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What are the economic consequences of heat stress and how much does it cost to prevent it?

IN COOPERATION WITH ARTEX BARN SOLUTIONS
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''In Cooperation with Artex Barn Solutions''

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Prologue

This thesis has been written by Stefan van ‘t Ooster a undergraduate (BSc) in Agricultural Entrepreneurship, Animal Husbandry on the Aeres University of Applied Sciences based in Dronten, The Netherlands.

The thesis subject: What are the economic consequences of heat stress and how much does it cost to prevent it? is a co-op question between Artex Barn Solutions and Stefan himself to know what the economic consequences from heat stress are and what the cost are to prevent it.

Special thanks go out to John Fleming and Dan Veeneman from Artex Barn Solutions for helping with the process of making this thesis by evaluating the results and having great discussions. I also want to thank my graduation teacher Jan van Beekhuizen for giving great feedback on my concept versions of my thesis which I found helpful during the process. My last thanks go out to the Artex Barn Solutions team for giving me a wonderful internship, which I absolutely enjoyed.

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Abstract

Animal welfare has a high importance this day and age. In 1998 the 'Five freedoms' of Brambell have been put in the European law. Thermal comfort for dairy cows is in these five freedoms and so thermal discomfort must be avoided. Heat stress affects animal welfare, milk-production, udder-health and reproduction and has economic consequences for the dairy farmers. For that reason, heat stress must be prevented. That is why the main question of this study is: *What are the economic consequences of heat stress and how much does it cost to prevent it?*

Through a literature study the sub-questions has been answered. With the following results: In an oceanic climate there is an average chance of 117 days of heat stress with threshold- and mild heat stress. Which could also be higher during a warmer season (138d) with more mild stress or lower during a colder season (64d) with less mild stress. The economic effects on milk-production losses were highly affected by high levels of heat stress. A warmer season had €16.784 loss this is double compared to the average year with €8.315. A colder season had €2.614 loss. The same was indicated for conception rates, the warmer the more damage. A warmer season had €10.212 loss, but the average only had €2.381 while a colder season didn't have effect. Udder-health is affected by heat stress but didn't give economic effect on an average somatic cell count.

The cost of heat stress prevention has been calculated for roof insulation and two mechanical ventilation systems. Roof Insulation was the most expensive in investment but didn't had operational cost which mechanical ventilation had. With a break-even point analyses these three investments had been analyzed on profitability. With a warmer- and an average season both the mechanical ventilation system were the first go break-even (0,5 vs. 2 yr.). Roof insulation took longer (1,5 vs. 4 yr.). But on a colder year all the investment didn't go break-even within ten years.

With the results of the sub-questions this study gives dairy farmers several standardized indicators for the economic consequences of heat stress and what it could cost to prevent it. Indicators because every dairy herd/barn is different and dairy farmers should first evaluate if their barn is suited against heat and what kind of herd they have. Consider the economic consequences and after that invest in heat stress prevention, to increase animal welfare and profitability.

Samenvatting

In deze tijd is dierenwelzijn een belangrijk onderwerp. In 1998 werden de 'vijf vrijheden' van Brambell geïntroduceerd in de Europese wetgeving. Thermisch comfort is één van deze vrijheden en daarmee moet thermisch discomfort worden vermeden. Hittestress is nadelig voor het dierenwelzijn maar ook voor de melkproductie, uiergezondheid en de reproductie en heeft daarmee economische consequenties voor de melkveehouder. Daarom is de hoofdvraag van dit onderzoek: *Wat zijn de economische consequenties van hittestress en hoeveel kost het om deze te voorkomen?*

Dankzij een literatuurstudie zijn de deelvragen beantwoord, met de volgende resultaten: In een zeeklimaat is er gemiddeld gezien 117 dagen kans op drempel- en milde hittestress. Dit kan ook hoger (138d) in een warmer seizoen met meer milde hittestress of lager (64d) in een kouder seizoen met minder milde hittestress. Het economische effect op melkproductie werd erg beïnvloed door het niveau van de hittestress. Een warm seizoen gaf een verlies van €16.787 dit was het dubbele van een gemiddeld seizoen, dat €8.315 aan verlies had. Een kouder seizoen had €2.614 verlies. Hetzelfde was waargenomen bij het conceptie percentage, bij warmer weer is er meer schade. Een warmer seizoen had €10.212 verlies terwijl het gemiddelde seizoen €2.381 verlies had en een kouder seizoen geen verliezen had. Uiergezondheid wordt beïnvloed door hittestress maar het gemiddelde celgetal gaf geen economisch effect aan.

De kosten van hittestress preventie zijn voor drie verschillende mogelijkheden berekend; dakisolatie en twee vormen van mechanische ventilatie. Dakisolatie is de grootste investering van de drie maar deze investering heeft geen operationele kosten, die wel van toepassing zijn op mechanische ventilatie. Om de winstgevendheid van deze investering te berekenen is er een break-even point analyse uitgevoerd. In het warme en gemiddelde seizoen waren beide mechanische ventilatiesystemen als eerste break-even (0,5 vs. 2 jr.). Dakisolatie had 1,5 vs. 4jr. nodig. Maar in een kouder seizoen gingen alle investeringen niet break-even binnen tien jaar.

Met de resultaten van de deelvragen is de hoofdvraag beantwoord. Dit onderzoek geeft melkveehouders meerdere gestandaardiseerde indicatoren van de economische consequenties van hittestress en hoeveel het kost om deze te voorkomen. Indicatoren omdat elke melkveehouderij anders is. Melkveehouders moeten daarom eerst identificeren hoe geschikt zijn/haar stal is tegen warmte, wat voor veestapel hij/zij heeft. En de economische consequenties van hittestress overwegen en daarna pas investeren in hittestress preventie. Om dierenwelzijn en omzet te verbeteren.

1 Preface

Today many dairy farmers see that animal welfare is not only important for social support/acceptance but is also beneficial for their business in general (Bos, 2012). This thesis is thereby focussing on helping dairy farmers to enlarge their animal welfare. Good welfare equals good health and the display of natural behaviour in the herd. Which will have direct impact on the performance of the animal, which will benefit its production (Ouweltjes, Dooren, & Ruis-Heutinck, 2002). By request of the UK government in 1993 the Brambell committee presented the ‘five freedoms’:

1. Freedom from hunger or thirst
2. Freedom from discomfort
3. Freedom from pain, injury or disease
4. Freedom to express (most) normal behaviour
5. Freedom from fear and distress

The five freedoms are the foundation of good animal welfare and are since 1998 also part of the European law (Europian Commission, 2017).

