Energy Audit Summary Report
CRP HENRI TUDOR
Audit no. 35 – France 05

Food & Beverages
Cooking factory

Centre de Ressources des Technologies pour l'Environnement

20th of January 2012

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AUDIT Nr 35 – FR05

1. Data of the auditors

1.1. Contact data of the auditors

Name: Jonathan Hervieu and Alex Bertrand

Organisation: Public Research Centre Henri Tudor

Country: Luxembourg

Profession: Engineer

Number of audits performed: 3

Date of the audit: 08/04/2011

Duration of the audit: 3 weeks

2. Introduction

2.1. Objectives

The objectives of this audit are twofold:

1. Understand and analyse the energy consumption structure of the heating processes in the cooking factory and
2. Explore options to recover waste heat and to use solar thermal energy.

3. Status Quo: processes, distribution, energy supply

3.1. General info of company

Type: Cooking factory

Location: France

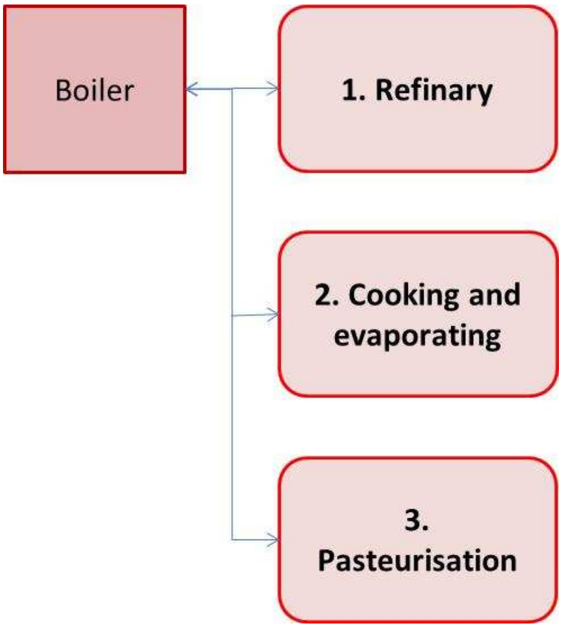
Sector: food and beverages

Number of employees: 150

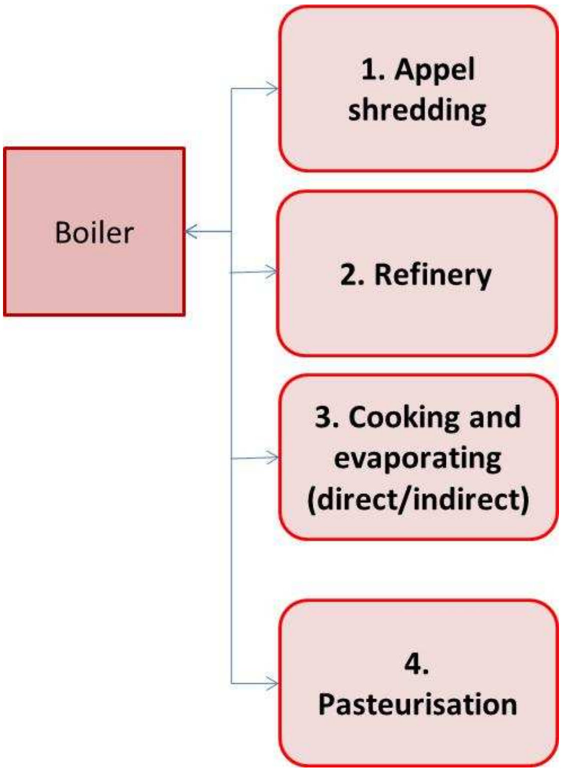
Product: Apple-based product

3.2. Flow sheet of the manufacturing side

3 production lines have the same structure:



The fourth line is structured as followed:



3.3. Description of the existing system

Heat is produced using three steam boilers. Two of the three are used during eight months for the three production lines mentioned above, and the third boiler is used during four months when all four production lines are active.

Primary energy consumption

Energy type (fuels / electricity)	PEC		PET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Total fuels	7 003	100,00	7 003	100,00
Total electricity	0	0,00	0	0,00
Total (fuels + electricity)	**7 003**	**100,00**	**7 003**	**100,00**

(Electricity consumption is zero, as cooling systems are not considered in this audit).

