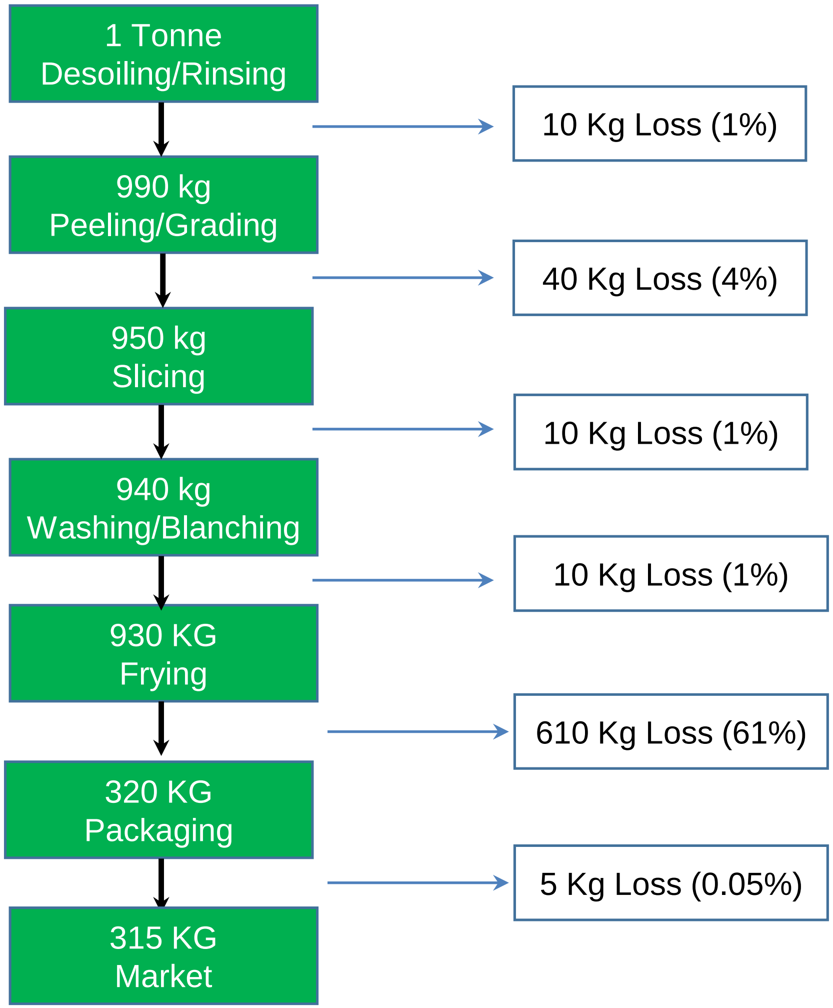
- Further analysis is needed to narrow down the process of identification of focus areas starting from the six hot spots identified above

Raw material focus area and cause analysis

- Mapping of Raw material losses in bakery departments

1. There were not recorded any significant losses of raw material in storage, conveying and baking.
2. Losses are identified in the cake department at the level of cake cutting which is the final stage of production. Waste weighing has shown that around 10% of cake production (~ 10 Tonnes/year) are wasted from this department.
3. MFCA assessment has shown that considerable loss occurred from returned bakery products which amounted to around 671 tonnes/year corresponding to 7.3% of total production. The benchmark for best practice of returned bakery product is 2%. The waste above benchmark level corresponds to 500 tonnes/year in raw materials, 400,000 kwhr/year of energy and around 1,000 m^3/year of water.
4. The worst wastage occurs at finished product level because much materials, energy and water have already been spent for its manufacture, this not to mention labor costs and production time and machines wear.

Mapping of Raw material losses in natural potato chips production line



The flowchart shows losses of mass flow in percent referenced to 1 Tonne potato input.

- The total loss amounts to 685 kg or 68.5% of raw potato input.
- The highest loss occurs at the frying stage where most of the water in the potato evaporates and to a much smaller extent because batch is lost due to electricity blackouts. Water loss is not considered a focus area because it is inherent to the frying process, and the released vapor is utilized to preheat the blancher water.
- The most environmentally significant loss is at the washing blanching stage where most of the bio-chemical pollution (BOD5) is released.
- The loss at the packaging stage is related to off standard bag sealing and bag rejects due to power outage or machine malfunction.
- Some of these losses may seem unavoidable, however loss reduction is possible.

Focus areas and cause analysis

Notes on mapping Raw material losses

- Basically three hotspots can be identified from raw material mapping in three different areas

1. Cake cutting in cake department of bakery division (area 1)
2. Products return of bakery division (area 2)
3. Weight loss during processing of potato tubers (de-soiling, peeling, slicing, washing/blanching, frying, packing). Considering the amount of potato processed is around 1,400 Tonnes, the raw material wastage amounts to around 960 Tonnes of which BOD_5 pollution amounts to around 160 Tonnes and COD some 180 Tonnes

Sources of losses and cause analysis

Sample ROOT CAUSE ANALYSIS			
Priority flow	**Focus area**	**Inefficiency**	**Root cause and possible remedial**
Raw material	Sales	*Product return 300% over benchmark*	*Production not in phase with real needs of the market*
			Poor coordination between production and sales
	Division 1 Cake production	*Product loss due to off specs top of cake cutting, 300% over benchmark*	*Sub-optimal emulsion of egg content and poor mixing of cake paste*
			Cooking temperature and time not optimized
		Product loss due to excessive side trimming, 300% over benchmark	*Cake does not have uniform edges*
			Use of knife for cutting is not suitable
			Trimmings are wasted instead of being valorized as by-products
	Division 2 NPC	*Product loss at peeling stage*	*Blunted cutting balls are not replaced regularly*
			Wet peeling is used, steam peeling may give better results
			Potato has hard skin that does not peel easily, procure soft skin tubers
		Product loss at packaging stage	*Packaging material quality needs closer scrutiny*
			Packaging machines are not properly adjusted