Dairy cow housing

The second point of the ‘five freedoms’ of Brambell is the ‘’freedom from discomfort’’ which is important in the housing of dairy cows. Good housing means that the cow should have comfort when they are resting. They should have enough space to move around freely and have good thermal comfort, the cow should not be too hot nor too cold (Welfare Quality, 2009). But how important are these signs? In the ‘’Cowel-model’’ it is stated that the amount and size of resting places, freedom to move freely and thermal comfort are in the top 10 of most important points for animal welfare (Animal Sciences Group of WageningenUR, 2008). When an entrepreneur is building a new barn, he is mainly focusing on space to walk, size of the free stalls and the amount of feeding spots. But barn-climate is not the first subject an entrepreneur thinks about (Versteeg, 2016).

Thermal Comfort

Dairy cows have a constant body temperature, to maintain temperature she (the cow) releases heat in the environment. This process cost energy depending on the temperature of the environment, airspeed and humidity. For the cow there are several zones of temperature trajectories that influence the amount of energy needed for the heat emission.

The comfort zone is the most optimal temperature, this lies between -4 °C and 18 °C. In this trajectory it doesn’t cost the cow extra energy to emit heat. The next trajectory is the thermoneutral zone, which is between -10 °C and 22 °C. In this trajectory the cow can still manage to maintain the right body temperature, but it can cost extra energy to do so. Temperatures above the thermoneutral zone can cause ‘’heat stress’’, this means that the cow can’t release enough heat in a longer period. Temperatures below the thermoneutral zone with high wind speeds above 6 m/s and feeling temperatures below < 30 °C can cause ‘’cold stress’’ which means that the cow is putting much effort in maintaining body temperature (Animal Sciences group, WageningUR, 2009).

The effects of Heat stress

When a cow is having stress because of the heat, she is having problems with maintaining her body temperature as written above. The first signs of heat stress are when her breath frequency is rising, and her body temperature rises slightly. When this continues for a longer period, her appetite will drop, and she will consume less energy. Which can result in a decrease in milk production, decreasing body condition or both. When the animal isn't consuming enough energy the body resistance can drop which most of the time results in bad udder-health. Heat stress has also effect on the fertility of cows mainly because of lower conception rates (Tao et al, 2012). Cows are less seen in heat and pregnant cows have a chance of abortion or have a born calf with a lower average weight, which results in less growth and less milk production once that specific calf is a full-grown cow. Research has also shown that cows that calved during heat stress also have more chance on metritis compared with cows that calved within thermal comfort. The level of harm depends on the temperature and humidity in the environment. A high humidity for example; 80% with 25 °C outside does more harm and gives more heat stress then 25% humidity with the same temperature. The exact levels of stress during temperature and humidity are shown in *Figure 1. Heat stress index* (Veehouder Veearts, 2016).

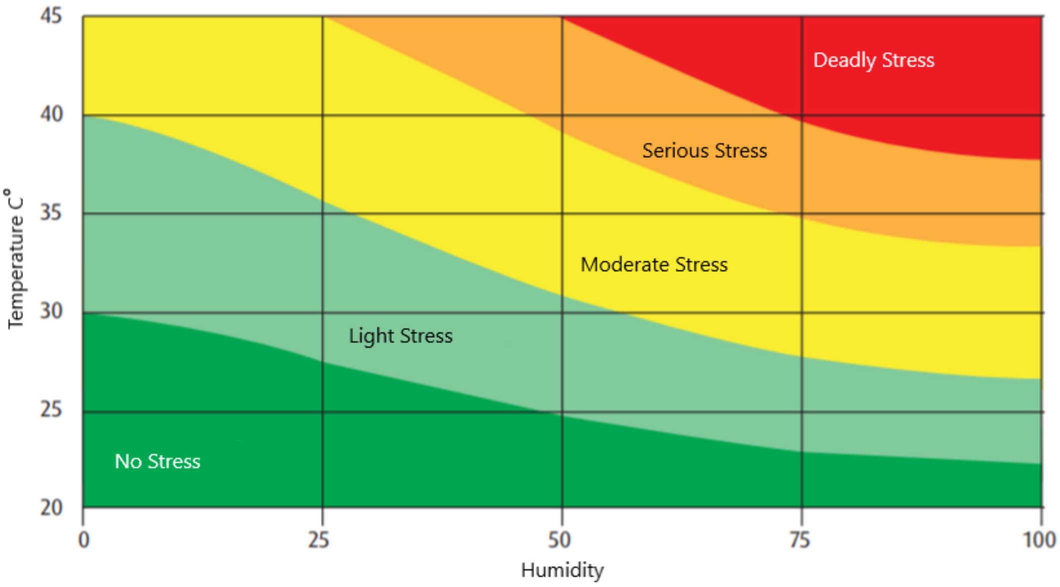


Figure 1. Heat stress index

Heat stress prevention

We know for now that heat stress is a serious issue and farmers that have dairy cows should be aware of the consequences that heat stress brings to their animals. But how can this be prevented? There are several possibilities that are used, the most used solutions are roof insulation and ventilation (Pijnappels, 2007). One of the solutions is: Evaporative cooling, Evaporative cooling drops the air temperature by 5-7 °C but let's the humidity rise 5-10%, this system is very effective but can only be used in climates with high temperatures and low humidity and is mostly used in combination with mechanical ventilation. Another option is soaking lines these are put above the feeding bunk and spray water over the cows. This is a cheap solution but if the cows get the udder wet there is a chance of a decrease in hygiene and possible mastitis. Another cheap solution is the use of Roof cooling. Roof cooling uses water sprinklers on top of the roof to cool the roof down so heat doesn't get in the barn. A different way of keeping the heat out is insulating the roof this helps with holding the heat out of the barn just like roof cooling, but this doesn't require water and is more expensive but gives a three to four-degree temperature drop inside (Versteeg, 2016). The last option is natural and mechanical ventilation which creates airflow to cooldown the barn by bringing in fresh air naturally or mechanically (van Ginneken, 2010). But when it’s high summer and the natural ventilation sides are fully opened, the heat is less likely to escape since there isn’t a lot of airflow output, because of under-pressure (Beerling, 2014). And mechanical ventilation can help with that!