Final energy consumption (FEC) per fuel and final energy demand thermal (FET),

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Natural gas	6 366	100,00	6 366	100,00
Electricity	0	0,00	0	0,00
Total	**6 366**	**100,00**	**6 366**	**100,00**

Useful supply heat (USH)

Equipment	Fuel type	USH by equipment	
		[MWh]	[% of Total]
Chaudiere Seum	Natural gas	1 642	27,73
Chaudirere Wanson	Natural gas	2 119	35,80
Chaudiere Stein Fasel	Natural gas	2 159	36,48
Total		**5 919**	**100,00**

- *Distribution system*

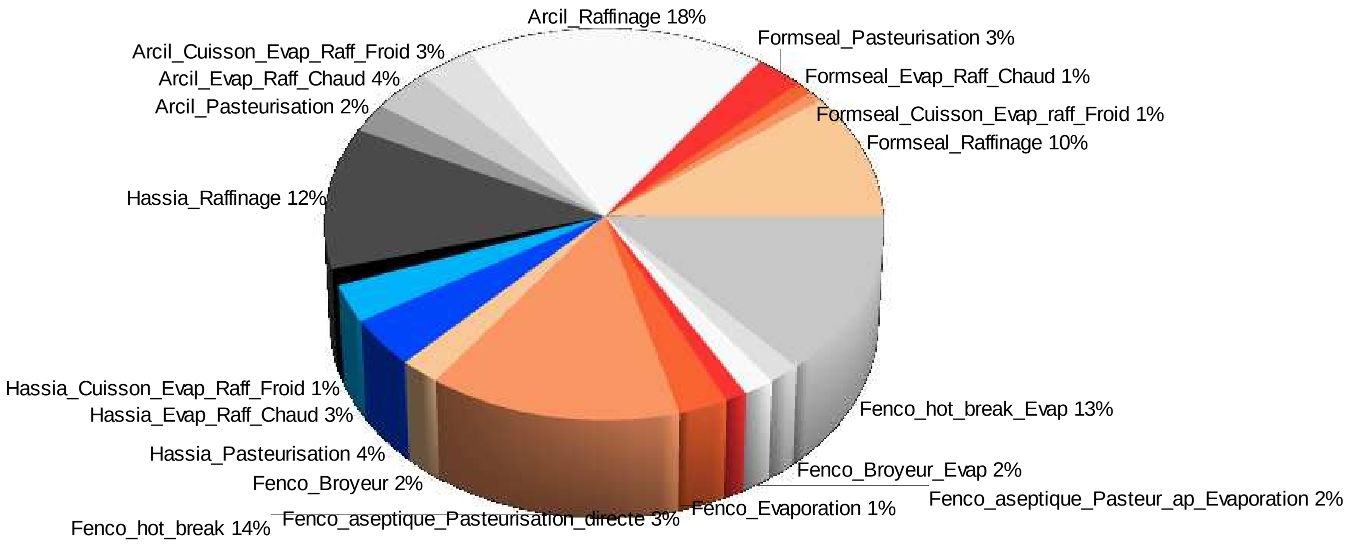
Heat is distributed via steam at 6 bar.

- *Main energy consuming energy processes and buildings*

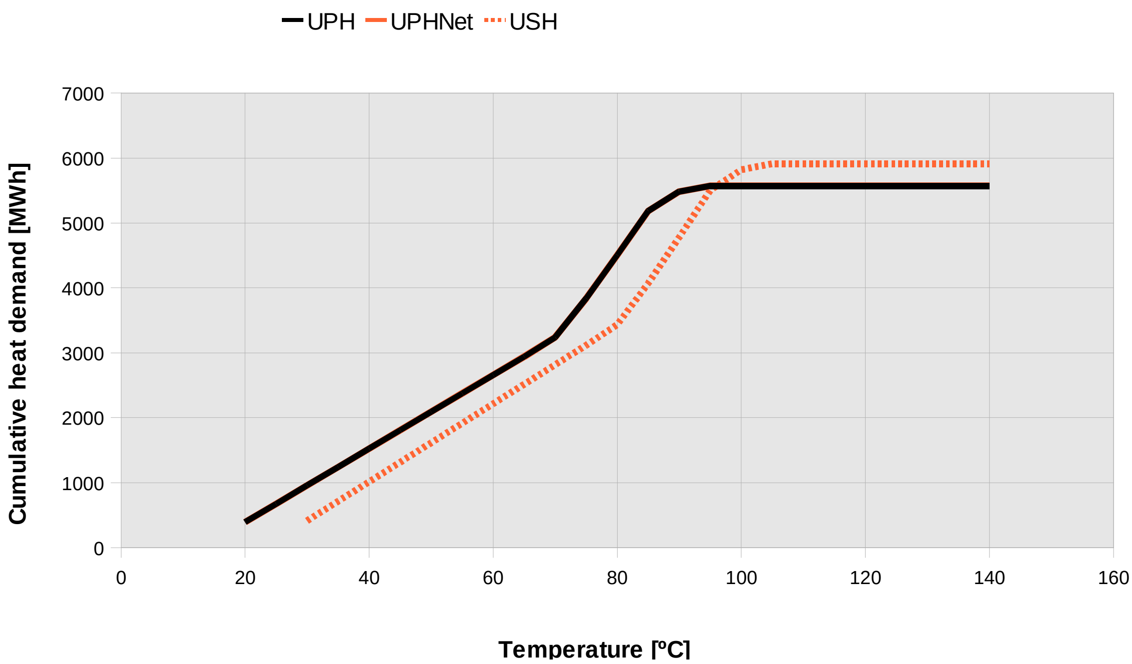
Only the heating processes of the four production lines were considered in the audit.