Sources of losses and cause analysis

Sample ROOT CAUSE ANALYSIS			
Priority flow	**Focus area**	**Inefficiency**	**Root cause and possible remedial**
Water	Water treatment	25% of input water is lost to drain	*Single stage RO module is not suitable, use double stage*
			Existing RO module needs replacement
	Division 2 NPC	*High water use, 50% above benchmark*	*Water is used once and sent to drain, recycle the blanching water, use in first wash (de-soiling) stage, water flow is excessive in first wash phase*
			Potato is heavily soiled, procure clean potato
			Procure potato with low starch content
Energy	Generators	Specific fuel consumption 30% above benchmark,	Low load factor, generators not properly sized for good load matching
			No heat recovery on generator exhaust and cooling circuit
			Poor maintenance
	Division 1 Arabic bread department	Specific energy consumption for arabic bread is 400% above BP	Burners fuel air mix needs adjustment and ovens chimneys draft not properly adjusted, no heat recovery from tunnel ovens chimneys
	Division 2 NPC	Specific energy consumption for NPC is 25% above benchmark	Pipes and equipment not properly insulated, boiler air fuel mix ratio not properly set, no heat recovery on thermal oil circuit, boiler internals not clean

Saving Catalogue – identified measures

ID	Initiative	Cost saving	Investment	Pay back	Reduced primary energy consump	Reduced water consump.	Reduced material	Reduced BOD5 & COD	Reduced CO2 emission	Reduced solid waste
		EUR/yr	EUR	years	MWh/yr	m³/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr
1	Material: Use improved cutting techniques for cake trimming	3,750	200	0.1	NA	NA	7.5	NA	NA	7.5
2	Energy: Optimize timing operations of French bread ovens	3,200	0	0	88	NA	NA	NA	17	NA
3	Energy: Shut off AC equipment when not needed	4,200	0	0	97	NA	NA	NA	30	NA
4	Energy: Shut off ventilation equipment when not needed	2,625	0	0	60	NA	NA	NA	19	NA
5	Energy: Adjust air fuel mix of Arabic bread burners	10,206	0	0	259	NA	NA	NA	63	NA
6	Material: Adopt improved management practices for market responsive production	840,000	45,000	0.1	28	1,000	500	5	158	450
7	Energy: Clean and replace periodically air compressors intake filters	1,254	70	0.1	29	NA	NA	NA	9	NA
8	Water: Re-use water discharge from blanching phase in first potato rinsing stage	24,400	7,500	0.3	6	9,360	NA	NA	3.5	NA

Saving Catalogue – identified measures

ID	Initiative	Cost saving	Investment	Pay back	Reduced primary energy consump	Reduced water consump.	Reduced material	Reduced BOD5 & COD	Reduced CO2 emission	Reduced solid waste
		EUR/yr	EUR	years	MWh/yr	m³/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr
9	Energy: Shutter both ends of extruded corn chips oven	1,100	200	0.2	25	NA	NA	NA	8	NA
10	Energy: Adjust air fuel mix of bread ovens burners	7,800	1,000	0.1	211	NA	NA	NA	51	NA
11	Energy: Clean and straighten fins of AC and refrigeration units condensers	2,347	100	0.1	56	-3	NA	NA	17	NA
12	Energy: Insulate frying oil storage tank at roof and related piping	2,578	549.5	0.2	65	NA	NA	NA	16	NA
13	Energy: Insulate frying oil storage tank at ground and related piping	5,157	1099	0.2	131	NA	NA	NA	32	NA
14	Energy: Clean combustion chambers of boilers and french bread ovens	8,300	2,000	0.2	211	NA	NA	NA	51	NA
15	Energy: Upgrade insulation of AC equipment liquid refrigerant lines	979	320	0.3	23	NA	NA	NA	7	NA

Saving Catalogue – identified measures

ID	Initiative	Cost saving	Investment	Pay back	Reduced primary energy consump	Reduced water consump.	Reduced material	Reduced BOD5 & COD	Reduced CO2 emission	Reduced solid waste
		EUR/yr	EUR	years	MWh/yr	m³/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr
16	Energy: Upgrade insulation of shock freeze refrigeration	924	350	0.4	21	NA	NA	NA	7	NA
17	Energy: Clean and replace periodically air filters of AC indoor units	556	200	0.4	17	NA	NA	NA	5	NA
18	Energy: Insulate NPC thermal oil pipework	1,490	700	0.5	38	NA	NA	NA	9	NA
19	Energy: Insulate ceiling and exposed wall of patisserie	1,148	600	0.5	26	NA	NA	NA	8	NA
20	Water: Install second stage for each RO system	20,500	12,000	2.4	-38	9,000	NA	NA	-12.5	NA
21	Energy: Upgrade insulation of service hot water piping	780	480	0.6	20	NA	NA	NA	5	NA
22	Energy: Fix leaks in compressed air network	3,763	2200	0.6	87	NA	NA	NA	27	NA
23	Energy: Upgrade Insulation of refrigeration piping in dispatching area Pain D'or	370	350	0.9	9	NA	NA	NA	3	NA

Saving Catalogue – identified measures

ID	Initiative	Cost saving	Investmen t	Pay back	Reduced primary energy consump	Reduced water consump.	Reduced material	Reduced BOD5 & COD	Reduced CO2 emission	Reduced solid waste
		EUR/yr	EUR	years	MWh/yr	m^3/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr
24	Energy: Insulate ceiling of dispatching area Pain D'or	412	400	1	9	NA	NA	NA	3	NA
25	Energy: Insulate wall and doubke glazing for partition between baking and viennoiseries areas	302	335	1.1	7	NA	NA	NA	2	NA
26	Energy: Insulate wall and doubke glazing for partition between baking and dispatching areas	313	425	1.4	7	NA	NA	NA	2	NA
27	Energy: Shade for AC & Refrigeration condensers	367	600	1.6	8	NA	NA	NA	3	NA
28	Energy: Arabic bread ovens heat recovery	55,000	85,000	1.6	1,036	NA	NA	NA	294	NA
29	Energy: Variable speed drives for ventilation fans	10,000	30,000	3	242	NA	NA	NA	75	NA
30A	Energy: Replace all generators with 4x800 KVA	98,204	400,000	4.1	1,859	0	NA	NA	454	NA
30B	Energy: Replace all generators with 4x800 KVA sets together with heat recovery	200,000	790,000	4	5,200	-5,400	0	NA	1,150	NA