Ventilation in dairy barns can be put in two separated categories. Natural ventilation and Mechanical ventilation. Natural ventilation is natural airflow that passes through opensides inside the barn and out again through the roof. Mechanical ventilation is ventilation that creates airflow mechanically and then uses the same concept as output as natural ventilation and should only be used as an extra element on top of the natural ventilation. Since natural ventilation isn’t reliable and airflow speed up to 4 m/s strongly affects the convective heat transfer rate, mechanical ventilation is needed to transfer heat (Wang, Zhang, & Choi, 2018). There are several forms of Mechanical ventilation, the most common forms are: HVLS (High volume, low speed) fans and panel fans that can be placed horizontal or vertical (Beunk, 2016).

Where is ventilation and roof insulation needed in the world to prevent heat stress?

If ventilation or roof insulation is needed depends on the climate where the cows are housed. The biggest dairy export regions in the world are the European Union, the United States, Brazil and New Zealand. These regions produce a significant amount more milk compared to other big dairy exporting regions in the world and the European Union produces the most milk of these four (ZuivelNL, 2016). Focusing on Europe there are three major climates in Europe: Oceanic in the western Europe, Continental in eastern Europe and Mediterranean in the southern Europe all these climates have several months with temperatures above 22 °C (Köppen, 1980). Which makes ventilation and roof insulation essential in cow barns to maintain a lower temperature and refrain from heat stress.

Conclusion

To maintain animal welfare and therefore dairy cow’s welfare it is essential to take barn climate in this process. Cows have their own ideal comfort zone between -4 °C and 18 °C and once surpassed above 22 °C there is chance on heat stress which causes stress, less energy consumption which could result in a decrease in milk production, body condition, udder health issues and fertility problems. That is why dairy farmers should make it a priority to keep their barns cool in the summer and for that roof insulation and ventilation is needed. But what are the economic consequences of heat stress in terms of milk-production, udder-health and reproduction. Does heat stress occur that often in an oceanic climate? And what does an investment in roof insulation or ventilation cost? And is the investment also profitable for a dairy farmer? That is why the main question of this thesis is:

What are the economic consequences of heat stress and how much does it cost to prevent it?

To answer the main question the following sub-questions are made:

1) *How many times a year can heat stress occur in an oceanic climate?*
2) *What are the effects and cost of heat stress on milk-production and udder-health?*
3) *What are the effects and cost of heat stress on conception rates?*
4) *What are the investment cost of heat stress prevention?*
5) *What is the break-even point of an investment in heat stress prevention?*

2 Approach

This investigation of the sub-questions had been taking place in June to the end of July in the year 2018. During my internship in Canada at Artex Barn Solutions in Abbotsford. The study itself had been focused on Europe.

How many times a year can heat stress occur in an oceanic climate?

This sub-question has been answered through a literature study. For this research information from one reliable institute has been used: The data is coming from the Royal Netherlands Metrological institute which is owned by the Government of the Netherlands. This location has been chosen because The Netherlands is one of countries in Europe with an Oceanic climate. The weather data has only been used from one weather station location called ''De Bilt''. In total there has been eleven years of data collected and used to conclude the amount of days of possible heat stress. The data itself has been put in a datasheet and into charts to draw conclusions. The data found will be displayed in Quartile 1 and Quartile 3 and the mean. With the data found and the thermal heat index (THI) the chance of heat stress was calculated per year.

What are the effects and cost of heat stress on milk-production and udder-health?

This sub-question has been answered through a literature study. Perimeters for this research had been using research and studies that came from a reliable source, for example: The Journal of Dairy Science, the studies must also be focusing on milk production combined with THI levels. There have been many studies found upon this subject, older and more recent have been used to draw a weighted conclusion about what the effects on milk-production and udder-health can be. With the results of research upon the oceanic climate the cost in euros per hundred cows has also been calculated. The costs are based upon the outcomes of the research on what the milk-production and udder health effects were on heat stress and the average European milk price from the last eight years.

What are the effects and cost of heat stress on conception rates?

By researching upon literature, the effects of heat stress on conception rates has been found. The perimeters for the research was to search for literature that was reliable, from example: studies writing down in the Journal of Dairy Science. And the studies must have been using THI as scale of effect of heat stress upon conception rates. Several kinds of literature have been found about the effects and the most useful has been used and reviewed. With knowing what the effect was, literature stated out what the cost per pregnancy loss was based upon research in the US. With that and the THI data of an Oceanic climate. The economic effects of heat stress on pregnancy loss had been calculated.

What are the investment cost of heat stress prevention?

To research this subject, a barn for a hundred cows have been drawn to make sure roof insulation and mechanical ventilation setups are equally calculated. Through a literature study the cost of roof insulation have been found. The perimeters for searching is that the cost would come from a reliable source, which could be used on the dimensions of the barn for equal calculations. Mechanical ventilation costs have been searched for and the highest average cost has been used. The cost of two different mechanical ventilation setups has been calculated by data from Artex Barn Solutions. Including operation cost of both the ventilation systems. The operation time has been calculated by using the oceanic climate data based on THI scale and the recommendations of Artex Barn Solutions.

What is the break-even point of an investment in heat stress prevention?

With the results of the first four sub-questions, this one has been made. Combining all the results in a break-even point analyses calculated in business economic method. The economic losses to heat stress have been turned around in profits, since there has been invested in heat stress prevention. The profit is put up against the cost of the investment, plus the variable cost. The break-even point analyses are made in three different parts; the top 25%, mean and the low 25% since cost and profits are different between these three as seen in the previous sub-questions. Everything is calculated for a hundred cows in euros. The timeframe used is 10 years to give a clear idea how long it would take to go break-even and generate a profit.

3 Results

In this chapter the results of the sub-questions will be answered, to eventually answer the question of this thesis.

3.1 How many times a year can heat stress occur in an oceanic climate?

As known from the preface the change of heat stress depends on the outside temperature and the percentage of humidity in the air. Through literature study the information given by the Royal Netherlands Metrological institute (KNMI) has been found and put in to a chart as seen in Figure 2. All the records of temperature and humidity of the last 10 years are collected at The Bilt (Weather station: 260) in The Netherlands. The Netherlands is a 100% oceanic climate in the west of Europe as seen on the Köppen climate classification (Köppen, 1980).

