HTHW TEMPERATURE REDUCTION

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Internship Assignment
Grolsche Bierbrouwerij Nederland B.V.

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Summary

The main research topic of this assignment was to determine whether or not the process in the brewery would run effectively if the temperature of the HTHW used to heat processes was reduced in temperature to below 105 degrees. The experience gained from this project would suggest that the temperature can certainly be reduced below 105 degrees. Perhaps the HTHW can be reduced further, even closer to 100 degrees if the right modifications are made to the process (particularly changes to the plate heat exchangers). The energy savings as a result of lowering the temperature of the HTHW have also been calculated. The reduction in heat losses from 120 degree HTHW to 104 degree has been estimated to be 1212 Gigajoules per year due to a lower ΔT between the water in the pipe and the surroundings. Assuming 9 euro per GJ it was possible to make an estimate of 11000 euro per year savings on energy costs in the brewery. If 100 degree water is used the savings will be even greater.

The main objective of reducing the temperature of the HTHW was to eliminate the need for safety checks on the heat exchangers etc. these checks require external companies to come to the brewery and stop production (which is expensive) for a number of hours. It became obvious during the course of this research that the legislation states boilers which are subjected to temperatures above 110 degrees Celsius must be checked. In this case the brewery's HTHW is already below the point of 110 degrees so perhaps it is not even necessary to reduce the temperature further. However certain equipment must be installed which ensures water above 110 degrees never passes through the equipment.

The savings on safety checks which are determined by the Pressure Equipment Directive regulations are estimated to be about 2887 euro per year for the checks alone. This does not include the possible money savings because production will not be stopped while the checks are performed.

The investigation regarding the possibilities of solar water heating did not return such positive results. Using the gas price paid by Grolsch for the calculations I was able to estimate a payback period of about 30 years. The lifetime of such a system is expected to be 20-30 years at most so it is certainly not an attractive option.

Foreword

I would like to thank everyone in the brewery who took time to help me during my internship at Grolsch. Everyone was extremely helpful when I asked for information. There was no one I asked who could not help me in some way. I found everyone I talked to in the brewery to be extremely friendly and nice people. I was very grateful to meet all of you and found it very easy to make friends with the workers in the brewery. I had a great time working for Grolsch and I want to thank you all for the experience. I wish you all the best of luck in the future with whatever you do.

Darren Coughlan, 2010

Contents:

1. Introduction

The Grolsch brewery distributes heating energy around the plant from the main energy utility building via high temperature hot water (HTHW) pipelines and steam pipelines. Steam is only used in the Bruiwhuis. For other thermal heating needs of the brewery HTHW is used. The HTHW used in the plant has 2 main purposes.

1. Room/ space heating
2. Process heating (Cleaning In Place, bottle washing, air drying, pasteurization etc.)

The brewery was originally designed to supply HTHW to many of the internal plant processes at a temperature of 120 degrees Celsius. The high pressure water used in the plant is heated using a number of heat exchangers and economizers in the Energy utilities department of the plant. The plant contains two large boilers which produce steam for certain on site processes. This steam is used to heat the HTHW to the desired temperature in the utilities department. For the purpose of this assignment a study has been made to assess the viability of lowering the temperature of the HTHW stream of the plant to 105 degrees Celsius or lower.

Lowering the temperature of the HTHW stream in the plant has 2 main advantages. Firstly the amount of energy required to heat the water is lower (good for the environment and the breweries bank balance). Also the temperature difference between the water in the pipes and the surroundings is smaller, this has the effect of reducing energy losses in the pipes (which saves more gas and money).
Secondly the legislation regarding heat exchanger safety checks becomes more lenient (less strict) when the temperature of the water is reduced to 110 degrees Celsius or lower.

However the effect of lowering the temperature of the HTHW on various plant processes which consume the HTHW was unknown at the beginning of the project. It was possible that some of the processes using the HTHW might not function as effectively as they should. It was predicted some processes might take longer to reach set point with a lower temperature HTHW supply. It was also possible that some of the heat exchangers simply would not have enough capacity to heat the process fluid sufficiently with the lower temperature HTHW. In this case it was foreseen the plate heat exchangers should be expanded in order to maintain the required heating capacity (kW) even with the lower temperature water. The following report examines the separate areas and processes of the Grolsch brewery to identify critical processes and possible bottlenecks. In the cases where processes will not work ideally under the new operating conditions (lower temperature HTHW) some suggestions are made as to how the process can be changed in order to make the project successful.

Along with saving money by reducing energy losses, reducing the temperature of the HTHW also has the added benefit of reducing the amount of money and maintenance hours spent on checking certain equipment (mainly pipes and heat exchangers) for safety reasons. The legislation surrounding this area is explained in a little more detail in the following chapter.

2. Legislation

Hot water boilers, < 110 ° C, do not need to be inspected, the user is responsible for the safety of this type of installation.
For hot water installations < 110 ° C there are also requirements. The most important requirements are as follows (NEN 3028 chapter 9):

- expansion facilities (present)
- pressure safety (present)
- temperature safety max 110°C (not present)
- water shortage safety (not present??)
- thermometers and manometers nearby hot water heat exchanger (present)

The paragraph and list above were taken directly from an e-mail received from Fons Heuven (KWA) regarding the laws surrounding high pressure and temperature installations.

We are currently using water at about 107/108 degrees which is not much lower than 110. For this project we aim to reduce it even further, thus guaranteeing it is below the 110 and also saving further on energy losses.

Gerard Groote Punt told me that Grolsch have an agreement with Energie Consult Holland B.V that every pice of pressure equipment can be checked for 450 euro no matter how big or small the item is, or no matter how long the item takes to check. It is the same cost for each piece of equipment. The time interval between checks always varies from 2-6 years depending on the piece of equipment in question.

Later in this report I have made an estimate of costs of such checks every year. If a piece of equipment only needs to be checked every 2 years then I assume this piece of equipment costs Grolsch 225 Euros per year.

3. Some Energy intensive processes examined in more detail

The following chapter describes some of the processes originally believed to be critical processes which might cause problems if the temperature of the HTHW was to be reduced. In this chapter I will explain in more detail how the processes work and what exactly will be the effect of lowering the HTHW temperature.

3.1 Space heating

The brewery can be divided into the following nine active heating systems:
1. Building heating energy (EN1)
2. HK 1,5,6
3. HK Brouwhuis 2,3,4 + 2.3
4. Beer Processing 1
5. Beer Processing 2
6. Beer Processing 3
7. Advertising Warehouse /beugel line
8. Empty Warehouse + full Warehouse
9. Warehouse CM2/CM3 / pressure tank DT1

Freddy (Software manager, Grolsch) explained how the space heating works here in the brewery. The overall space heating system in the brewery has 2 separate heat inputs. One input is via the radiators on the walls of the rooms and the other input is via the HVAC system. On a particularly cold morning (say after the weekend when the brewery has had lots of time to cool) both inputs can be used to help heat up the building quickly. Once the desired temperature has been reached the power requirements of the heating system are greatly reduced.

The HVAC system is used to refresh the air in the brewery 5 times every hour. During the winter months the wall radiators are always transferring heat to the rooms so the HVAC only needs to do a small amount of heating.

From the computer system which controls the space heating I can see at the moment (Oct/Nov) the control valve for the HTHW in the HVAC is generally shut. It opens when the air is being refreshed every 20 minutes but to less than 1/3 of its full capacity.

From speaking with Freddy and Richard about the space heating system in the brewery I am very confident to say that there will not be any problems with space heating if the temperature of the HTHW is reduced slightly.

The areas which require the largest thermal power input for space heating can be seen from the distributie diagram to be the large warehouses of the brewery. It is not foreseen that there will be any problem here but even in the case that the power output is slightly reduced because the temperature of the HTHW is dropped by a couple of degrees it must be remembered that the workers in these areas also have electric forklifts with heated cabins.

One area that might be worth investigating (David Johnstone from SABMIller mentioned during the sustainable development audits.) is when the air is refreshed every 20 minutes. Is the warm air dumped outside or is there some heat recovery while refreshing.

3.2 Pasteurizers

There are 2 types of pasteurization processes used in the Grolsch brewery. Flash pasteurization and tunnel pasteurization. Tunnel pasteurization is the most reliable form for guaranteeing micro-biological stability but a tunnel pasteurizer is generally one of the most expensive, space consuming and energy intensive piece of equipment in the filling department. It is more reliable than flash pasteurization because the bottles are already filled and closed before pasteurization, thus eliminating the opportunity of infections during filling. In the case of flash pasteurization the beer is pasteurized before it is filled and crowned. For this reason flash pasteurization relies heavily on having sterile filling equipment and bottles as well (about 50% of foreign organisms are introduced during filling). From the book-"Technology of brewing and malting" (Kunze, p. 514), we can see that a temperature of only 60 degrees Celsius is sufficient to perform a flash pasteurization effectively. However it has been found from experiments that the time for pasteurization can be reduced exponentially by increasing the temperature only slightly.

The following relation describes how many pasteurization units the beer has obtained:

$$Number\ of\ PU = time * 1.393^{(Temperature\ in\ heater - 60℃)}$$

Time in this equation should be expressed in minutes.

According to this relation 2.70 PU's are delivered every minute at 63℃ while 7.30 are delivered every minute at 66℃. Therefore increasing the temperature of the pasteurizer slightly means the time for pasteurization can be reduced.

This is also true for the case where the temperature of the pasteurization must be reduced, the time for pasteurization can be increased, although this slows production and costs money. Although from the results of this study I can conclude that the temperature of the pasteurization in the brewery will not have to be lowered. I will now examine the 2 types of pasteurizers used in the brewery.

3.2.1 Tunnel pasteurizer

Figure 1 Tunnel Pasteurizer picture

There are 3 tunnel pasteurizers in the brewery:

Can line KL08
NRB line KL07
Special line KL02

From the SIG "Use and maintenance" folders it is illustrated that the temperature in the can line tunnel pasteur should be 62.2 degrees Celsius at the warmest point in the pasteurizer. This agrees with the information from the book-"Technology of brewing and malting" (Kunze, p. 516), which states that about 20 PU's are desirable for can pasteurization but the temperature should not go above 62 degrees Celsius because it might cause the internal pressure to raise above the point which exceeds the cans resistance (above 6 bar internal pressure can cause bulging or swelling of the can).

From the 'Brewmaxx' system and from the PLC's on the pasteurizers themselves it can be seen that the can tunnel pasteurizer (KL08-514) is indeed kept at about 62°C all the time.

The NRB (non return bottle) line Pasteur (KL07-438) is also running at about 62°C although when Miller is in production it is switched to the same settings as a bottle warmer and it runs at about 40 degrees Celsius. The special bottle line is also running at about 62 degrees Celsius. The special beer bottle pasteurizer is also running at around 63 degrees Celsius.