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Overview of the RECP deficiency	The company generates much thermal energy during production whether from generators to produce electricity, from ovens to produce bread or from boilers to heat frying oil. Some 60% of the precious generated heat is lost to the environment mostly through exhaust stacks and radiators. The energy content of the wasted heat on a yearly basis is estimated at around 8,000,000 KWhr while its value in monetary terms is around 450,000 EUR. Thus every year the company sends around half a million Euros of wasted heat through the chimney, this is practically 25% of its energy bill. Furthermore this wasted heat entails 2,000 Tonnes of CO_2 emissions. In addition, the diesel generators fuel consumption is rather high, some 20% over best practice, their replacement is largely overdue.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Description of the solution	As mentioned above, the company uses a lot of heat in its production processes, the idea is to use the surplus heat from one area to be used in another area thus displacing precious fuels and electricity. This could result in more than EUR 200,000/year on energy bill savings. The equipment from which heat could be recovered are mainly the diesel generators and the Arabic bread tunnel ovens The areas that could benefit from the recovered heat are the trays washing department, the air conditioning of the production areas and the heating circuit of the frying oil of NPC production line. The solution is a mix of several measures included in the savings catalogue further above. The details are a s follows: Interventions on sources of heat recovery A) Replace all existing generators with 4x800 KVA prime rated 3 duty - 1 standby generators with synchronizer load management unit. The calculated average load factor is 75%. The target in-house average generation efficiency is 37% for the first 5 years instead of the actual average 27% efficiency. B) Decouple the plant from the electricity utility network from 7 AM till 10 PM. Use the utility when available during remaining hours (10 PM till 7 AM). The reasons behind decoupling the plant from utility are as folows:

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Description of the solution	1. To reduce the wear and tear on production equipment as well as loss of production and products due to frequent and unscheduled black outs. 2. To allow heat recovery from generators because experience has shown that heat recovery from generators or any other machine is not economically feasible if the heat recovery equipment does not operate at least 6 hours in a row esprecially for large systems. 3. Most black outs occur between 7 AM and 10 PM and they are intermittent, therefore the best approach is to run on generators during the peak production of the plant 4. During the period 10 PM – 7 AM the plant production lines are not operating except for Arabic bread therefore there is not much opportunity for co-generation except for the absorption chiller. Furthermore the specific in-house generated electricity cost cannot compete with utility electricity cost during that time period even with co-generation. 5. Even if there are black outs during the 10PM – 7 AM period, the sudden electricity shut down will not affect production because most of the plant is not operating.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Description of the solution (cont'd)	C) Install a 200 KW Heat Recovery Thermal Oil Exchanger (HRTOE) on the exhaust of each generator to supply thermal oil @ 300°C. The recovered heat will be used to heat the frying oil of the natural potato chips line (60% coverage factor). (See figures 1& 2 below) D) Install a 100 KW Heat Recovery Steam Generator (HRSG) on the exhaust of each generator to deliver 110 kg/hr of steam at 9 bars for the 250 KWrefr double effect absorption chiller with 500 KW cooling tower (See figures 1 & 2 below) E) Install a 100 KW Heat Recovery Generator (HRE) on the jacket cooling system of each generator to deliver hot water at 85°C for tray washing and other applications. F) Replace generators every five years before major overhauls are due G) Install a 75 KW Heat Recovery Steam Generator (HRSG) at the exhaust of each of the three tunnel ovens of the arabic bread department, Each can produce around 90 kg/hr of saturated steam at 9 bars (180°C) for the 250 KWrefr double effect chiller mentionned in item D above. The tunnel ovens operate from 6 PM till 6AM.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Description of the solution (cont'd)	The usage of the recovered heat is as follows: A) The thermal oil from the recovered heat (see item C above) will be used to heat the frying oil of the natural potato chips line (60% coverage factor). (See figures 1& 2 below) B) A steam fired 250 KW double effect absorption chiller with an average Coefficient of Performance (COP) of around 1.2 will be installed together with a 500 KW cooling tower. The purpose of the absorption chiller is to displace the same capacity of vapor compression chillers that operate on electricity, thus by using absorption chillers which operate on recovered heat, electricity could be saved. Air conditioning in the production area is kept on 24 hours over the whole year. During the period 8AM – 10 PM the absorption chiller will operate on steam supplied by the generators and from 10PM till 6AM it will operate on steam supplied by the Arabic bread tunnel ovens. The two hours dead interval are not critical because the period 6AM – 8AM has low cooling load which could be easily covered by the remaining capacity of vapor compression machines. The plant has an installed air conditioning capacity of 750 KW of which 250 KW are planned to be covered by the absorption chiller. The only drawback of the absorption chiller is that it needs a cooling tower thus an expenditure of water estimated at 2,000 m^3/year. These could be mostly recovered from the potato peeling section of the NPC production line.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Description of the solution (cont'd)	C) The hot water generated by heat recovery from the generators jacket cooling system will be used to cover the hot water requirements of the tray washing department as well as other hot water uses. It will displace the diesel fired boiler used to generate hot water **Performance Monitoring and Verification Plan (PMVP)** In order to monitor the performance of the measures being implemented, an information system is an integral part of the proposal as follows: - Energy meter across thermal oil headers feeding the HRTOE - Hot water meter at feedwater main feeding the HRSG - Energy meter across hot water headers feeding the HRE - Steam meter at header feeding the absorption chiller - Energy meter across chilled water headers of absorption chiller - Water meter at make up line of condensate tank of HRSG - Water meter at make up line of cooling tower - Temperature sensors at inlet and outlet of all heat recovery equipment