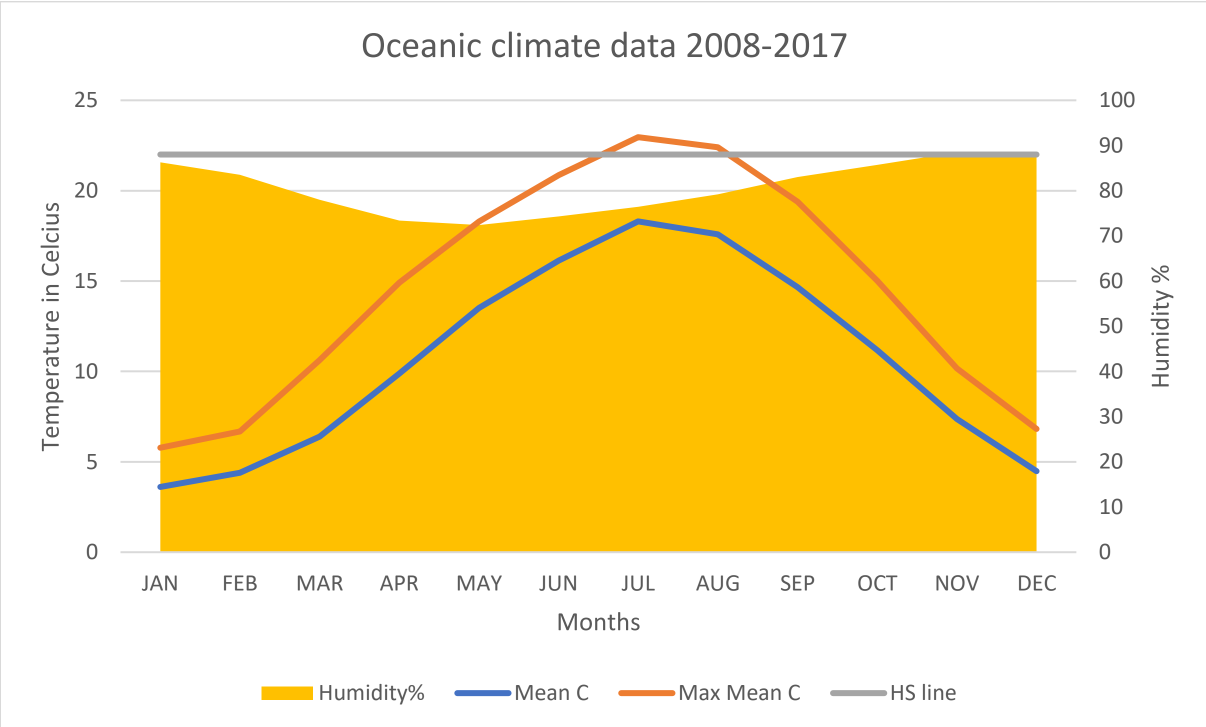


Figure 2. Oceanic climate between 2008-2017 (Royal Netherlands Metrological Institute, 2017).

In the last ten years the mean temperature (day and night) in the oceanic climate of the Netherlands is not heat stress prone. But the average maximum temperature per month is, as seen in *Figure 2* in the months June, July and August the average maximum temperature rises around or above 22 degrees Celsius. But what exactly happened during these months? The data per days gives a closer look of these three months but for chances on extremes in the last ten years the months May and September where also added. The following is seen in *Figure 3, 4, 5, 6 and 7.* In all these charts the daily humidity together with the maximum temperature is used to calculate the Thermal Heat Index (Annex I (Artex Barn Solutions, 2018)). With the thermal heat index (THI), we know when heat stress can start. THI of 66-71 for threshold heat stress, 72-79 for mild heat stress, 80-89 for moderate stress and 90+ for severe heat stress. The Top 25% and the Low 25% are calculated by quartile 3 and quartile 1. All the data that has been used to make these charts can be found in *Annex II: Oceanic climate data*. The reason why the maximum temperature has been chosen is because studies from (Brügemann, Gernand, König von Borstel, & König, 2012) has shown that the maximum temperature has more effect on heat stress then the daily average.

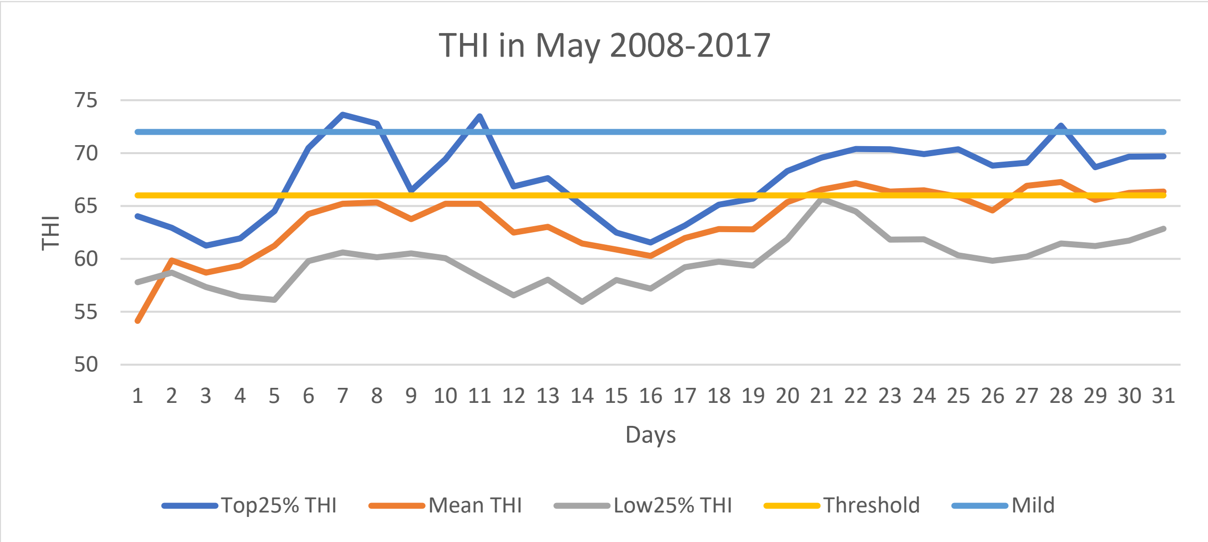


Figure 3. May 2008-2017 (Royal Netherlands Metrological Institute, 2017).

In the yearly chart there seems to be no heat stress in this month. But by looking at the monthly data from the last ten years indicates a difference *(See Figure 3)*. The low 25% indicates one day of a THI of 66. The mean THI gives ten days of threshold heat stress. And the top 25% indicates 17 days of threshold heat stress and four days of mild heat stress.