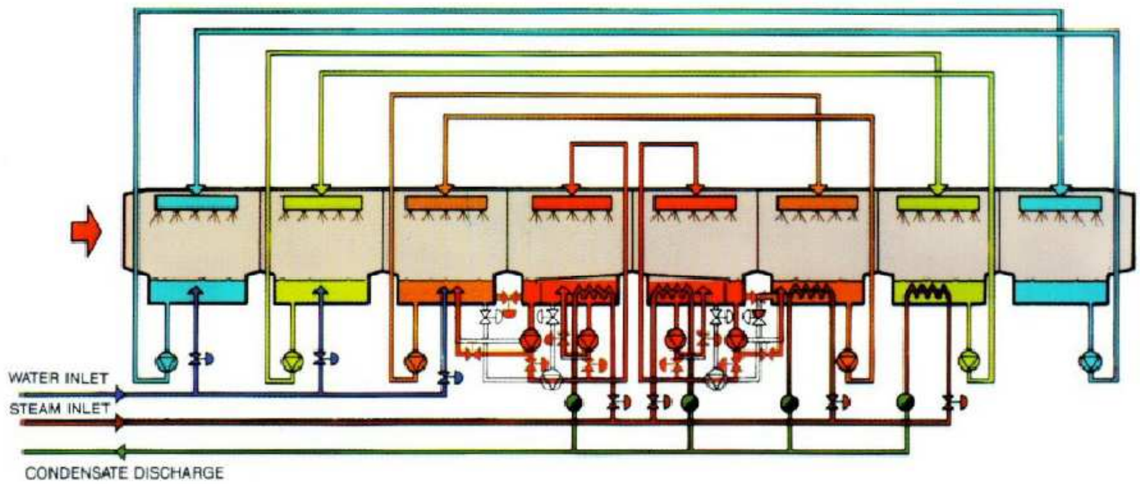


Figure 2 Tunnel Pasteur flow scheme

The above diagram shows the set-up of a tunnel pasteurizer. The only difference with the pasteurizers in Grolsch is that HTHW is used instead of steam. We can see there is a great deal of energy recovery in these tunnel pasteurizers (although a lot of energy is lost through the walls and roof which have a very large surface area). Water is constantly pumped from one side to the other so the pasteurizer acts like a giant heat exchanger.

Table 1Tunnel Pasteur Specs.

Tunnel Pasteurizer		
Voltage	(V)	400
Electrical Frequency	(Hz)	50
Power during production	(kW)	552
Power at start-up	(kW)	1163

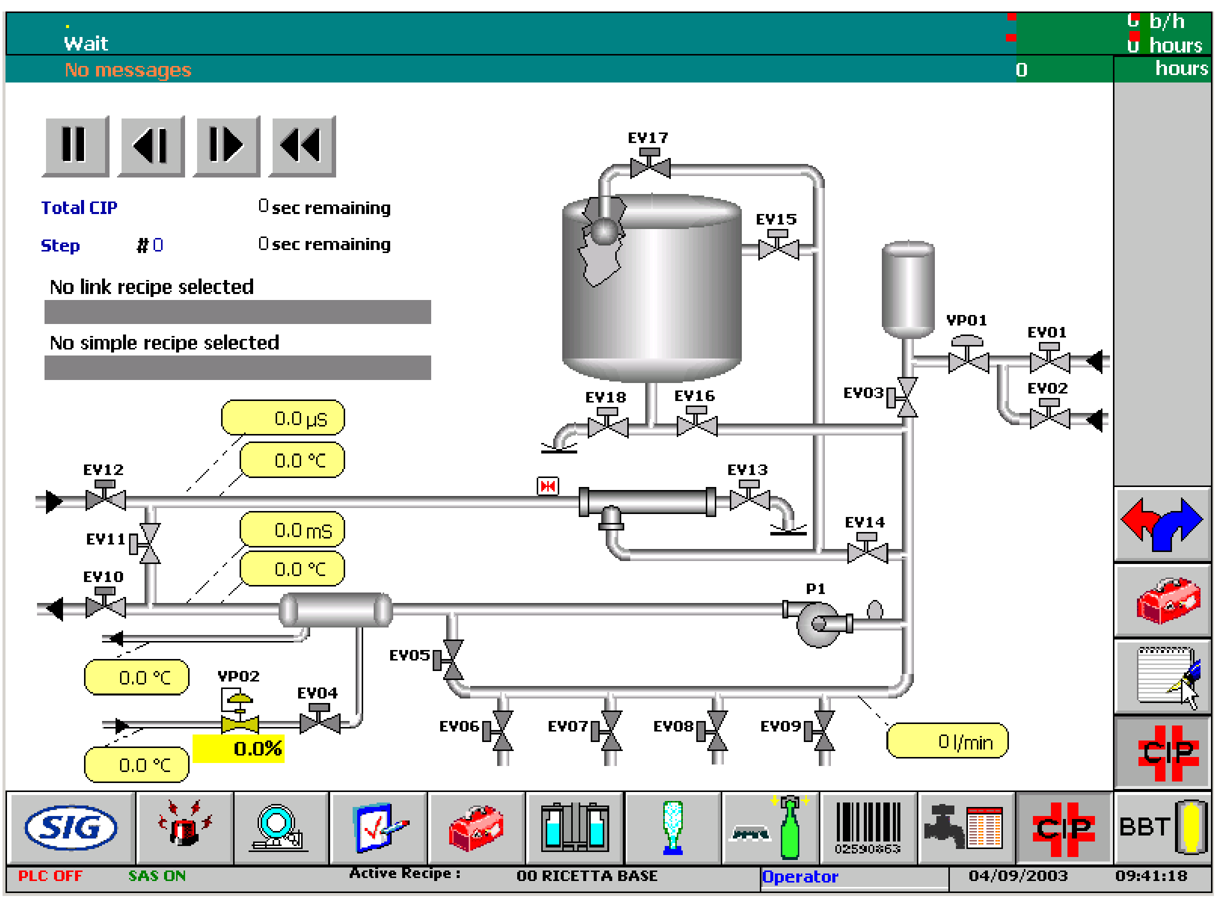
The tunnel pasteurizers, a lot like the bottle washers will use a lot less thermal power during production than during start up (roughly half). For this reason it is easy to say that there will be no problem during production. If the power used during start-up is sufficient to heat the baths (even though it will take a small while longer) and the power used during production is about half the starting up power there will be no foreseeable problems with running the tunnel pasteurizers with lower temperature HTHW.

3.2.2 Flash pasteurizers

Flash pasteurization is much more energy efficient and simpler than tunnel pasteurization. David Johnstone from SABMIller suggested that the design recovery % does not always match the actual values. In this case he has advised to test the temperature on both sides of the hot junction and both sides of the cold junction and calculate the actual recovery. If the recovery is lower than design then some plates should be added in the recovery section which will have the effect of saving some energy in the process.

The flash pasteurizers I examined in the brewery have a massive heat recovery and even quite a lot of overcapacity in the plates themselves and the control valves. I think it is possible to operate these with a lower temperature HTHW stream. Of course lowering the temperature of the HTHW will mean less heat recovery and more losses but there is no reason it cannot be done. One option to reduce heat losses is simply expanding the pasteurizers. This will cost a couple of thousand euros (estimate based on previous GEA quotation) and will probably disrupt production costing more money in the long run.

3.3 CIP



[Figure 3 CIP flow diagram

The CIP sets in the bottling department are used to clean only the fillers. Giobbe (Sidel) and Reinhard (Software engineer) told me that it's difficult to heat up the filler so quickly; it's very heavy and will take some time to heat up in any case. One option is increase the flow of hot water and CIP fluid through the filler. This can be done by adding more plates to the exchanger and reducing pressure drop or by increasing pumping power. Otherwise the temperature of the CIP and hot water streams can be increased further above 88 degrees but there is an upper limit of 95 degrees with the filler. There is some space to improve and increase heating up time for sure. Although the manufacturers (Sidel) told me it is important to beware of thermal shock, heating up or cooling down too quickly could cause the filler to deform.

Also it is interesting to note that the acid run (only the acid run of a full CIP because with a single acid run on its own the temperature must be kept high) could be performed at about 55 degrees. The manufacturer (Sidel's CIP recipe sheet included in the appendices) suggests that 55 degrees Celsius is enough for the acid step when running a full CIP cycle. Apparently the acid becomes more corrosive at higher temperatures. On top of this using acid at 55 degrees (rather than 80) also has the effect of pre-cooling the filler. This helps avoid thermal shock and will also reduce the length of time required to cool the filler after the CIP. In this case energy (and production time) is saved. Erich Brandes (Software expert, Grolsch) told me that the setpoint for the acid run can be changed quite easily. There will be no problem in making the adjustment but Erick will not alter anything until he is asked to do so by management.

Brewhouse CIP's are slightly different to the CIP sets in the bottling department. They are much bigger for a start because they are responsible for cleaning a lot of different processes. These have been designed with some overcapacity actually. The valves never open more than 70% while I observed the brewmaxx system and only for a short time before closing to below 50%. We can see from the design specifications that these CIP sets were designed to heat CIP fluid from 60 to 90 degrees. In practice these will never actually heat from 60 to 90 degrees because the tanks are filled with 85 degree product water and the contents of the tank are circulated through a heat exchanger when it drops in temperature.

Table 2 some important heat exchanger specs.