Figure 1: schematic of heat recovery proposal for generators

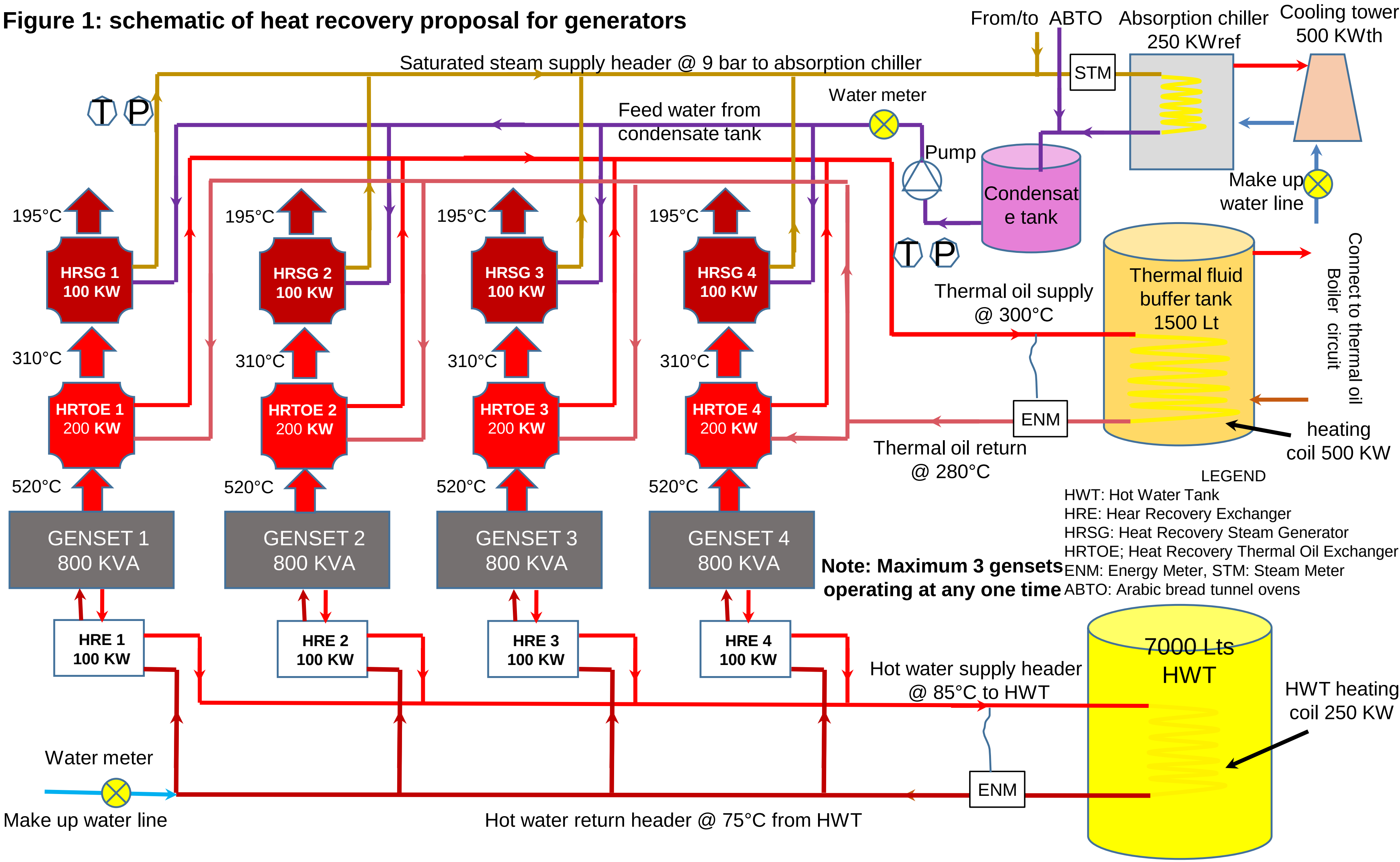