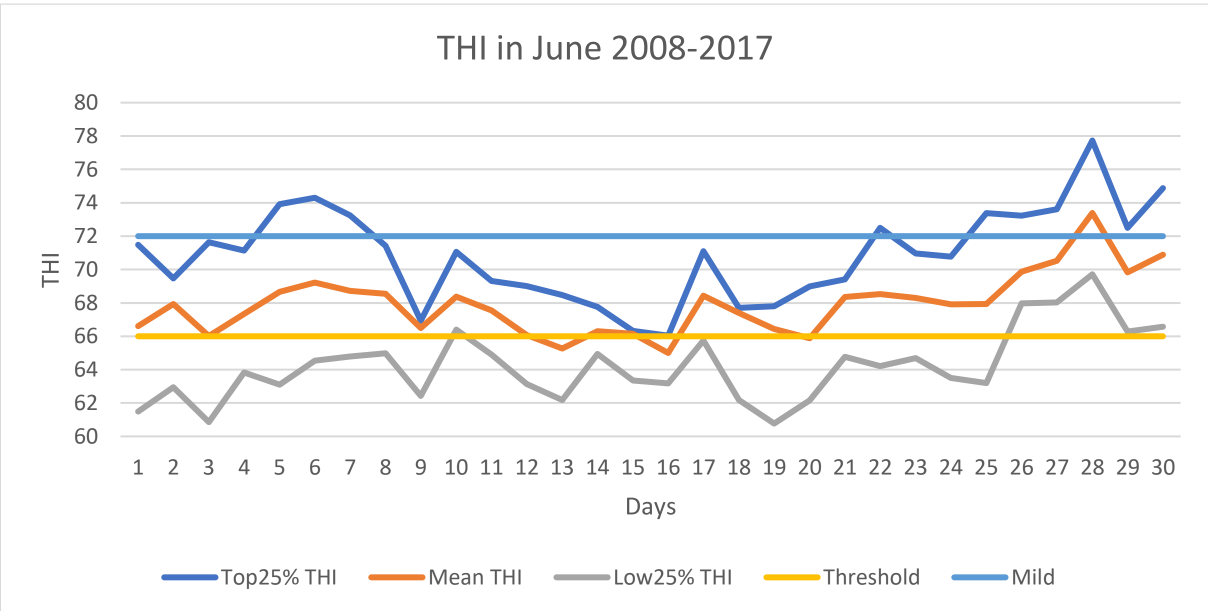


Figure 4. June 2008-2017 (Royal Netherlands Metrological Institute, 2017).

The last ten years of June *(See Figure 4)* indicates that the maximum temperature on averages reaches the change of threshold heat stress at least 27 times but will only go once above mild heat stress and never above moderate heat stress. But the top 25% of the last ten years indicates that there is indeed a strong change of rising above threshold heat stress (19x) and moderate heat stress (11x). The low 25% indicates only seven days of threshold heat stress which is much lower compared to the other data.

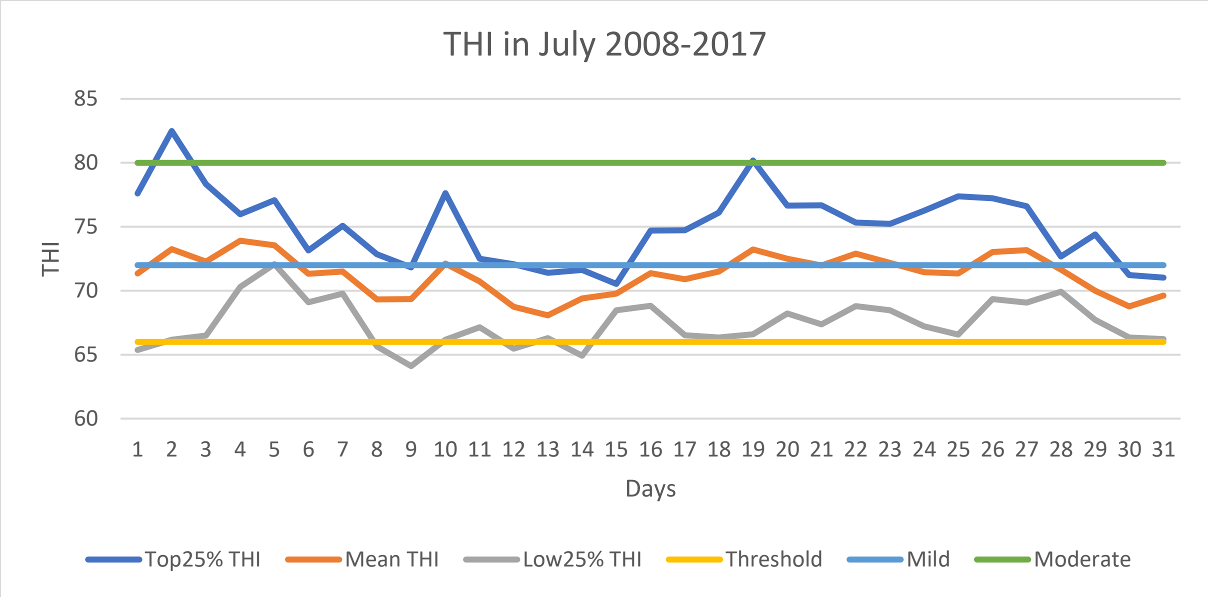


Figure 5. July 2008-2017 (Royal Netherlands Metrological Institute, 2017).

The last ten years of July is different compared to June (*See Figure 5)* and indicates a lot more peaks on maximum temperature averages. The low 25% goes 26 times in threshold heat stress and once at mild heat stress level but never goes above that after. The average instead hits threshold heat stress and moderate heat stress several times, 31 days in total which is 14 days in mild heat stress and 17 days in threshold heat stress. But the top 25% indicates the whole month as stress with only four days in threshold heat stress, 25 days in mild heat stress and two days at moderate heat stress.