Process	Total [MWh]	Circulation [MWh]	Maintenance [MWh]
Formseal_Raffinage	583	583	0
Formseal_Cuisson_Evap_raff_Froid	48	35	13
Formseal_Evap_Raff_Chaud	60	16	44
Formseal_Pasteurisation	158	158	0
Arcil_Raffinage	1 008	1 008	0
Arcil_Cuisson_Evap_Raff_Froid	189	113	76
Arcil_Evap_Raff_Chaud	197	45	152
Arcil_Pasteurisation	131	131	0
Hassia_Raffinage	652	652	0
Hassia_Cuisson_Evap_Raff_Froid	76	19	57
Hassia_Evap_Raff_Chaud	174	4	170
Hassia_Pasteurisation	226	226	0
Fenco_Broyeur	125	59	66
Fenco_hot_break	785	785	0
Fenco_aseptique_Pasteurisation_directe	152	152	0
Fenco_Evaporation	68	7	61
Fenco_aseptique_Pasteur_ap_Evaporation	97	97	0
Fenco_Broyeur_Evap	98	56	42
Fenco_hot_break_Evap	746	746	0
Total	**5 573**	**4 892**	**681**

- *H&C demand (proc),*



- *H&C demand (temp),*



3.4. General

Due to its processes (heating up then cooling down), the company has an interesting potential for heat recovery. Unfortunately, the application of such a concept is very difficult, as it implies that heat is recovered from solid flows, which would require some intermediate devices, therefore increasing the costs for such a solution.

As the site is located in the South of France, a solar thermal solution also appears to be interesting. The production processes are designed to use steam (although the highest temperature demand reaches 90°C), which would imply the use of specific, high temperature, collectors. As this investment would represent even higher costs than a normal solar thermal installation, the following assessments considered instead classical evacuated tube collectors, in order to at least show the company that solar energy is also an interesting solution.

The main assumptions made were:

- The thermodynamical parameters of the apple flows are identical to water,
- Apple temperature entering the production line is averaged over the year
- Exclusion of heating demand of the building (according to a former audit, the according energy demand should be very small) as well as cooling demand.