Fig2: Gensets HRSG, HRTOE & HRE schematic

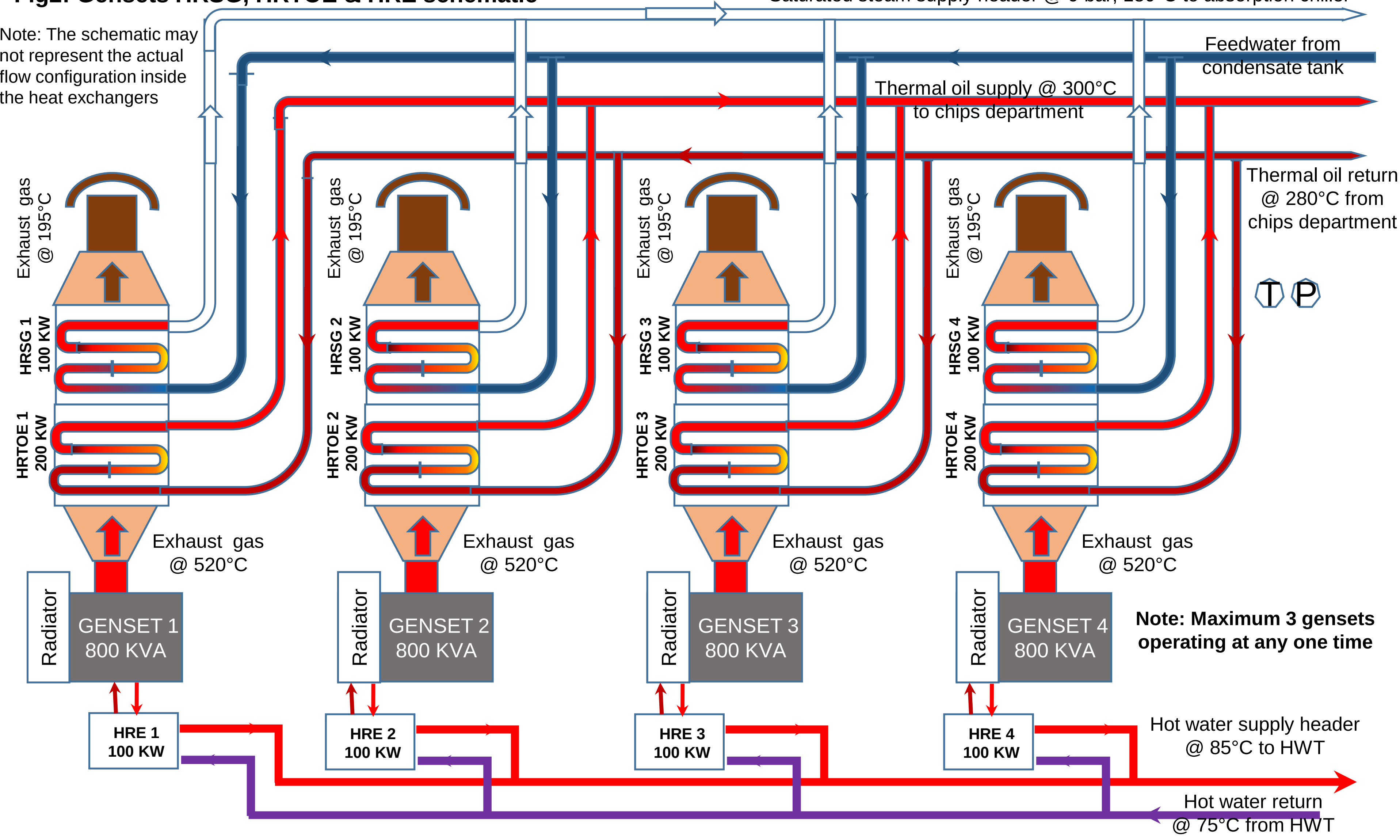
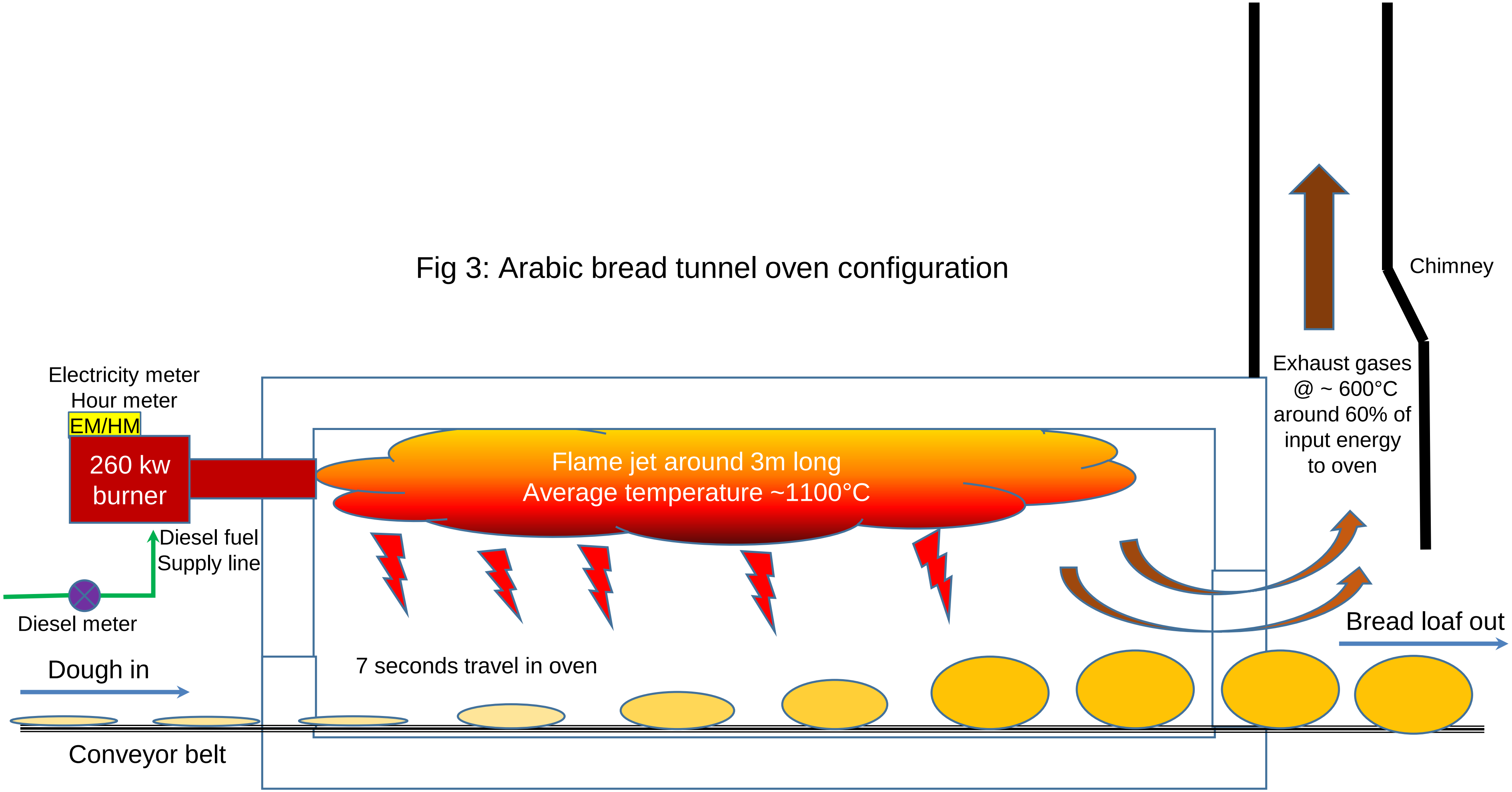