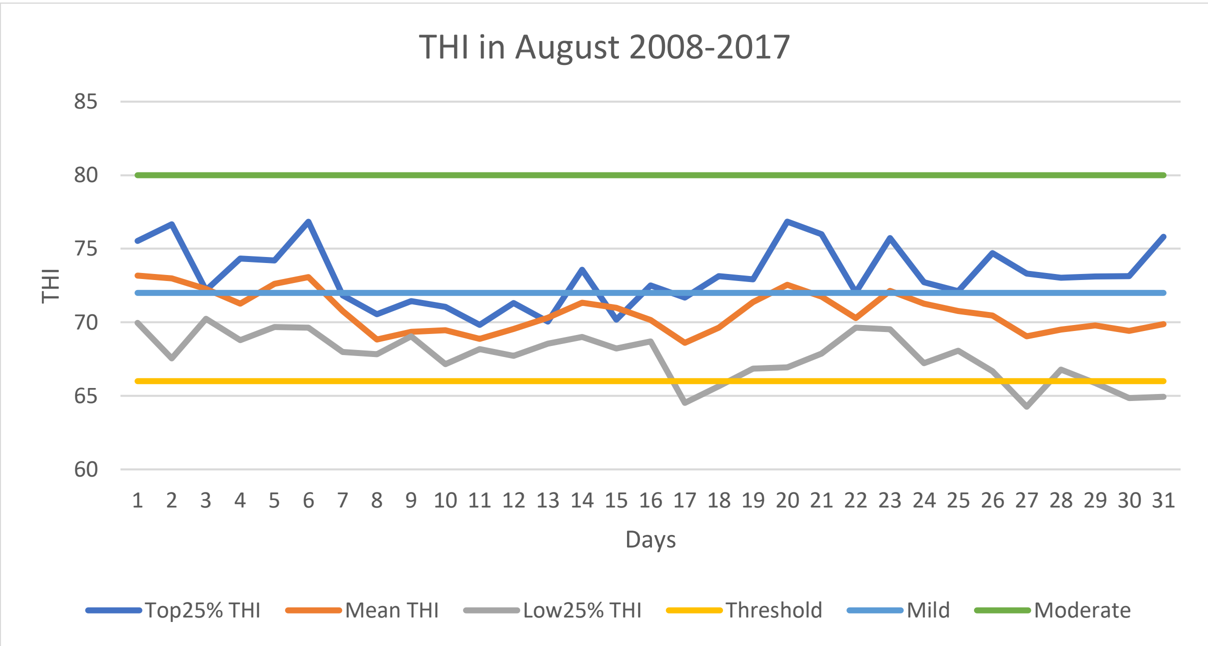


Figure 6. August 2008-2017 (Royal Netherlands Metrological Institute, 2017).

The last ten years in August also had been hot *(See Figure 6)* like it was in June. The low 25% hits threshold heat stress 27 days but never goes in or above mild heat stress. The average instead is 23 days in threshold heat stress level and eight days in mild heat stress level which is the same amount of days as June but with less mild heat stress. The top 25% is as expected higher with 31 days in total which are seven days in threshold heat stress and 24 days in mild heat stress, but no days go into the moderate heat stress.

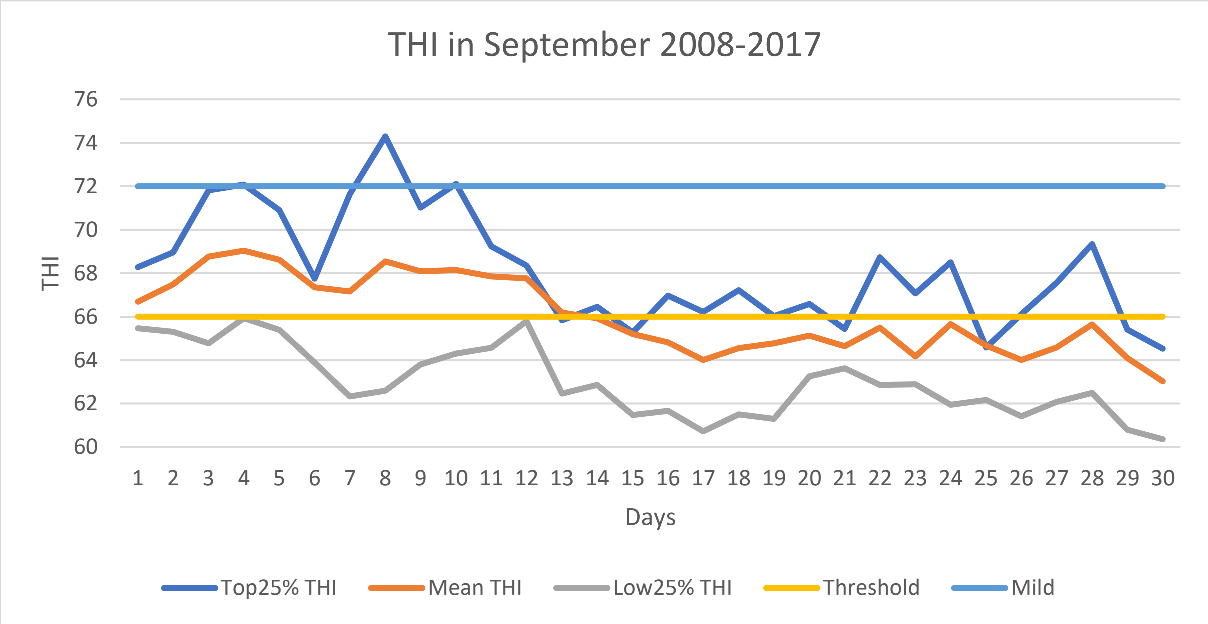


Figure 7. September 2008-2017 (Royal Netherlands Metrological Institute, 2017).

September is the end of the summer which is clearly to see in *Figure 7*. The low 25% maximum temperatures do hit threshold heat stress twice. The average maximum temperature has 17 days of threshold heat stress in the beginning of the month and goes down after. The top 25% instead has five days chance on mild heat stress and 20 days on threshold heat stress in the month.

To conclude that *Table 1* gives the amount of days in these five months that there is a change chance on threshold-, mild- and moderate heat stress.

Table 1: Days of chance on heat stress

	Top 25%	Mean	Low 25%
Heat stress threshold	52 days	65 days	34 days
Mild stress	69 days	23 days	1 days
Moderate stress	2 days	0 days	0 days
Total	**138 days**	**117 days**	**64 days**

In an Oceanic climate there is on average a 138-day chance on a maximum temperature that gives threshold- to mild- heat stress to dairy cows. The top 25% average of the last ten years instead gives 138 days of chance on heat stress which adds a few days extra but triples the amount of days in mild heat stress. But if you are looking at the low 25% of these ten years it would only result in 64 days of chance on heat stress which is around half of the mean.

3.2 What are the effects and cost of heat stress on milk-production and udder-health?

In this paragraph the results of the sub-question two are answered. The economic consequences will be based on the results of the first sub-question in paragraph 3.1.