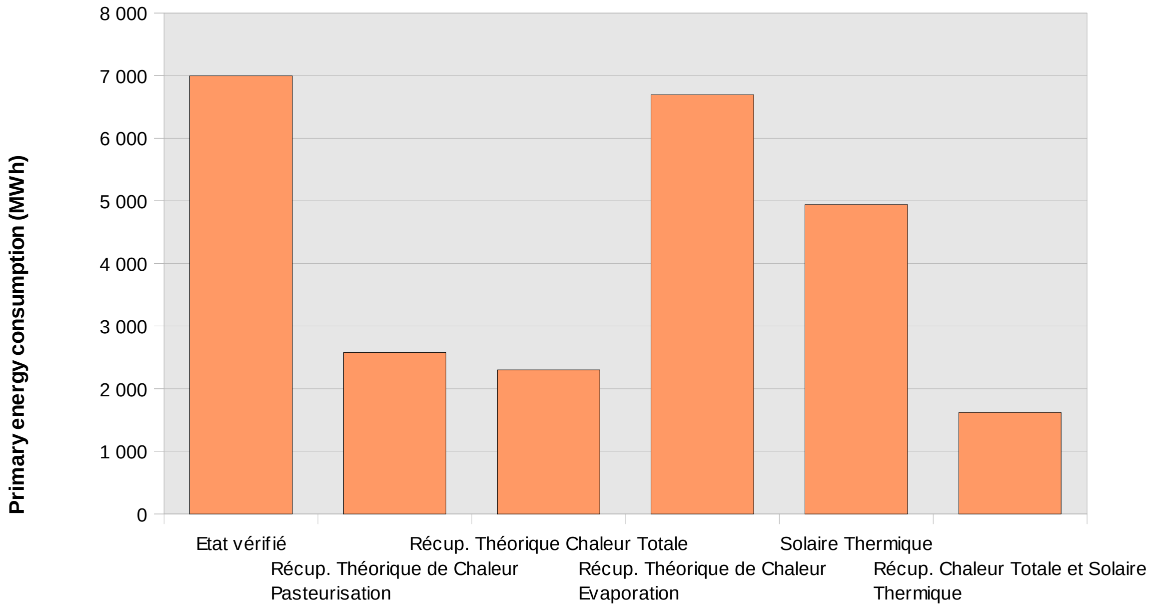
4. Comparative study

4.1. Proposed alternatives

Following the elements discussed in the chapter before, several heat recovery concepts and solar thermal uses were assessed:

1. Heat recovery on the pasteurisation for a preheating of the apples (5 heat exchangers between 126 and 567 kW).
2. Heat recovery on pasteurisation and evaporation on the 4th. production line (6 heat exchangers between 126 and 567 kW) for the preheating of the apples.
3. Heat recovery on the evaporation of the four cooking process (4 heat exchangers between 1 and 249 kW).
4. Solar thermal heat production (evacuated tube collectors, 30% of total heat demand).
5. Heat recovery on pasteurisation and evaporation on the 4th. production line with solar thermal heat production (6 heat exchangers between 126 and 567 kW, evacuated tube collectors, 30% of total heat demand).

4.2. Primary energy demands



5. Selected alternative(s) and conclusions

5.1. Selected alternative

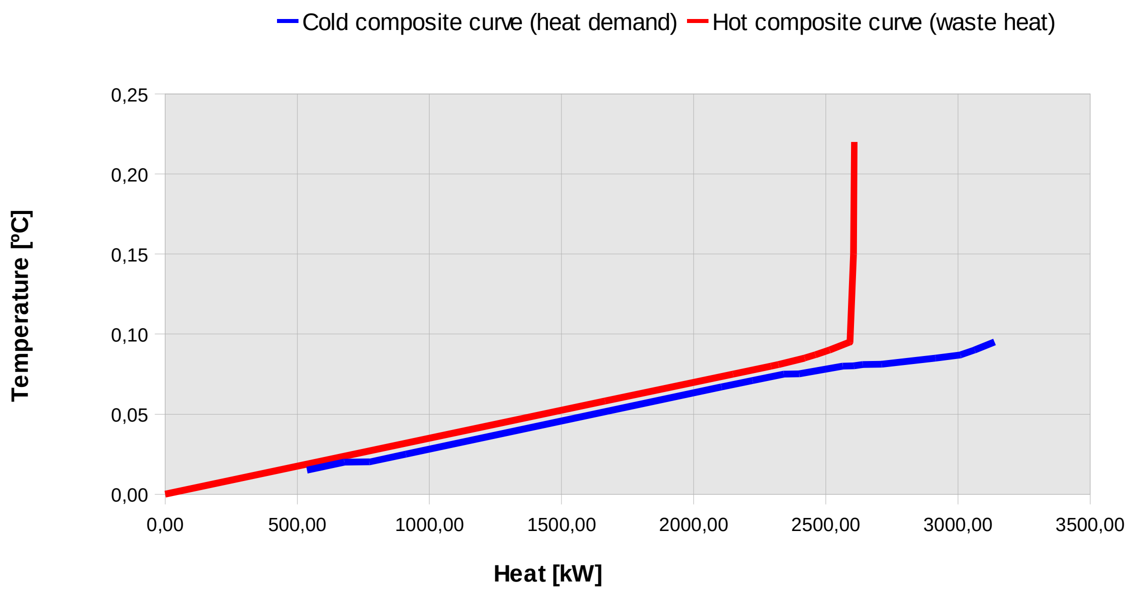
Due to the important primary energy saving potential, the last alternative was selected as the most relevant one.