Fig 3: Arabic bread tunnel oven configuration



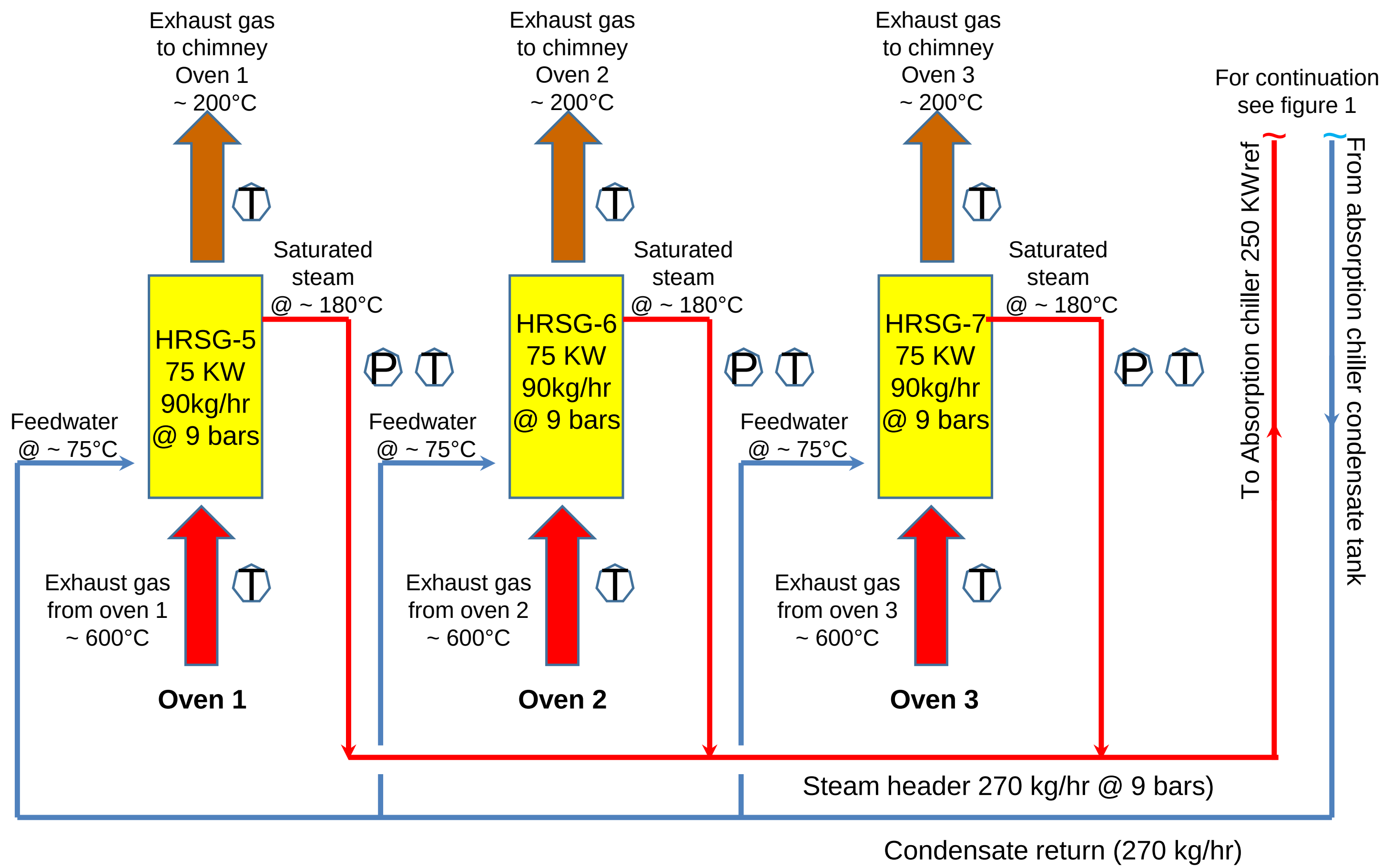


Figure 2: Arabic bread tunnel ovens heat recovery system configuration

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Economic Benefits	The economic benefits take into consideration eight major components, 1. Increase in in-house average electricity generation efficiency from 28% to 37% 2. Heat recovered to displace part of the diesel oil used to fire the thermal oil boiler to heat the frying oil for the natural potato chips line 3. Heat recovered to displace part of the vapor compression air conditioning equipment that uses electricity and replace with absorption chiller that uses steam 4. Heat recovered to displace all of the diesel oil used to fire the boiler to produce hot water for utensils washing and other housekeeping operations 5. Reduced equipment breakdown, product loss and production downtime costs related to blackouts during production shifts 6. Reduced generators maintenance and downtime costs 7. Generators operation between 7 AM and 10 PM displaces low cost utility electricity (0.055 EUR/KWhre) between 7 AM and 6.30 PM when available and high cost utility electricity (0.19 EUR/KWhre) between 6.30 PM and 9.30 PM. 8. It is assumed that resell value of generators will offset the costs of maintenance. Alternatively generators could be leased, lease could be funded from the savings achieved. The new generators have longer periods of diurnal operation compared to base case, their fuel consumption will be higher even though their efficiency is much better. However they are displacing utility electricity which is unreliable and results in additional operating costs.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Economic Benefits (cont'd)	Base case electricity production in-house: 2,400 Mwhre/year Base case diesel fuel consumed to produce in-house electricity: 8,400 MWhrth/year (thermal equivalent) Base case utility electricity consumption: 4,500 MWhre/year Proposal diesel fuel consumed to produce in-house electricity: 16,000 MWhrth/year Proposal utility electricity consumption: 1500 MWhre/year (Occuring between 10 PM – 7 AM at low rate) Market price diesel fuel: 600 EUR/Tonne equivalent to 54 EUR/MWhrth Price utility electricity combined rate: 90 EUR/MWhre (weighted rate over 24 hours) Price utility electricity low rate (7 AM – 6.30 PM) : 55 EUR/MWhre Base case Cost on generators overhaul and maintenance: 27 EUR/Mwhre (over new generators costs) ***Proposal cost saving diesel fuel to produce in-house electricity: (8,400 – 16,000)*54 = - 410,000 EUR/year*** ***Proposal cost savings in utility electricity: 4,500*90 – 1500*55 = 322,000 EUR/year*** ***Proposal cost saving on generators overhaul and maintenance: 2,400*27 = 65,000 EUR/year*** Proposal diesel fuel savings for cooking oil heating(HRTOE): 1,300 MWhrth (29% coverage) ***Proposal cost saving diesel fuel for cooking oil heating(HRTOE): 1,300*54 = 70,000 EUR*** Proposal electricity savings for air conditioning: 400 Mwhre (generator heat recovery) Price electricity: 140 EUR/Mwhre (Combined utility/in-house generation cost at base case) ***Proposal cost saving electricity for air conditioning: 400*140 = 56,000 EUR/year (generator heat recovery)*** Proposal electricity savings air conditioning: 300 Mwhre (Arabic bread tunnel ovens) Price electricity: 80 EUR/Mwhre (Combined utility/in-house generation cost at base case) ***Proposal cost saving electricity for air conditioning: 300*80 = 24,000 EUR/year (ABTO)*** ***Proposal TOTAL cost saving electricity for air conditioning: 56,000 + 24,000 = 80,000 EUR/year***

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Economic Benefits (cont'd)	Proposal diesel fuel savings for hot water heating(HRE): 500 MWhrth (100% coverage) ***Proposal cost saving diesel fuel for hot water heating(HRE): 500*54 = 27,000 EUR/year*** ***Proposal cost saving for loss of product, downtime, breakdowns: 40,000 EUR/year*** Proposal water consumption in cooling tower: 2100 m^3/year Market price of water: 2.5 EUR/m^3 Proposal cost of water for cooling tower: 2100*2.5 = 5,250 EUR/year Proposal electricity consumption to run equipment included in proposal: 15 Mwhre/year (gensets HR) Proposal electricity consumption to run equipment included in proposal: 3 Mwhre/year (ABTO HR) Proposal cost of electricity: 15*110 = 1700 EUR/year (genset) Proposal cost of electricity: 3*80 = 240 EUR/year (ABTO) Proposal TOTAL cost electricity = 1,700 + 240 = 1,940 EUR/year Maintenance costs of HRSGs and absorption chiller offset by vapor compression equipment.