Serial No.	Purpose	Process fluid Flowrate	HTHW Flowrate	Duty	Design T. HTHW in	out	Process in	out
		(m3/hr)	(m3/hr)	(W)	(C)	(C)	(C)	(C)
s171/16584	Pasteur/warmer keggy	27	25	149740	76	70,74	69,05	74,1
s170/15938	ret. CC special waarmer	20	22	112740	75	70,49	68,97	74,1
s170/15939	ret. CC bulk waarmer	20	22	112740	75	70,49	68,97	74,1
s171/16585	bottle warmer swingtop	30	23	126980	87	82,12	81,35	85,1
s170/15926	Heater for CIP 2A-S	20	20,23	681240	115	85	60	90
s170/15927	Heater for CIP 2B-S	40	40,46	1362470	115	85	60	90
s170/15928	Heater for CIP 2C-S	50	50,58	1703090	115	85	60	90
s170/15929	Heater for CIP 2D-S	50	50,58	1703090	115	85	60	90
s170/15930	Heater for CIP 3A-S	50	50,58	1703090	115	85	60	90
s170/15931	Heater for CIP 3B-S	60	60,7	2043710	115	85	60	90
s170/15932	Heater for CIP 7A-S	30	30,35	1021850	115	85	60	90
s170/15933	Heater for CIP 7B-S	30	30,35	1021850	115	85	60	90
s170/15934	Heater for CIP 7C-S	44	44,51	1498720	115	85	60	90
s170/15935	Heater for CIP 7D-S	44	44,51	1498720	115	85	60	90
s171/16582	warmer GL plant (pasteur)	30	23	126980	87	82,12	81,35	85,1
s171/16583	warmer GL plant (pasteur)	30	23	126980	87	82,12	81,35	85,1
s171/16586	beer pasteurizer	25	27	149470	76	70,74	69,05	74,1
s170/16404	CIP Kolonne 8	25	16	484700	120	92,93	70	88
s170/16403	CIP Kolonne 7	25	16	484700	120	92,93	70	88
s170/16402	CIP Kolonne 4	25	16	484700	120	92,93	70	88
s170/16592	CIP Kolonne 2	35	37,5	596730	115	100,77	70	88
s170/17484	CIP Kolonne 5	25	16	484700	120	92,93	70	88
s170/17485	CIP Kolonne 3	25	16	484700	120	92,93	70	88
s170/21697	CIP Kolonne 6	25	16	484700	120	92,93	70	88
s169/13735	CIP Kolonne 1 section 1	5,4	5,4	293250	79	31,57	8	55
s169/13735	CIP Kolonne 1 section 2	5,4	9,4	192170	115	96,72	55	86,2

The cells which are highlighted green are the real (although maybe 70 degrees at the inlet of the exchanger is probably too low because product water is used to fill the tanks) operating temperatures for the CIP's in the bottling department. I highlighted them green because I changed the values from what is shown in the original GEA documentation. The original GEA heat exchanger manual for the brewery suggests these heat exchangers are designed to heat the CIP fluid from 47 to 64 degrees. This allows about 17 degrees of heating when using water at 115 degrees, however the valves and exchanger system has been designed with a slight overcapacity. It is also possible to increase pumping power in the brewery to gain extra heat transfer in the heat exchangers.

From a flashback file made by Erich Brandes (Software expert, Grolsch) it was possible to further examine the valve % (controlling the HTHW flow through the heat exchanger) open position while running a full CIP on Kolonne 8. Also, as it is KL08 which is close to the end of the production line, the HTHW temperature is lower than when it left the utilities building. It can be seen that the valve position for the HTHW supply is open 100% for the first 7 minutes of the caustic and then drops steadily to about 8% and is never opened more than 25 % for the rest of the CIP cycle. I believe the initial 7 minutes at 100% is used to heat the filler to temperature (the 7 minutes is programmed into the PLC's of the machines but I am not sure that it is necessary to keep the valve open for 7 minutes exactly to heat up the filler), after this point has been reached very little heating energy is required because there is so much residual energy stored in the filler itself. Also the temperature of the fluid leaving the filler continues to increase above 90 degrees as the CIP continues even with the valve closed below 25%.In reality as the CIP Tank is filled with 85 degree product water, the heat exchangers here should never have to heat CIP fluid from below 80 degrees because the tanks are filled just before the CIP begins. I have assumed the heat exchanger will never have to raise the temperature of the CIP fluid more than 18 degrees Celsius (from 70 degrees to 88 degrees Celsius). Although like I mentioned already this is probably an over estimate to make. In reality it will be something closer to 80-88 degrees.

I got a quotation (in the computer folder I prepared) from GEA for how expensive it would be to increase the number of plates of all the heat exchangers in the brewery so that the HTHW temperature could be reduced by about 5 degrees. This came to around 10,000 euro. It is possible to simply open valves further or increase pumping speed but then the average temperature in the pipes will increase and more energy losses will occur. If the plates are increased then there will be increased money savings due to the decrease in heat losses.

If the time taken to heat up the fillers increases with lower temperature HTHW then it is possible to add plates only to the heat exchangers on the filler lines.

3.4 Bottle washers

The bottle washers in the Grolsch brewery use a lot of thermal energy when they are running.The following table contains some important technical data taken from the manual of the bottle washers here in the brewery.

Table 3 Bottle washer specs.

Bottle Washer		
Voltage	(V)	400/230
Electrical Frequency	(Hz)	50
Power during production	(kW)	347
Water during production	(m3/hr)	19,4
Heating energy at start-up	(kWh)	7.822

Grolsch could also potentially lower the set point temperature of the baths to 80 degrees like in the Bavaria brewery as is shown in the following diagram.

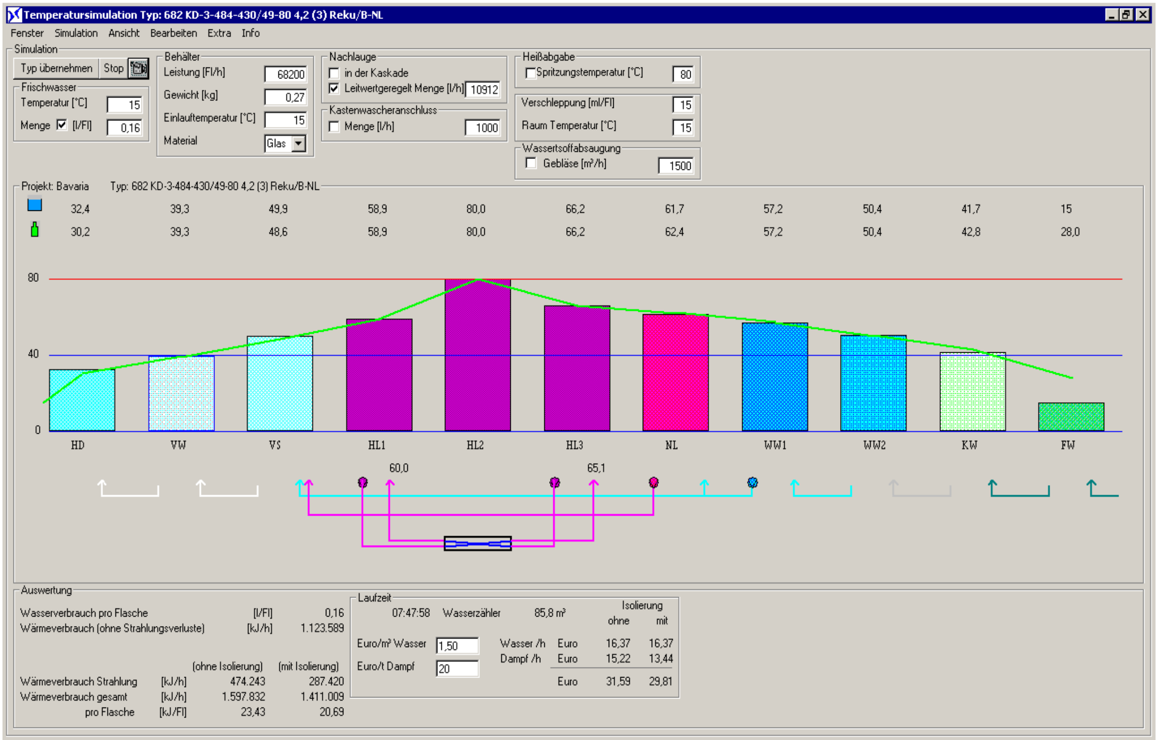


Figure 4 Bavaria's bottle washer thermal data

It is also stated in the Kunze technology of Brewing and Malting book (pg. 456) that temperatures between 60 and 85 degrees should be used. The temperature of the bottle washer may be reduced as long as the caustic concentration is increased. The book suggests that a 50% increase in concentration has the same cleaning effect as increasing the temperature by 5.5 degrees. However it must be kept in mind the more caustic used, the more polluting is the stream to the drain. This will cause some extra loading for the waste water treatment facility which could cost more energy in the long term (I did not have time to calculate the extra energy required in the waste water treatment facility).

It is also an option to change nothing with the bottle washer except the temperature of the entering HTHW. Reducing the temperature of the HTHW alone will have the effect of increasing the bottle washers heating up time (7.822 kWh is needed to heat the water baths initially). Since the bottle washers and pasteurizers are generally only shut down at the weekend and restarted for the weeks brewing it is possible that longer heating up times do not cause any major problems.The simplest conclusion to make is: If the bottle washer will take 10 minutes extra to heat up, the operators can start the machine 10 minutes earlier after the weekend.

4 Separate areas and processes using the HTHW system examined

In performing this study the distribution diagram was used to help locate all the relevant processes for the assignment. The following chapter looks at each area of the brewery which is connected to the HTHW system. There are a lot of similarities in the brewery with much of the areas working in exactly the same manner as others. This is especially true with the different production lines. I have tried to avoid repeating myself as much as possible in these cases.

The entire system which is connected to the HTHW supply can be seen in the distribution diagram on the following page. For a clearer representation the PDF and e-drawings may be found on sharepoint under the name "Distributie diagram".