Heat stress on milk-production

There have been many studies researching the effects of heat stress on milk-production of dairy cows and they all conclude that there is a significant relation between milk-production and heat stress based on the thermal heat index or rectal temperatures. (Ingraham, Stanley, & Wagner, 1979) stated that per unit of THI increase milk-production would decrease by 0,31 kg per day. Another study showed that starting from THI 72 milk-production would decrease 0,2 kg per day, but this study didn't look at production below a THI of 72 (Ravagnolo, Misztal, & Hoogenboom, 2000). The same goes for the research made by (West, Mullinix, & Bernard, 2003) this study stated that for Holstein-Friesian cow's milk-production will decrease 0,88 kg per day per THI unit with a 2-day lag starting at a THI of 72. But the study by (Bouraoui, Lahmar, Majdoub, Djemali, & Belyea, 2002) stated that starting from a THI of 69 milk-production will decrease 0,41 kg per day per THI unit without noticing any possible lag. The study from (Spiers, Spain, Sampson, & Rhoads, 2004) didn't not study upon THI but noticed that there is at least a four-day lag after heat stress has occurred. Most recent study made by (Bernabucci, et al., 2014) stated that there is an eight-day lag after a day of heat stress at a breaking point between a THI of 65 to 76 with a decrease of 0,9 to 1,2 kg of milk-production per lag day. For higher THI-units like 81 and greater is a 1,1 kg decrease per unit increase (Rejeb, Sadraoui, Najar, & M'rad, 2016).

By building up all this information we now know that a decrease of milk-production starts at a THI of 69 starting with a decrease of 0,41 kg milk production per THI unit decrease. Once THI goes above 72 there will be a decrease of 1 kg per day lag that takes eight days until milk production is back on the normal level (significantly), but this lag will only happen if the higher THI period is 2 days or longer. If THI comes above 81 there will be a greater decline in production which is 1,1 kg per THI unit. But what does heat stress do on protein and fat yield? (Bernabucci, et al., 2014) stated that protein and fat yields have a twelve days lag after a THI breaking point of 69 THI for protein and 72 THI for fat yields. After this break point protein yield will decrease 0,04 kg per day and fat will decrease 0,05 kg per day for the next twelve days.

With that information an economic analysis can be made. In *Table 2* you will see the results of the calculations that has been made in *Annex III.* In this calculation the total days of heat stress from the oceanic climate data has been used 138 days for the Top 25%, 117 days for the mean and 64 days for the Low 25%. The average Dutch cow according to (Wageningen University & Research, 2017) has been used to calculate the normal revenue of the average Dutch cow, this cow produces 8.500 kg of milk with 3,5% protein and 4,4% fat in a 305-day lactation. The milk-price used is: €33,06 per 100kg milk which is €630 p/100kg of protein and €250 p/100kg of fat. This price is the 8-year average (2009-2016) from multiply European milk processors (LTO Nederland, ZuivelNL, European dairy farmers, 2017).

Table 2: Economic loss due heat stress on milk-production

	Normal	Top 25%	Mean	Low 25%
Revenue p/cow	€2.809	€2.641	€2.726	€2.783
Loss p/cow		€ -167	€ -83	€ -26
Loss p/100 cows		**€-16.784**	**€-8.315**	**€-2.614**

Heat stress on udder-health

As we know now heat stress has a big decreasing effect on milk production depending on the level of THI on dairy cows. But does heat stress also have effect on udder-health and by those means milk-quality? The study from (Shock, et al., 2015) said that bulk milk somatic cell count (BMSCC) data showed a repeatable cyclicity, with the highest levels experienced during warm, humid seasons. An older study by (Olde Riekerink, Barkema , & Stryhn, 2007) also confirms that BMSCC also was higher during summer months. This study also stated that individual cow somatic cell count (ICSCC) could get higher or stayed higher during the months May and August. And there was a higher chance of E. coli clinical mastitis infections during the summer on herds that were housed. Streptococcus Uberis was higher during summer months on herds that were pastured.

So, it is statistically proven that during summer months bulk milk somatic cell count does rise which means a decline in a) udder health and b) milk quality. But is heat stress the responsible factor? A study by (Li, et al., 2016) stated that long-term heat caused an inflammatory response in dairy cows, which means that there is a higher infection risk. A recent study by (Nasr & El-Tarabany, 2017) showed that THI levels and therefore heat stress indeed have a significant effect on Somatic cell count (SCC). During the study cows with no heat stress (THI <70) had a SCC of 190 (x1000 cell/ml). When THI went up to 70-80 which indicates mild stress to moderate stress SCC went up to 216 (x1000 cell/ml), which is a 13% increase and when THI went above 80+ Moderate to severe stress, SCC was 259 (x1000 cell/ml). Which is a 36% increase compared to a low THI level.

The effect of SCC on milk-production is not considered high, study by (Halasa, et al., 2009) stated that SCC had effect on milk-production once SCC reaches 200 (x1000 cell/ml) or higher. Milk losses differed between primiparous (-0,30 kg/d) and multiparous cows (-0,54 kg/d). But the study by (Jertina, Skorjanc, & Babnik, 2017) which is more recent stated that primiparous cows would have a 0,8 to 0,9 kg/d loss and multiparous cows 1,3 to 4,3 kg/d, which is a lot more. The chance of Clinical Mastitis (CM) depends the SCC itself, the study by (Idriss, et al., 2013) stated that starting from a SCC of 400 (x1000 cell/ml) there is an 80% chance of having pathogens that can start CM.

To consider economic effect of heat stress it really depends on what the SCC of the depending cow is. In 2017 the average SCC in The Netherlands was 174 (x1000 cell/ml) (QLIP, 2017). Which is lower then the threshold of milk loses generated by SCC which is 200 (x1000 cell/ml). Heat stress between a THI of 70-80 has an increasing effect of 13% on SCC and which means the average will come upon 201 (x1000 cell/ml). Which makes chance on milk losses minimum and the chance on CM nonviable which needs at least 400 (x1000 cell/ml). According to the data of the oceanic climate a THI of 80+ only occurs twice on a top 25% and therefore a calculation for an 36% increase is not needed.

To conclude for what is known from this literature study, heat stress does have effect on SCC and therefore on milk-production and maybe CM. But considering the average SCC of dairy herds in the Netherlands together with the THI data in the Oceanic climate, concludes that heat stress does not have an economic effect on the average dairy herd in the Netherlands.

3.3 What are the effects and cost of heat stress on conception rates?

Heat stress has several effects on fertility in Holstein-Friesian dairy cows, before insemination, during pregnancy and after calving. But what is the effect on conception rates? Conception rate is the number of cows in percentage that have been inseminated 63-84 days earlier. This indicates how many cows got pregnant from insemination and is therefore an important indicator (CRV4ALL, 2015).