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Economic Benefits		
Saving component	**EUR/year**	**% saving w/r to base case expenditure**
utility electricity	322,000	80%
generators overhaul and maintenance	65,000	100%
diesel fuel for cooking oil heating	70,000	29%
electricity cost savings for air conditioning	80,000	50%
diesel fuel for hot water heating	27,000	100%
loss of product, downtime, breakdowns	40,000	100%
diesel fuel to produce in-house electricity	- 410,000	-200%
Water cost	- 5,250	NA
Electricity cost	-1,940	NA
Net savings	187,000	9.3% of overall energy consumption

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

ENVIRONMENTAL BENEFITS/NEGATIVE IMPACTS				
	Diesel saving	Electricity saving	CO2 emissions	Water saving
Components of savings	MWhrth/year	Mwhre/year	Tonnes CO_2/year	m^3/year
utility electricity	NA	3,000	3,000	NA
generators overhaul and maintenance	NA	NA	NA	NA
diesel fuel for cooking oil heating	1,300	NA	317	NA
electricity cost savings for air conditioning	NA	700	700	NA
diesel fuel for hot water heating	500	NA	122	NA
loss of product, downtime, breakdowns	10	1	23	20
diesel fuel to produce in-house electricity	-7,600	NA	-1800	NA
Water and electricity to operate heat recovery	NA	-18	-18	-2100
Net savings	-6,600	3,683	2344	-2100

Specific emission for base case electricity grid: 1 Tonne CO_2/ MWhr
Specific emission for diesel fuel 0.24 Tonne/MWhrth

Avoided CO2 emissions: 2,300 TonnesCO2/year
Base case overall CO2 emissions: 7,700 Tonnes/year
Percentage reduction in CO2 emissions with respect to base case: 2300/7700 = 30%
Base case overall water consumption: 89,000 m^3/year
Percentage increase in water consumption with respect to base case: 5100/89,000 = 5.7%

Best Practice 1
(Heat recovery from generators and tunnel ovens) - Energy

Capital investments & financial indicators	Cost of intervention: 820,000 EUR Return on investment (simple payback): 4.4 years
Other aspects	- The cost of intervention shown above includes the cost of the information system to implement a Performance Monitoring and Verification Plan for that intervention - Accurate actual consumption figures were obtained thanks to the information system installed by the company at the start of the project at the request of the MED TEST II team. The following instruments relevant to this proposal were installed (Readings were taken on a daily basis) 1. Level readings/diesel meters for diesel tanks in the plant (generators, boilers) 2. Electricity meters at the electricity feeders of the plant 3. Run hour meters for generators Above calculations are based on readings taken from July 2016 till June 2017 - The financial pay back of this is proposal is not much sensitive to fluctuations in the price of diesel
Implementation	A detailed study is being undertaken by the company and suppliers are currently being asked to provide quotations. Implementation may take place by end 2018
Barriers	Financing is a major issue, the possibility of implementing leasing is under study

Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Description of the problem (Base scenario):	The Material Flow Cost Accounting assessment performed in this company at the early steps of the TEST methodology showed that considerable loss occurred from returned products which amounted to around 671 tonnes per year corresponding to 7.3% of the total production. The benchmark for best practice of returned product losses is 2% in the sector of activity of this company. The waste above benchmark level corresponds to 500 tonnes/year in raw materials, 400,000 kwhr/year of energy and around 1,000 m³/year of water. It is obvious that the worst wastage occurs at finished product level because much materials, energy and water have already been spent for its manufacture, this not to mention labor costs and production machines wear. The return is not due to product defects but rather to expiry dates considering the short shelf life of fresh bread. Therefore the issue is one of mismatch between supply and market demand, the company is producing more than what market coverage requires. Further enquiries have shown poor communication between the sales and production departments, these do not even have a common identification code for the same product being manufactured by the company.

Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Description of the solution	The proposal consists of a mix of simple Good House keeping measures that do not involve any cost, and other more complex solutions requiring investments. A brief listing is as follows; - Adopt common identification codes of products in sales and production departments. - Strengthen the communication channels between production, accounts and sales departments - Carry out a market study to determine true market demand and needs including seasonality and geographic specificities - Adopt just-in time manufacturing practices by introducing production, cost and stock control software. - Adopt MFCA methodology in company accounting in order to better allocate actual costs and record actual losses - Make accountable company salespersons that tend to inflate sales volume by flooding the market at the expense of company environmental and financial performances. Considerable savings in raw material, energy and water could be achieved if above practices are implemented aiming to better match production with demand.

Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Economic Benefits	The estimated savings are as follows - Raw material savings: 500 tonnes/year estimated at 820,000 EUR - Energy savings: 400,000 Kwhr of which 80% is diesel and 20% electricity - Diesel price as energy: 0.05 EUR/Kwhrth (based on diesel price of 600 EUR/Tonne) - Electricity price at plant: 0.14 EUR/Kwhre - Savings Energy cost: 400,000*(0.8*0.05 + 0.2*.14) = 27,000 EUR/year - Water savings: 1,000 m^3/year, - Water market price: 2.5 EUR/m^3 - Water cost savings: 1,000*2.5 = 2,500 EUR/year - Total cost savings: 820,000 + 27,000 + 2,500 = 850,000 EUR/year - Revenues from return sales: 10,000 EUR/year (10% of return is sold the rest is sent to waste) - Net savings: 850,000 - 10,000 = 840,000 EUR/year
Environmental Benefits **Health and safety impact**	Reduced solid waste: 450 Tonnes/year Specific CO_2 emissions of diesel fuel as energy: 0.244 kgCO_2/kwhrth Specific CO_2 emissions of electricity grid: 1 kgCO_2/kwhre Estimated Avoided CO_2 emissions: 400,000*(0.8*0.244 + 0.2*1) = 158,000 kg CO_2/year Estimated avoided BOD loading in waste water: 5 Tonnes/year Reduced solid waste and BOD will contribute to reduce the propagation of diseases

Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Capital investments & financial indicators	Cost of intervention: 45,000 EUR (consultant, market study and software)) Return on investment (simple payback): 0.1 year
Other aspects	- The market cost of water in the country is considered and not the official utility cost which is much less - Above calculations are based mainly on MFCA assessment and to a lesser degree on readings from the information system for the period August 2016 September 2017
Implementation	Proposal is being currently implemented and is not expected to be finalized before mid 2019
Barriers	Company culture is a major factor that could contribute to the success of this measure

Best Practice 3
(Adding a second stage to the existing RO system) - Water

Description of the problem (Base scenario):	The raw water available to the plant has high hardness which is not suitable for production, a Reverse Osmosis (RO) system is used to obtain treated water (permeate). This system is a single stage type (See fig 1 below), the reject water (fraction of the water with high salinity that exits the RO) does not undergo a further stage of treatment. The output from the system consists of 75% permeate and 25% reject water which is wasted to drain. Reject water amounted to 20% of overall water use in this plant.
Description of the solution	The proposal was to add a second stage to the existing RO system where the reject water is the input to the second stage (see fig.2 below). More than half of the reject water could be recovered as treated water thus saving large quantities of water. Of course there will be more electricity consumption and maintenance costs but the net result is a benefit in both financial and environmental terms.