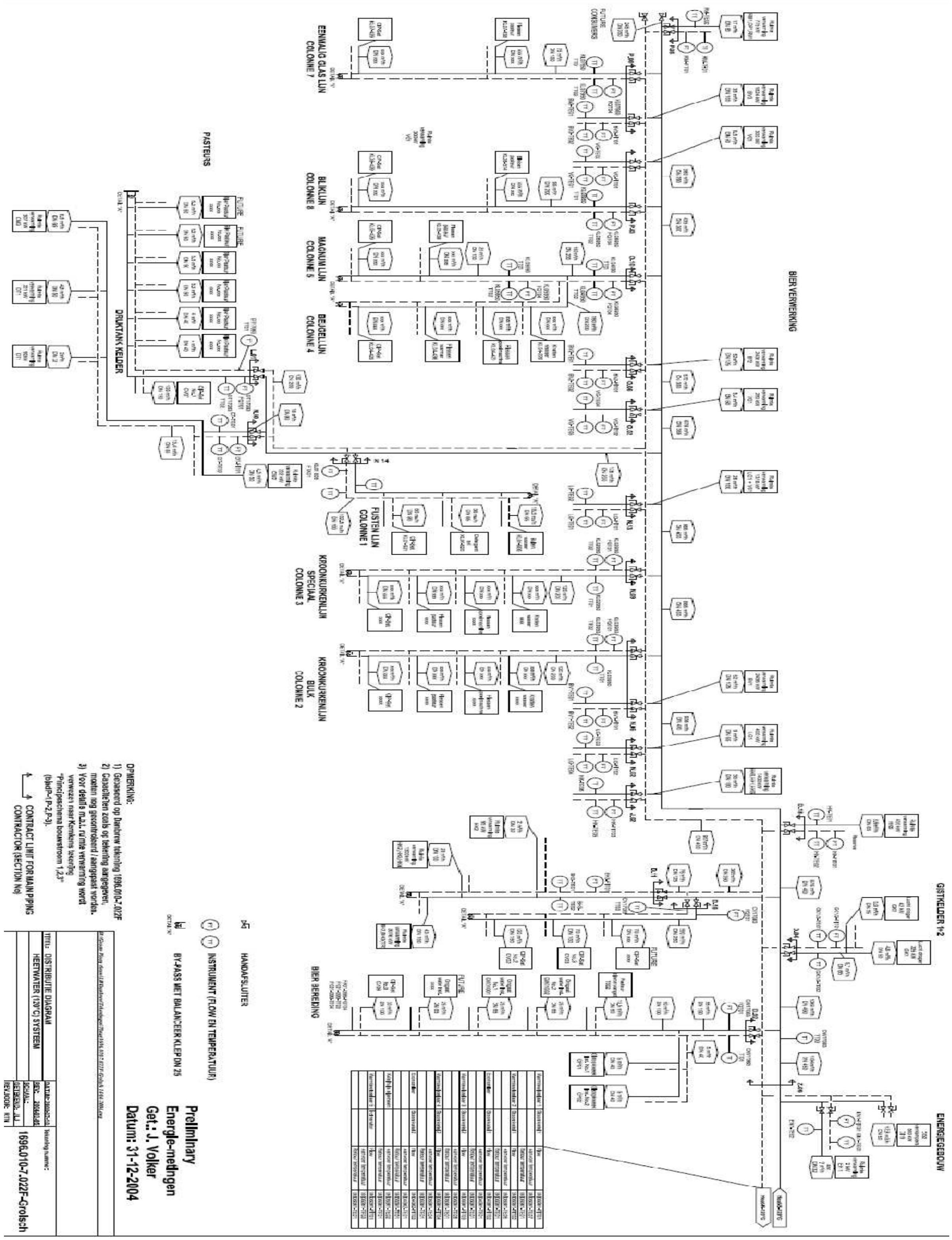


Figure 5 HTHW distribution diagram

4.1 Energiegebouw

4.1.1 CO2 Verdamping

The CO2 is evaporated using warm (but not hot) glycol coming from the air compressor. In case there is no warm glycol coming from the air compressor, 85 degree product water can be used. There is also a connection for HTHW to be used although it is very unlikely there is any need. This is certainly not a critical process.

4.2 Bier Bereiding

4.2.1 Ontgast water installation

The degassed water installation is set up similar to the CO2 evaporator, warm glycol or hot product water at 85 degrees can used, but there is a HTHW connection for special cases when glycol or hot product water are unavailable. There are 2 water degassers in the Filter cellar side by side.

4.2.2 Degassed water Pasteur

There are also another 2 pasteurizers in the filter cellar which are used for pasteurizing the degassed water. I was unable to find much information about these but I think it is safe to assume they also have some overcapacity like the other flash pasteurizers in the brewery.

4.3 Gist Kelder

4.3.1 Lucht Drogers

I called the manufacturers of the air dryers (Munters) to see would we have any problems when we reduce the temperature of the HTHW. I was told the running time will increase by a couple of % depending on how much the delta T is lowered. For example if it takes one hour to reach set point using HTHW at 107 degrees then it might take one hour and 5 minutes to reach the set point with HTHW at 104 degrees. I spoke with Gerard and Erick Zwiers about the air dryers and they said it will not be a problem. Once the set-point is reached it is easy to maintain it as long as the doors are not being opened very frequently etc. to allow in outside air.

4.4 Brewhouse

4.4.1 CIP set 1A and 1B

CIP sets 1A and 1B which are used to clean the brewhouse and wort pipes do not use HTHW. The storage tanks are filled using 85 degree product water and the heat exchanger which is used to raise the temperature by a couple of degrees (when taking fluid from the storage tanks to CIP location) uses steam on the hot side.

4.4.2 Yeast propagation

I spoke with Juriaan Jansen (Process engineer, Grolsch) about this area and he told me that the HTHW is no longer used. The HTHW is only used to heat the wort to ensure it is free of bacteria etc.. The original design of the plant was such that wort after it has been cooled in the wort cooler was used to propagate the yeast. Juriaan told me that they now take hot wort before it goes through the wort cooler. This is more energy efficient and also guarantees there is no contamination before it reaches the yeast.

4.5 Bier Verwerking

In this chapter I try not to repeat any information because there are so many similarities in the lines that there is no need.

4.5.1 Kolonne 1

4.5.1.1 Keg washer

The keg washer will not be any problem because like the crate washers the temperatures are quite low.

4.5.1.2 CIP

The CIP sets have been dealt with in the beginning of this report when I examined the energy intensive processes in more detail. These heat exchangers are small but since the amount of heat transfer necessary is not huge (tanks filled with 85 degree product water) so I don't expect there to be problems. But in the event that the temperature of the HTHW is lowered further than it already is now, say below 104 and the exit temperature from the heat exchanger is too low it is very easy to add some extra plates to these exchangers.

4.5.2 Kolonne 2

4.5.2.1 Tunnel pasteurizer

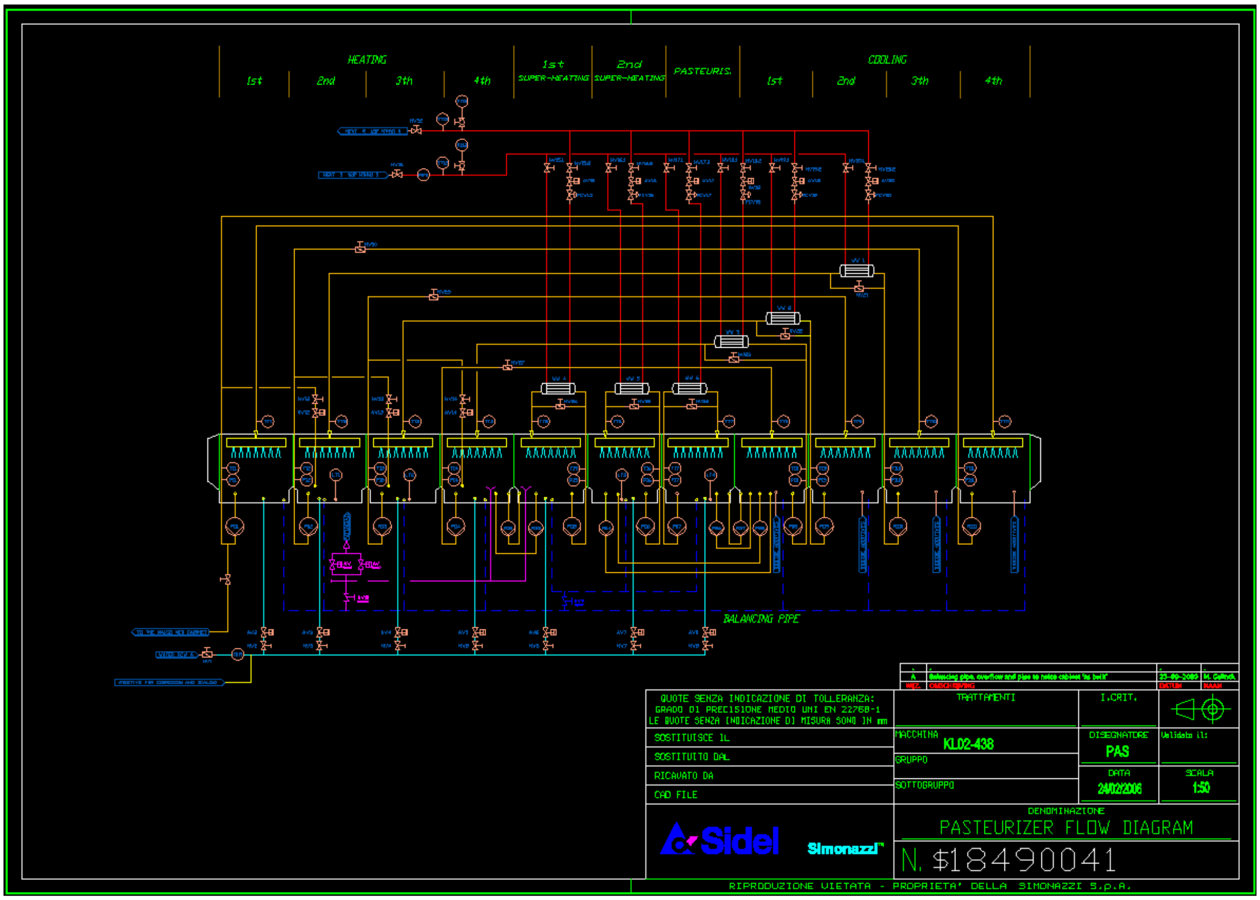


Figure 6 Pasteurizer flow diagram

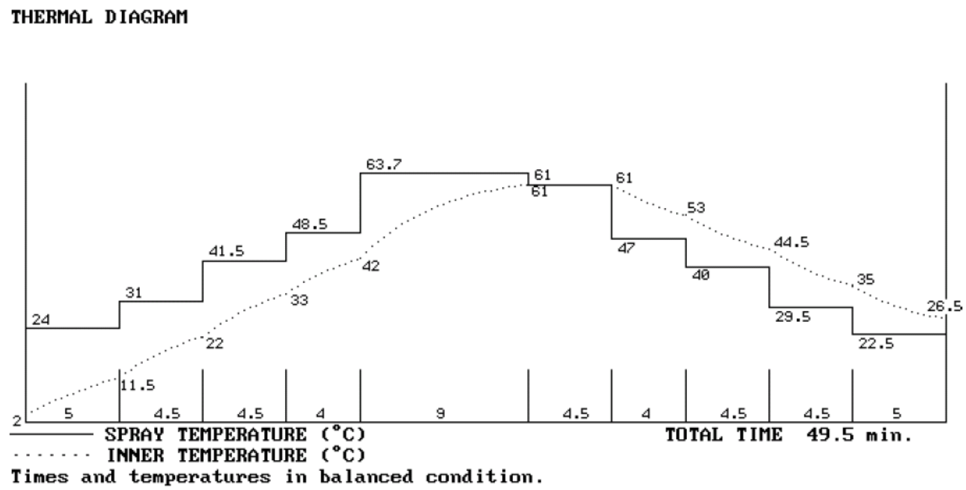


Figure 7 Pasteurizer thermal diagram

The 2 previos diagrams show the flow scheme of the pasteurizers and the thermal profile within the pasteurizer respectively. We can see the large amount of heat recovery and also the relatively low temperature of the warmest baths in the pasteurizers. I will not go into any more detail in this section because it has been covered sufficiently in section 3, as I said these require much less energy after the baths have been heated to temperature.