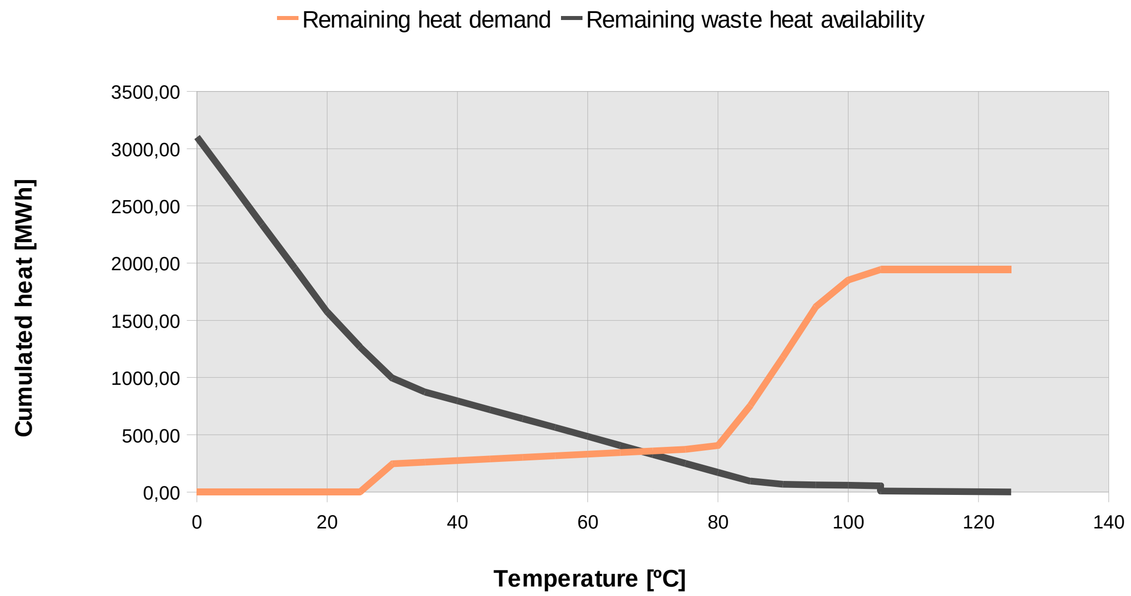
5.1.1. Process optimisation (written proposals)

n.a.

5.1.2. Heat recovery

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
Formseal_Past	126	Formseal_Pasteurisation	Formseal_Raffinage	583	15,57
Arcil_Past	245	Arcil_Pasteurisation	Arcil_Raffinage	980	26,18
Hassia_Past	146	Hassia_Pasteurisation	Hassia_Raffinage	652	17,42
Fenco_Direct_Past	545	Fenco_aseptique_Pasteurisation_directe	Fenco_hot_break	785	20,98
Fenco_Evap_Past	567	Fenco_aseptique_Pasteur_ap_Evaporation	Fenco_hot_break_Evap	517	13,81
Fenco_Evap_Evap	249	Fenco_Evaporation	Fenco_hot_break_Evap	227	6,06


Cold composite curve (heat demand)
Hot composite curve (waste heat)
Temperature [ºC]
0,25
0,20
0,15
0,10
0,05
0,00
0,00
500,00
1000,00
1500,00
2000,00
2500,00
3000,00
3500,00
Heat [kW]


Remaining heat demand
Remaining waste heat availability
Cumulated heat [MWh]
3500,00
3000,00
2500,00
2000,00
1500,00
1000,00
500,00
0,00
0
20
40
60
80
100
120
140
Temperature [ºC]

5.1.3. Heat and Cold Supply

Equipment	**Type**	**Heat and cooling supplied to pipe/duct**	**Nominal capacity**	**Contribution to total heat and cooling supply**	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (evacuated tubes)	o==Vapeur Formseal Hassia==o o==Vapeur Fenco==o o==Vapeur Arcil==o	972	592	30,50
Chaudiere Seum	steam boiler	o==Vapeur Arcil==o	1 500	383	19,70
Chaudirere Wanson	steam boiler	o==Vapeur Formseal Hassia==o	1 500	515	26,50
Chaudiere Stein Fasel	steam boiler	o==Vapeur Fenco==o	2 400	453	23,30
Total			**6 372**	**1 943**	**100**

The 3 existing steam boilers were kept in place. It should be verified if the use of the Stein Fasel boiler can be partially avoided with the combination of the solar collector and the two other boilers.