Fig 1: Single stage RO system

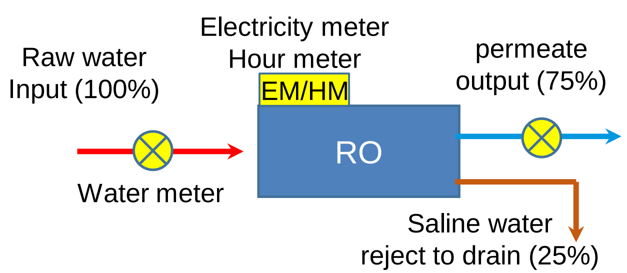
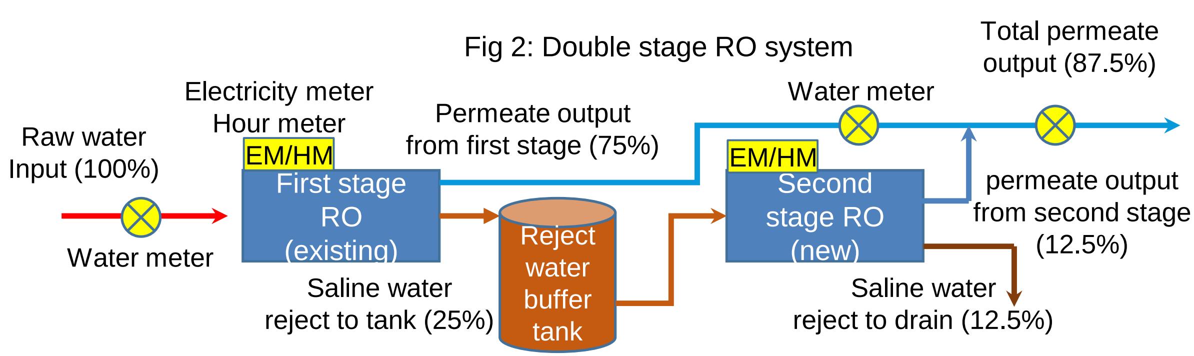


Fig 2: Double stage RO system



Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Economic Benefits	Base case RO water reject: 18,000 m³/yr Market price of water: 2.5 EUR/m³ Base case water reject cost at market prices: 18,000*2.5 = 45,000 EUR/year Expected RO water reject after intervention: 9,000 m³/yr Expected water reject cost at market prices after improvement: 9,000*2.5 = 22,500 EUR/year Expected savings at market prices from reduced water reject: 22,500 EUR/year Expected increase in electricity consumption after improvement: 12,500 Kwhre/year Electricity cost at plant: 0.14 EUR/Kwhre Expected maintenance cost of second stage RO unit: 1,250 EUR/year Expected increase in electricity and maintenance costs: 12,500*0.14 + 1,250 = 3,000 EUR/year Expected Net savings for improvement: 22,500 – 3,000 = 19,500 EUR/year
Environmental Benefits	Expected water savings: 9,000 m³/yr (50% reduction in reject water) Reject water from RO will drop to around 11% of overall plant water consumption instead of the base case 20%.
Environmental negative impacts	Specific CO_2 emissions electricity grid: 1 kgCO_2/Kwhre CO_2 emissions due to increased electricity use: 12,500*1 = 12,500 kgCO_2/year
Other benefits	Reduced load on drainage network
Health and safety impact	Not applicable

Best Practice 2
(Reduce market return of products due to supply demand mismatch) – Raw materials

Capital investments & financial indicators	Cost of intervention: 14,000 EUR Return on investment (simple payback): 0.7 years

Other aspects	- The market cost of water in the country is considered and not the official utility cost which is much less.
	- The cost of intervention shown above includes the cost of the information system to implement a Performance Monitoring and Verification Plan for that intervention
	- Accurate values were obtained thanks to the information system installed by the company at the start of the project at the request of the MED TEST II team. The following measuring devices were installed related to this intervention;
	  - water meter at each of the supply and permeate lines of the two existing single stage RO units (working in parallel).
	  - Electricity meters and hour counters for the two existing RO units.
	Readings were taken on a daily basis.
	- Above calculations are based on production period between September 2016 and August 2017

Implementation	Proposal has been implemented in July 2018

Management system integration

- Till the present time the company did not adopt a management system other than ISO 22000.
- The MED TEST II program has induced RECP thinking in the company, the installation of an information system at the start of the project has made people aware to the importance of performance monitoring.
- The accounting department has greatly benefited from the MFCA exercise, there is closer coordination between accounting and production. Production output is now recorded on a weight basis for each product, this was not the case before the implementation of the TEST methodology in this company.
- The staff has gained a kind of self confidence and pride because they feel they have gone through a special experience that can help them have better control of production parameters.

Performance Monitoring

- The company installed water meters on the second stage RO system (BP3), readings are showing that the results of the implementation are as per design of implemented measure.
- The preliminary results of the ongoing implementation of BP2 show considerable reduction in market returns, data is still being analyzed.
- All measures are automatically submitted with their own Project Monitoring and Verification Plan whenever they exceed 5,000 USD in capital outlays. For example for the heat recovery measure, the PMVP will include all measuring devices shown in slide 34 as well as the performance indicators to be calculated and compared against the set benchmarks (financial, environmental and technical)

Results

- 31 measures were proposed in Saving Catalogue (see slide 24) and 30 were included in the Action Plan. Out of these 30 measures, 4 are already implemented, 8 are being implemented while the rest is under study
- Economic savings of the 30 mentioned measures amount to 1,213,454 EUR/year with an average PBP of 0.8 years
- Total annual Water savings : 17%
- Total annual Energy savings : 22%
- Total annual Raw Material savings : 5.4%

- Non-Product output costs reduced by 27%
- CO_2-emission reduction by 27%