4.5.3 Kolonne 3

4.5.3.1 CIP set

I have dealt with CIP sets on the production lines in much more detail in the previous chapter.

4.5.4 Kolonne 4

4.5.4.1 Flessen Warmer

All the bottle warmers only need to heat the bottles to about 40 degrees Celsius, there will certainly be no problems here if we reduce the temperature of the HTHW by a couple of degrees.

4.5.4.2 Kraiten Wasser

These machines require very little energy anyway but in this case waste heat taken from the bottle washers exit stream can be used. This will certainly not cause any problems

4.5.4.3 Flessen spoelmachine

The bottle washers have been investigated in more detail in the previous chapter. Power requirements are much lower than start up after the machines baths have been heated. In the case of baths taking longer to heat up, operators can simply begin the machines earlier.

4.5.5 Kolonne 5

There is nothing new in this line so there is no need to repeat information.

4.5.6 Kolonne 6

The equipment in this line is slightly different from other lines. The Cheersch line fills the containers and then adds a special nozzle system. None of the specialized equipment in this area requires high energy HTHW.
Any equipment which does use the HTHW has already been covered in the other lines.

4.5.7 Kolonne 7

There is no new equipment to discuss in this line.

4.5.8 Kolonne 8

There is no new equipment to discuss in line 8. The only difference here is the can pasteurizer rather than a bottle pasteurizer which has a slightly different operating temperature.

4.6 Druktank Kelder

4.6.1 Pasteurs

These are very large heat exchangers with 3 sections. Not like tunnel Pasteur (internal heat exchangers and flow control valves). The have a heating section, a cooling section, and in the center a regeneration section with a lot of plates so as to recover as much heat as possible. These have also been designed with a large overcapacity in the plates and the control valves associated with these systems. These have been discussed in more detail in chapter 3.

4.7 HTHW Temperature Reduction Conclusion

The temperature of the HTHW does not necessarily need to be reduced further than it already has been because according to the legislation if the equipment is only in contact with fluid at a temperature which is below 110 degrees Celsius then the brewery is responsible for the safety of the equipment. There is no need to pay external companies to perform the checks and disrupt production. However it is important to note that water shortage safety devices and maximum temperature safety devices must be installed before these items of equipment can be removed from the external audit system.

It is also possible to reduce the temperature of the HTHW even further which will have the effect of lowering energy losses in distribution. The plate heat exchangers can be expanded in the brewery as long as the pumps have an overcapacity which we believe they do. Although it is probably not necessary to lower the temperature further than it already is. It is possible that the temperature can be reduced by another 1 or 2 degrees because of the overcapacity already existing in the brewery (opening valves or increasing pumping power) but this will not result in energy savings.

5 Savings resulting from the reduction of brewery HTHW temperature

5.1 Savings due to reduced pressure equipment checks

Gerard Groote Punt (Gist Kelder, Grolsch) helped me find the details on the Energieconsultie website. There is a large list of equipment which must be checked. The list also explains if the equipment in question should be checked from anywhere between 2 and 6 years. Jaap Profijt helped me distinguish between all the types of equipment listed so I could list only the equipment which will be removed from the safety check system after the temperature of the HTHW is reduced below 110 degrees and the necessary changes have been made to the supply system.

Since it is 450 euro per check of each piece of equipment I was able to estimate a price per year for each piece of equipment depending on the frequency of the checks. For example If a piece of equipment needs to be checked every 2 years then I assume it will cost Grolsch 225 euro per year etc.

From this calculation I was able to conclude that Grolsch will save 2887 euro per year on these checks whan the equipment has been removed from the system. Of course savings will be much greater when you consider the time production will no longer have to be stopped.

5.2 Savings due to reduced energy losses in transmission

The amount of energy lost while transporting a hot gas/fluid through a pipe system is directly proportional to temperature difference between the fluid and the surrounding air. Reducing the temperature difference or Insulating pipes has the effect of reducing these energy losses. The HTHW pipes in the brewery are all fitted with type I insulation. This is made up of mineral wool and comes in prefabricated cubs which differ in size depending on the size of the pipe they will insulate. Insulation can only reduce energy losses from a hot pipe, it cannot completely eliminate them. After making some simplifying assumptions I was able to estimate the total amount of energy lost at 120 and at 104 degrees respectively. From the difference in losses it was possible to calculate the amount of money saved in losses by reducing the temperature of the HTHW stream in the brewery. Also because a certain amount of gas was not burned I was able to calculate the savings on carbon emissions:

Table 4 Heat flow equations

TABLE 3.3 One-dimensional, steady-state solutions to the heat equation with no generation

	Plane Wall	Cylindrical Wall[a]	Spherical Wall[a]
Heat equation	$\frac{d^2T}{dx^2} = 0$	$\frac{1}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right) = 0$	$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{dT}{dr}\right) = 0$
Temperature distribution	$T_{s,1} - \Delta T\frac{x}{L}$	$T_{s,2} + \Delta T\frac{\ln(r/r_2)}{\ln(r_1/r_2)}$	$T_{s,1} - \Delta T\left[\frac{1-(r_1/r)}{1-(r_1/r_2)}\right]$
Heat flux (q'')	$k\frac{\Delta T}{L}$	$\frac{k\,\Delta T}{r\ln(r_2/r_1)}$	$\frac{k\,\Delta T}{r^2[(1/r_1)-(1/r_2)]}$
Heat rate (q)	$kA\frac{\Delta T}{L}$	$\frac{2\pi Lk\,\Delta T}{\ln(r_2/r_1)}$	$\frac{4\pi k\,\Delta T}{(1/r_1)-(1/r_2)}$
Thermal resistance ($R_{t,cond}$)	$\frac{L}{kA}$	$\frac{\ln(r_2/r_1)}{2\pi Lk}$	$\frac{(1/r_1)-(1/r_2)}{4\pi k}$

[a]The critical radius of insulation is $r_{cr} = k/h$ for the cylinder and $r_{cr} = 2k/h$ for the sphere.

To simplify the calculations some assumptions have been made:

- The main spine which is held up by the piping bridge is in total 1170 meters in length (Supply and return pipes).
- The main spine can be divided into 3 parts:

  1. The piping section which is outside or in the filter cellar (430 meters).
  2. The piping section in the Bottling area (530 meters).
  3. The piping section in the storage area (210 meters).

- The main spline has an average diameter of DN400 all the way along the pipes.
- The smaller pipelines which extrude from the main spline (inside the buildings) are in total 600 meters in length (Supply and return).
- The smaller pipes have an average diameter of DN100.
- The average temperature outdoors in the Netherlands is 9 degrees Celsius.
- The average temperature in the filter cellar is 9 degrees Celsius.
- The average temperature in the bottling area is 18 degrees Celsius.
- The average temperature in the store is 12 degrees Celsius.
- The smaller pipes are in an environment which is at an average temperature of 18 degrees Celsius (although a small fraction of the pipes are in different environments).
- The average temperature of the water in the pipes (supply and return) is 110 degrees when 120 degree water is leaving the energy utilities building.
- The average temperature of the water in the pipes (supply and return) is 107 degrees when 120 degree water is leaving the energy utilities building.
- The average temperature of the water in the pipes (supply and return) is 97 degrees when 104 degree water is leaving the energy utilities building.

With the insulation, the thermal circuit is of the form

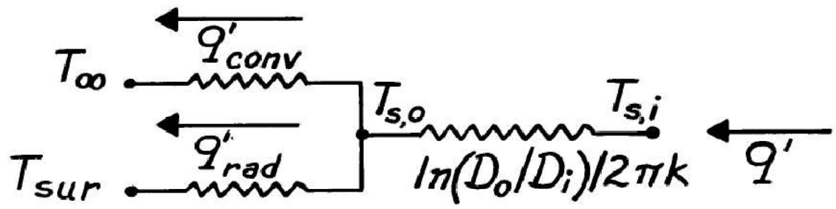


Figure 8 Heat flow diagram

The diagram above was taken from the book- “Fundamentals of heat and mass transfer” by Incropera and Dewitt. It shows that the sum of energy carried away from an insulated pipe (convection and radiation) is the same amount of energy that has been transported from the inner surface of the pipe to the outer surface via conduction. This relationship leads to the following equation:

[Equation 1]

$$\frac{2\pi k(T_{si} - T_{so})}{\ln\left(\frac{D_o}{D_i}\right)} = h\pi D_o(T_{so} - T_{ambient}) + \boldsymbol{\varepsilon\sigma\pi} D_o(T_{so}^4 - T_{ambient}^4)$$

(Conduction) = (Convection) + (Radiation)

Where:

- ε is the emissivity of the surface.
- k is the thermal conductivity of the material.

- D_o, D_i are the outer and inner diameters respectively.
- σ is the Stefan-boltzmann constant.
- Tso is the outer surface temperature of the pipe.

The emissivity (relative ability of a surface to emit energy via radiation) varies depending on the material of the outer surface of the radiating body. The emissivity of some common materials can be found at: http://www.engineeringtoolbox.com/emissivity-coefficients-d_447.html or on another website after a quick internet search.

The emissivity of the outer surface of the insulation (commercial sheet of aluminum, slightly oxidized) has been taken as 0.1 for these calculations. This is a typical value found from literature.

Table 5 Heat transfer coefficients

TABLE 1.1 Typical values of the convection heat transfer coefficient

Process	h ($W/m^2 \cdot K$)
Free convection	
Gases	2–25
Liquids	50–1000
Forced convection	
Gases	25–250
Liquids	100–20,000
Convection with phase change	
Boiling or condensation	2500–100,000

From the above table we can see that for free convection a typical value for the convection heat transfer coefficient lies somewhere between 2 and 25 W/m²K. For forced convection it can be anywhere from 25 to 250 W/m²K.
For the sake of these calculations I have assumed that when the pipes are indoors (free convection) the value for h is 5 W/m²K. In the case when the pipes are outdoors (Somewhere between free and forced convection) I assume a value of 25 W/m²K. To make a more accurate estimate of the convection heat transfer coefficient the wind speed outside the pipes should be known. I think the h values I used for the calculations are slightly conservative. In reality I imagine the h values will be slightly larger and thus the rate of heat loss from the pipes will actually be larger.