5.2. Comparative study and conclusions

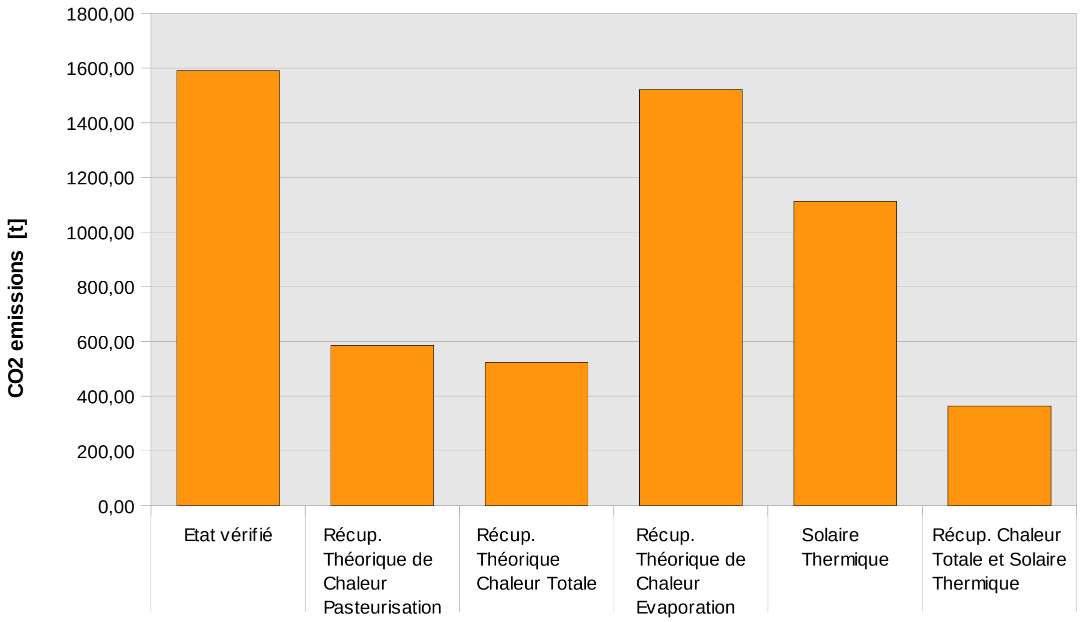
In case of more than one alternative selected insert more tables

Use the present state column for the present state and leave the field empty as no information is available

		Present state	**Alternative**	**Saving**
Total primary energy consumption (1)				
- total	[MWh]	7 003	1 618	77%
- fuels	[MWh]	7 003	1 598	77%
- electricity	[MWh]	0	20	
Primary energy saving due to renewable energy	[MWh]	-	700	-
CO_2 emissions	[t/a]	1 592	364	77%
Annual energy system cost (2)	[EUR]	235 995	218 086	8%
Total investment costs	[EUR]	-	1 084 713	-

(1) including primary energy consumption for non-thermal uses

(2) including energy cost (fuel and electricity bills), operation and maintenance costs and annuity of total investment.



5.2.1. Energy and environmental analysis

As can be seen from the figures above, the last alternative presents a very high energy saving potential. Both primary as well as CO_2 emissions could be reduced by 77% is such a combination of solutions was implemented.

5.2.2. Economic analysis

From the economic point of view, the investments considered would reach more tahn 1 000 000 €, which is an huge investment for a company of 150 employees.

5.2.3. Conclusions and outlook

As mentioned above, the assessment conducted here is rather theoretical, as it would imply both heat recovery on solids as well as the application of solar energy not reaching the necessary temperature level. Nevertheless, the conclusions here can serve as basis for future development of the production lines. Priority must be given to heat recovery, as it yields a very high energy saving potential. It is suggested that the company applies this measure stepwise, e.g. in the framework of the replacement of machines or when a major rework of the site is due. Some conceptual work from the production line manufacturers would certainly support the improvement of the energy efficiency of the company. Once the processes are optimised, the implementation of solar thermal technology should be considered to limit the use of fossil fuels. To further reduce the energy consumption, heating demand for building as well as cooling demand should also be considered in an integrated manner in a next audit.