Using the above relation we can calculate the temperature of the outer surface of the pipe and thus the heat loss per meter of pipe. Any equation solver can be used to find the outer surface temperature of the pipe. For the calculations in this report an online equation solver was used. This tool can be found at:
http://www.quickmath.com/webMathematica3/quickmath/page.jsp?s1=equations&s2=solve&s3=basic

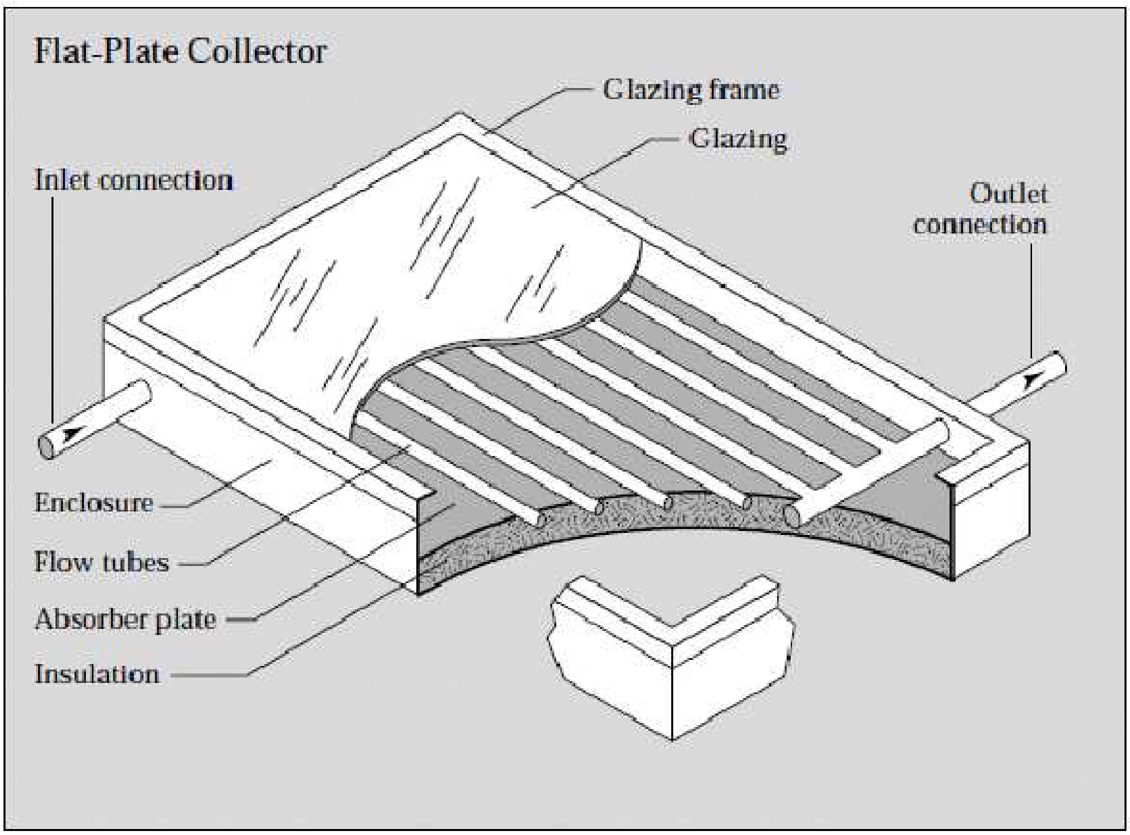
I found the amount of energy lost along all the pipes to be about 251854 Watts or 251854 Joules per second when the HTHW was at 120 degrees Celsius. When I considered the heat losses for 104 degree HTHW I found a value of 213401.14. This translates to a reduction in heat losses of about 38453 Watts. This means there is a difference of about 38.5 kJ/s when the HTHW is reduced from 120 degrees to 104 degrees. When this is converted to a value of energy losses per year we find a staggering 1212 Gigajoule saving.

Multiplying the amount of GJ saved by 9 euros to get a rough estimate of the money saved yearly because of this project gives a value of 11000 euro per year. If the average temperature in the pipes is decreased even further then more savings can be made.

6 Solar water heater on the roof of the plant

6.1 Introduction to solar water heating

There are basically 3 types of solar water heaters, flat plate, evacuated tube and concentrating.



A flat-plate collector is an insulated, weatherproofed box containing a dark absorber plate. The plate heats up and transfers the heat to the fluid flowing through tubes in or near the absorber plate.

Figure 9 Flat plate collector

The diagram below (taken from a Solahart presentation on efficiencies of different solar water heating options) shows the efficiencies of flat plate collectors (blue line), vacuum tube collectors and pool solar water heater systems. The diagram shows three different temperature zones. The pool heating zone (ΔT below 20 degrees), the domestic hot water (DHW) zone (ΔT between 30 and 60) and the process water zone (ΔT above 60 degrees).

It is very important to note that the x-axis of the graph represents the ΔT between the collector fluid and the ambient temperature outside. The graph can be used as a guideline for choosing when evacuated tube collectors (more expensive) are useful. Only at large ΔT values will evacuated tubes be an attractive option. When dealing with ΔT's of around 40 or 50 degrees Celsius the efficiency of flat plate and evacuated tubes is the same. In this case flat plates being the least expensive option (and roughly same efficiency as the flat plate collectors) should be used.

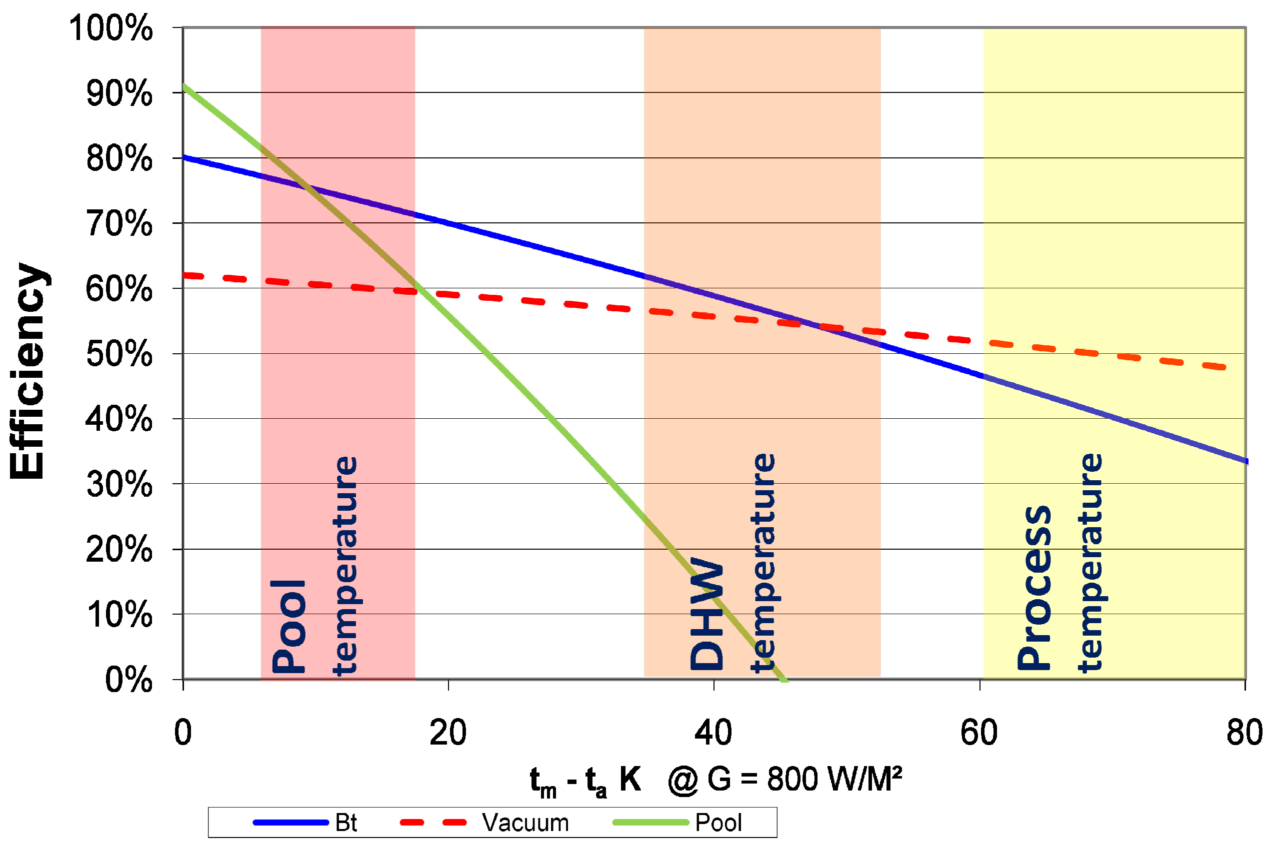
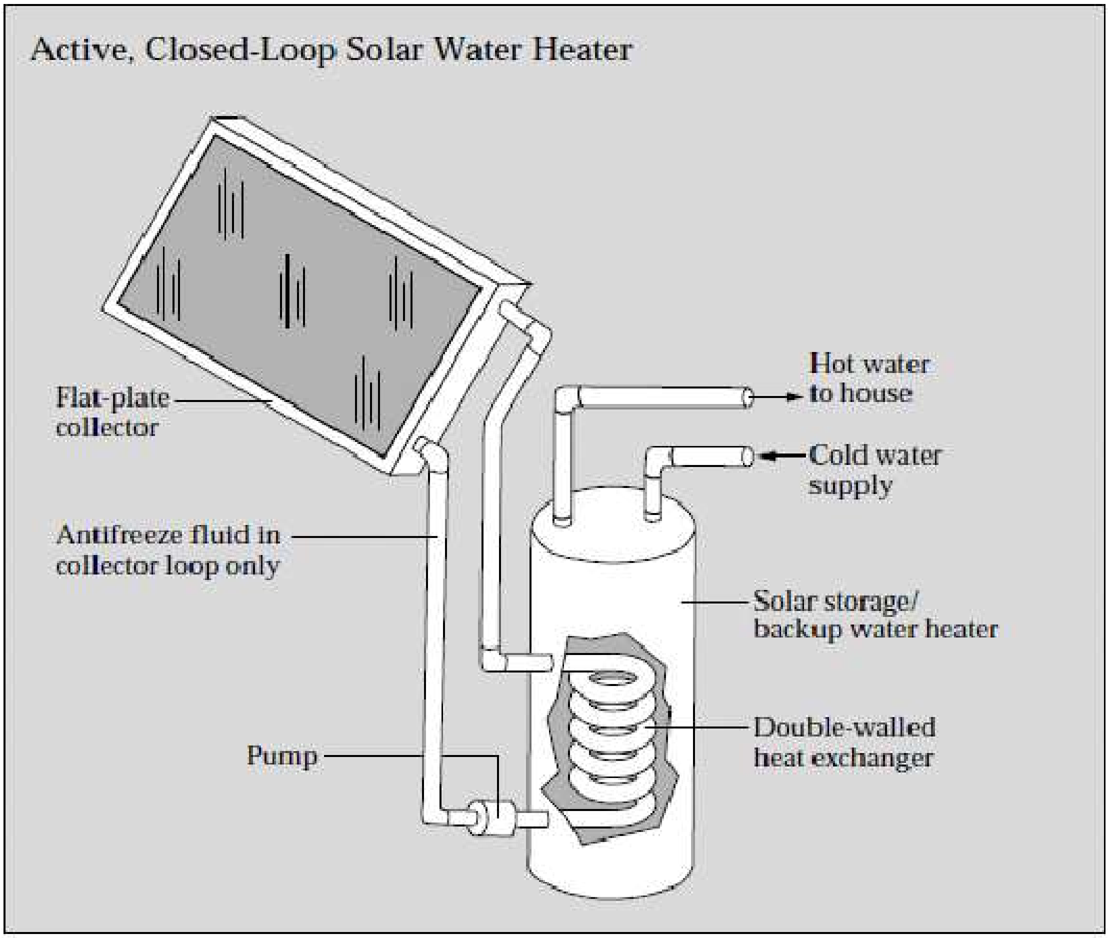


Figure 10 Efficiency of different collectors



An active, closed-loop system heats a heat-transfer fluid (such as water or antifreeze) in the collector and uses a heat exchanger to transfer the heat to the household water.

Figure 11 Flat plate collector with heat exchanger

The diagram above shows one solar thermal setup which is commonly used in single homes. In the case of heating water for the brewery the setup will be very similar, with a flat plate collector on the roof of the brewery and a plate heat exchanger in the brewery to transfer the heat to the process water.

6.2 Ecofys Netherlands

Anton Schaap from Ecofys Netherlands told me that the most impotant paramater is the desired temperature of the water. The desired temperature of the water determines the efficiency of the system and also the amount of water which can be heated per square meter of collector available.

He highlighted one example as if Grolsch was interested in producing water at 60 degrees celsius. He informed me that for a temperature of 60 degrees 1 m² of collector yields 1.5GJ per year (3/4 of which is in the "summer half" of the year). He says this translates to an average of about 20 L of hot water a day.

He also told me that it is possible to get steam from solar energy but it is more costly, and the payback ratio gets even bigger. For steam special evacuated tubes with focusing mirrors must be used.

6.3 Solahart

Rob Meesters of solahart, Europe (also the Netherlands) informed me that if we consider the general rule for solar thermal conversion an efficiency of 0.44 can be assumed (this accounts for heat losses at the collector and piping etc.)

Taking Bocholt as a reference we find a solar radiation of approximately 1000kWh per square meter of collector per year. Using the 0.44 value mentioned before as the efficiency we can estimate a useable heat energy value of 440kWh per square meter per year. This translates to a value of 1.21 kWh per square meter per day.

Taking the example of the brewery at the moment, heating product water to 85 degrees Celsius at the weekends. In the current situation plenty of 85 degree Celsius product water is being produced at the wort cooler during the week while brewing is taking place. At the weekends when the brewing has stopped, steam is used to heat water to 85 degrees and store it in the 2 large hot water storage tanks in the brewery. The tanks are filled until they reach 2000 hL and the computer automatically stops the heating process. From records in the computer system it can be seen that every weekend somewhere between 1000 and 2000 hL must be heated to 85 degrees and stored in the hot water tanks (roughly 500 to 1000 hL are needed in each tank to reach the 2000hL setpoint.

So lets assume we now want to use solar water heating to preheat the cold water at the weekends. Assume we need 1000 hL (100000 liters) and we want to heat from 15 to 25 degrees. In order to achieve this 10 degree dT we would need approximately 1166kWh. We can divide this value by 1.21 to find the area of solar collectors which would be required to produce 1166kWh in one day. From this calculation we find that approximately 960 square meter of collector surface is needed.

In the case of the evaporation rate being lowered in the future and the demand for 85 degree product water can be met using solar thermal energy all week:

Lets say we place 1000 square meters of collectors on the roof of the brewery then 1000*1.21 is 1211kWh per day. Multiplying by 3600 we find that there is 4359600 kJ of energy available every day for this 1000 m² collector system.

Say we want to heat the water from 15 to 45 degrees in this case, taking the specific heat capacity of water to be 4.18 kJ/kg-K, we find 34765 kg of water can be heated by 30 degrees Celsius every day with 1000 m² of collector plates.

This translates to 34765 L of 45 degree water
Or 34.7 m³
Or 347 hL per day

Cost indication for 1000m2 collectors including frames as estimated by Rob Meesters.

For 1000M2 of collector surface we need about 520 collectors. this is 65 fields of 8 collectors.

The delivered cost for the collector field including frames to place the collectors on a flat roof or field is:

€ 235000,-

For instalaltion cost and piping with insulation you have to think at about the same amount.
So totally you have to think in the direction of €450000 to €470000. This is just an indicative price level.

For the payback it depends on your cost of gas. With 1000 square meters of collector surface you can save about 440000kWh per year on energy.

6.2 Genersys

Genersys and future heating in England simulated a system for Grolsch at a value of 150,000 pounds. The system can be seen in the diagram below. This system assumes that Grolsch wants 10m³ of water at 70 degrees Celsius every day. The simulation estimates the percentage of energy out of the total required which can be delivered by the sun so that 10 m³ can be delivered every day using an auxiliary gas condensing boiler when needed. The following graph shows the energy distribution over the course of the year. [The full report can also be found in the folder I provided on USB stick.]

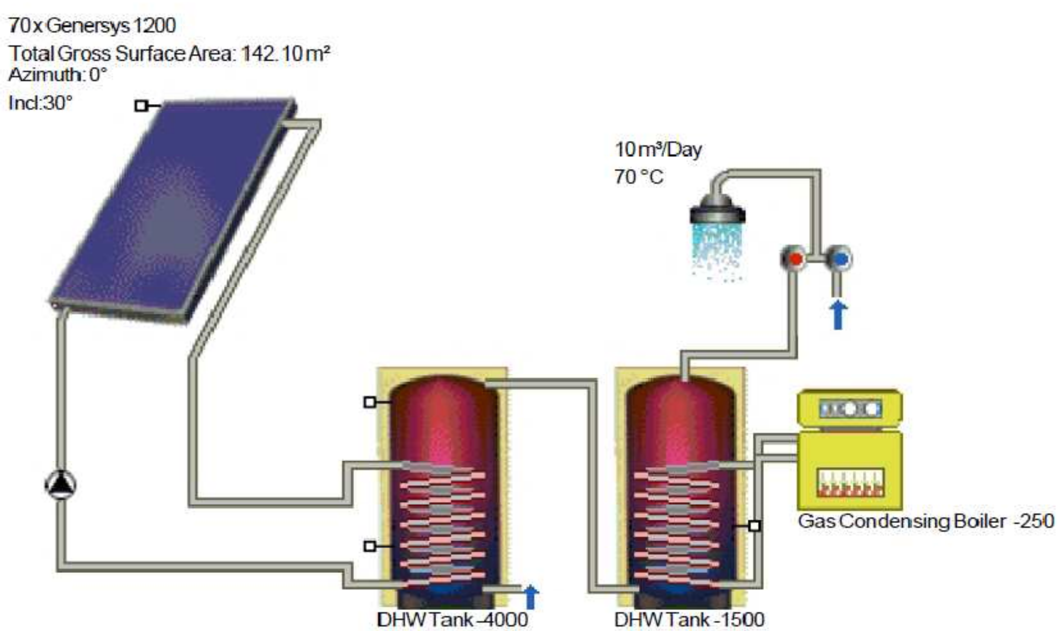


Figure 12 Genersys system

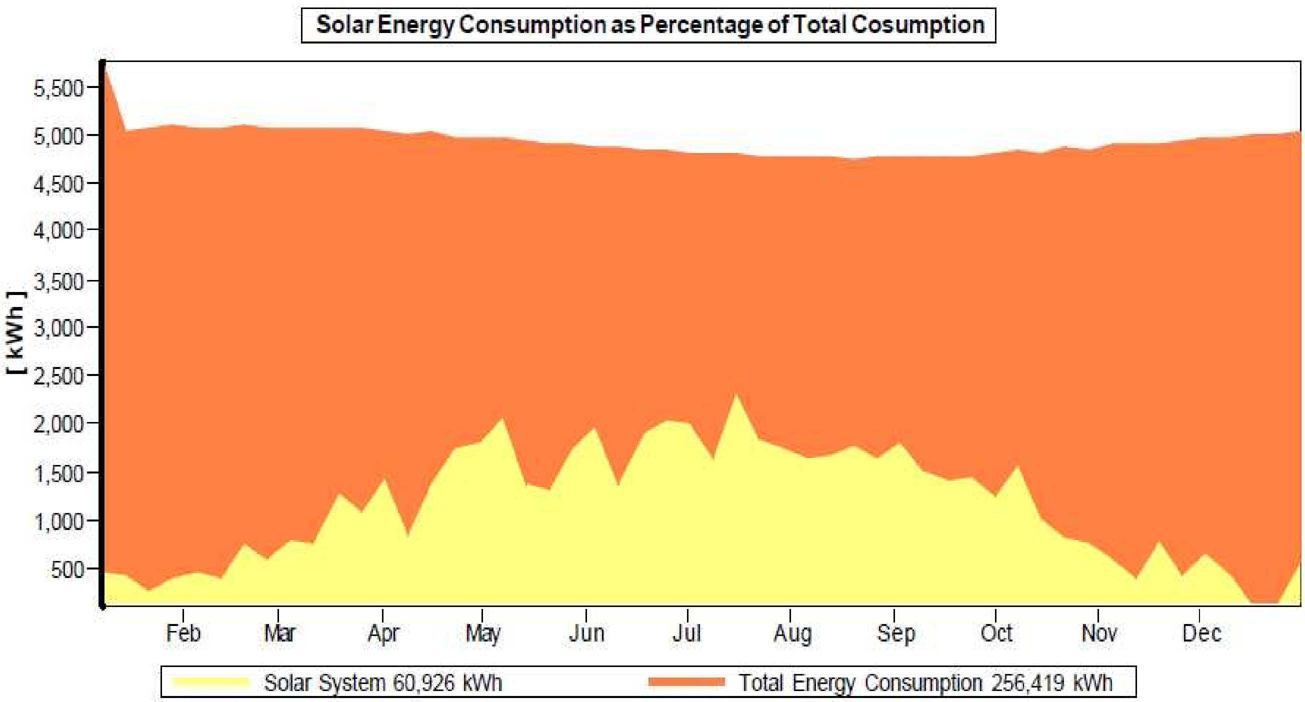


Figure 13 Solar contribution graph

The simulation estimates:

256.4 MWh are needed yearly.
60.93 MWh can be provided by solar energy.
195.49 MWh must be provided by gas.

7321.7 m³ of gas saved yearly.
15482.66 kg of CO2 emmisions saved yearly.

24.2% is the fraction of energy saved due to solar.
45.7% is the overall System efficiency.

This looks interesting at first glance but it must be noted that the simulation only considers the case of heating 10 m³ of water. The fraction of energy saved due to solar gets a lot smaller when you consider the case of heating 10000 to 15000 hL as would be the case in the Grolsch brewery (85 degree water requirements per day) if the evaporation rate in the brewhouse is reduced.

6.3 Insulation issues

In the case that solar collectors will be put on the roof of the brewery facing south (which is the best option) some modifications would need to be made to the roof. From a conversation with Mr. Buffinga in Kooy Insulatie it is apparent that no weight should be put directly on the insulation. The insulation is not designed to withstand more than a couple of cm of rain. One option is to place the collectors on the ground in the surrounding area. Another option is to have a metal frame made to suspend the collectors above the insulation. The cost of such a system is unkown but it can be sure to increase the expected payback period slightly. Solar collector manufacturers generally don't design frames for their collectors ask for customers to organize the metal framework from another supplier.

Figure 14 Picture of frame support for panels

6.4 Solar water heating conclusions

I believe flat plate is the best option when considering the case in Grolsch. Looking at the example of the Genersys simulation which was made for Grolsch we can see 150, 000 pounds will roughly account for 142 m² of collector surface. The simulation here was done using a detailed weather profile (UK) similar to the Netherlands profile. The Genersys simulation shows the amount of energy to produce 10 m³ (100 hL) of 70 degree Celsius water every day.

I think the results obtained from Genersys and Rob Meesters in Solahart are very similar in nature and show the credibility of both companies' efforts to provide an estimate for this feasibility study.Rob Meesters uses an efficiency of 44% which is close to the 45% in the simulation made by Genersys.

Also if you take rob Meesters average value of 1.21 kWh per day per square meter of collector for the Genersys system which is approx 140 square meters.

1.21 kWh * 142 m² = 171.82 kWh per day
171.82 kWh/day * 365 = 62714 kWh = 62 MWh per year

I believe the extra 2 MWh in Rob Meesters calculations can be explained by the fact that Genersys used a British weather profile while Rob uses a German profile for Bocholt which is relatively close to Enschede.

The calculation above allows me confidence in Rob Meesters assumption of 1.21 kWh per day per square meter of collector. I will use this assumption for the following calculations.

Assumptions:

- Cold water in the brewery is always at 12 degrees Celsius.
- 1 m² of collector will provide 1.21 kWh per day.
- 4.18 kJ/kgK is always the specific heat capacity of water.
- 11000 hL 85 degree water are used on average every day

The following excel sheet shows some estimates I have made for different design cases which might be interesting for Grolsch.

Table 6 Savings per square meter of solar collectors

Surface Area (m2)	100	150	200	250	300	1000
kWh per day	121	181,5	242	302,5	363	1210
kWh per year	44165	66247,5	88330	110412,5	132495	441650
Gas savings (m3)	5306,875834	7960,313752	10613,75167	13267,18959	15920,6275	53068,75834
CO2 savings (kg)	11224,04239	16836,06358	22448,08478	28060,10597	33672,12717	112240,4239
Gas savings (Euros/yr)	1523,073364	2284,610047	3046,146729	3807,683411	4569,220093	15230,73364
ΔT	73	73	73	73	73	73
Volume required	11000	11000	11000	11000	11000	11000
Required kWh	34031586,11	34031586,11	34031586,11	34031586,11	34031586,11	34031586,11
Aux. kWh needed	33987421,11	33965338,61	33943256,11	33921173,61	33899091,11	33589936,11
% saved with solar	0,001297765	0,001946647	0,00259553	0,003244412	0,003893295	0,01297765

To calculate the required amount of kWh for each volume of water and ΔT considered I simply multiply the specific heat capacity (kJ/kg-K) of water by the mass of the water to be heated and the amount of degrees temperature rise (ΔT) needed then divide by 3600 to convert kJ to kWh.

I have also assumed the values in the Genersys report for converting MWh used to m³of gas is accurate. This value will depend on the efficiency of the boiler used. For these calculations I assume it is a good assumption and calculate the amount of m³ gas saved in each scenario along with the CO² emissions saved. In this case 29.96 MJ/m³ is the value used by Genersys. I know Natural gas is taken to have 35-47 MJ/ m³ in literature but when boiler/pipe efficiency etc. is taken into account it must drop to about 29 useful MJ as the Genersys computer simulation has calculated. They also take it as being 2.115 kg of CO² for every m³ which is about the same as the values quoted in literature.In previous calculations I have kept the volume of water needed constant at 11000 hL. As it's clear from the table a very large area of solar collectors would be needed to provide the breweries total needs of 85 degree water. However some energy savings can be made with any amount. The larger the surface area the larger the energy savings will be of course. As the required ΔT of the water or the required volume of water increases so does the overall required thermal energy. However the available energy remains roughly the same unless the surface area of collectors is increased.

The expected lifetime of a system is expected to be over 20 years. However having made a quick calculation on the simulation produced by Genersys in the UK which describes a system with 142 m² (£150,000) collector area:

- Solar contribution: 60.93 MWh per year.
- Natural gas savings: 7321 m³ per year.
- CO² emissions avoided: 15482 kg per year.

At the Grolsch brewery gas price of € 0.278 per m³ there is only a saving of € 2035 per year. With the solar project costing £150,000 or more and with a lifetime of 20-30 years it would make no sense to invest in the project.

Say for example Grolsch is interested in producing all its 85 degree water with solar energy, then to raise 11000 hL of water by 73 degrees requires 335654000 kJ of energy or 93237,22 kWh.

Such a project might get interesting with government subsidies. Subsidy options are dealt with further in the next chapter of this report.

8. Subsidy Information

8.1 Tax related subsidies

When a company invests in a solar collector system they can think about the EIA (Energy Investment Allowance).

This tax relief programme gives a direct financial advantage to Dutch companies that invest in energy-saving equipment and sustainable energy. Entrepreneurs may deduct 44% of the investment costs for such equipment (purchase and/or production costs) from their company's fiscal profit, over the calendar year in which the equipment was purchased. Investment costs up to a maximum of EUR 113 million may be reported per calendar year.

The Energy List determines which types of equipment qualify for this programme.
The EIA scheme also includes the costs of obtaining energy advice, provided that the advice results in an investment in energy-saving equipment. You should report your investments to 'Bureau Investeringsregelingen en Willekeurige afschrijving (IRWA)' in Breda within three months of ordering these corporate assets. Solar collector systems are indeed on the energy list 2010.

The Netherlands government supports the expansion of solar thermal resources. The Energy Investment Allowance (EIA) programme for entrepreneurs in the Netherlands supports sustainable energy and energy-efficient technologies since 1997.

The following table highlights some important details from the EIA programme.

Table 7 EIA programme

Country / region	The Netherlands
Name of programme	Energy Investment Allowance (EIA)
Type of incentive	Tax credit for entrepreneurs
Eligible technologies	All kind of sustainable energy and other, e.g., energy-efficient technologies
Applicable sectors	• corporate buildings • processes • transport resources
Amount	Income or corporate tax deduction of 44 % of investment costs
Maximum incentive	The maximum incentive depends on the system's size, therefore differing from applicant to applicant
Requirements for system	Companies applying for EIA must be in possession of a valid environmental permit.
Requirements for installation	Application form to be sent within three month after purchase was made
Finance provider	Ministry of Finance and Economic Affairs (EZ) and The Belastingdienst (Dutch tax authorities)
Total funds	EUR 113 million (only for solar thermal technology)
Effective date	1997
Expiration date	No expiration date
Website	http://regelingen.agentschapnl.nl/content/brochure-energy-and-companies-energy-list-2010
Last review of this tabloid	October 2010
Contact	Helpdesk AgentschapNL EIA Postbus 10073, 8000 GB Zwolle Tel: +31/88 602 2430 Fax: +31/88 6029022 E-mail: eia@agentschapnl.nl

The tax-related subsidies are on:
- energy savings (EIA): 44%
- environmental (MIA) 20 -40 %

This means, when an investment is accepted, you may deduct an extra amount, equal to 44% of the investment amount, from your corporate profit.
The corporate profit (Vpb, Vennootschapsbelasting) in the Netherlands is taxed on 25,5% (2010, 25% 2011).

Calculation example
The fiscal profit for 2010 amounts to € 500,000. Corporation tax is 20% over the first level (up to € 200,000) and 25.5% above € 200,000.
You invest in energy-saving assets valued at € 300,000. The EIA amounts to 44% of €300,000, which is € 132,000. Your fiscal profit is now € 368,000 (€ 500,000 - € 132,000). Without EIA you would pay € 116,500 in corporation tax. By using the EIA scheme you pay just € 82,840 in corporation tax. Your direct fiscal advantage is thus € 33,660. The net EIA advantage is around 11%.

Unfortunately due to the fact that Grolsch has been taken over by SABMiller, in the coming years no fiscal profit is foreseen. So Grolsch theoretically don't pay tax and therefore cannot claim taxrefunds on corporation tax from the government.

An alternative way to use the tax-benefits of the EIA, is a financial lease construction. Financial lease is a way to finance your investments: a lease company buys the equipment and you pay a monthly/yearly fee for it, during a certain period. Afterwards you own the equipment The lease company can use the tax-advantage. The fee will be lower due to the tax advantage. The total costs might be higher, since the lease company also wants to make a profit. It should be calculated if the lease construction with tax advantages is lower than buying the equipment yourselves without the tax advantage.

8.2 Subsidies unrelated to profit or tax

Alex Bulten (SubVice, the subsidy consultant for Grolsch) told me that there are certain agencies which will still grant subsidies to Grolsch and it will be unrelated to taxes. The money is directly paid to Grolsch for the sustainable development project.
Since the use of solar water heating for process water purposes is relatively new in the Netherlands, there are some possibilities. For example, in 2010 the Province Overijssel had a subsidy program on sustainable energy and energy saving (Subsidieregeling Duurzame energie en energiebesparing Overijssel). Besides endorsing feasibility studies the program also endorse investments for energy savings in industry.
It is not yet known if this program will be open for 2011.

Alex told me that research and development can be subsidized in this manner. In that case any hour spent researching certain sustainable projects such as the HTHW temperature reduction project and the solar thermal water heating project which were the main themes of my assignment in Grolsch. Each hour of research and development spent on these topics warrants a subsidy of 22.50 euro regardless of the wage paid to the employee doing the research.

9. Appendices