A study by (Schüller, Burfeind, & Heuwieser, 2014) indicates that conception rate (CR) is highly effected by heat stress. The study shown that heat stress influences CR from a THI threshold of 73. A day with a maximum THI of 73 or Higher already has a significant effect on the CR were 22% of the cows was less likely to get pregnant. A nine-hour period on the day of breeding with a THI of 73 or higher already has an effect of 26% less likely to get pregnant. A full day with the mean temperature being above a THI of 73 or higher will result in a 39% chance of less likely being pregnant. An ongoing period of 21 days of a THI of 73 and above before breeding has an effect of 61% less likely to getting pregnant. But once the ongoing periods is going to be higher then 42 days this percentage will drop to 31% less likely to get pregnant. Another study stated by (García-Ispierto, et al., 2007) said that CR dropped 21-35% at a THI of 75 and higher one day after breeding. The same has ben said by the study of (Pavani, et al., 2015) but with a THI threshold of 70,6.

Now we know how much heat stress affects a decrease on conception rates. Now the economic effect can be calculated. According to (Je-In & Ill-Hwa, 2007) one pregnancy loss cost €2.000. This cost includes; medical cost, production, labor, culling, etc. To know how much loss that is per hundred cows, per year the following formula has been used, based on the oceanic climate data:

*1-day period of THI 73+ = ((100 / 415 * single days above 73 THI) *26%) *2.000*
*2 days+ periods of THI 73+ = ((100 / 415 * days above 73 THI) *39%) *2.000*
*21 days+ periods of THI 73+ = ((100 / 415 * days above 73 THI) *61%) *2.000*

The formula starts with 100 for hundred cows, times the calving interval. The calving interval is 415 days. This is the ten years average from cows in the Netherlands (2008-2017) (CRV BV, 2018). Followed by the amount of days above a THI of 73 based on the oceanic climate data. Completing that creates the number of cows per year that are affected by heat stress. This time the percentage of being less likely to be pregnant, will calculate the number of cows that will loss pregnancy due to heat stress. This amount times €2.000 per pregnancy loss will create the economic loss based on a herd size of a hundred cows. In *Annex IV* the calculations can be found. *Table 3: Cost of pregnancy loss due to heat stress* indicates the total loss.

Table 3: Cost of pregnancy loss due to heat stress

	Top 25%	Mean	Low 25%
Loss p/100 cows	€-10.212	€-2.381	€-0

Based on the formula the low 25% doesn't have effect on pregnancy loss because there isn't a day above a THI of 73. For the mean there is a total of 14 days which results in a loss of €2.381. The top 25% reaches out with 56 days above a THI of 73. Which given a loss of €10.212 per hundred cows.

3.4 What are the investment cost of heat stress prevention?

In this paragraph the investment cost of heat stress prevention was calculated. For roof insulation and two systems of mechanical ventilation. All these investments are based on a barn for hundred cows.

Defining the barn

An Average barn has been drawn, to make an equal comparison between the possibilities of heat stress prevention (See Figure 8 & 9). This barn is drawn without other specific areas, for example a milking parlour, calving area, etc. Because this study was purely based upon the living space of the dairy cows. The barn is a double head-to-head freestall barn with a feeding bunk in the middle. Measurements for the freestalls and walking area has been defined by the standards from (Animal Sciences group, WageningUR, 2009). Walking areas are 4m wide. Freestalls are 1,20m wide with a total length of 2,50m. And the feeding bunk is 5m wide. This makes the total barn 38m long and 31m wide.

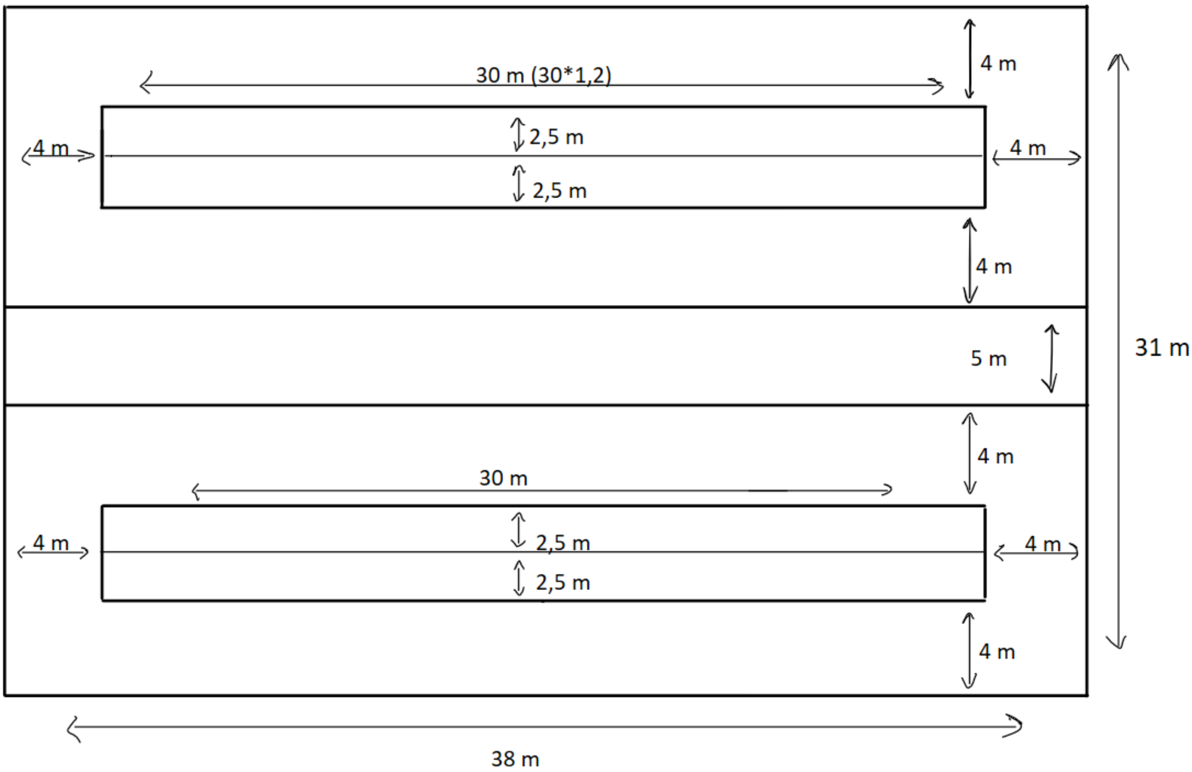


Figure 8. Top-view barn

The top of the barn is 10 meters high and the roofs are 15,81m wide to the center from both sides. With the chimney the roof will be 14,06m wide on both sides.

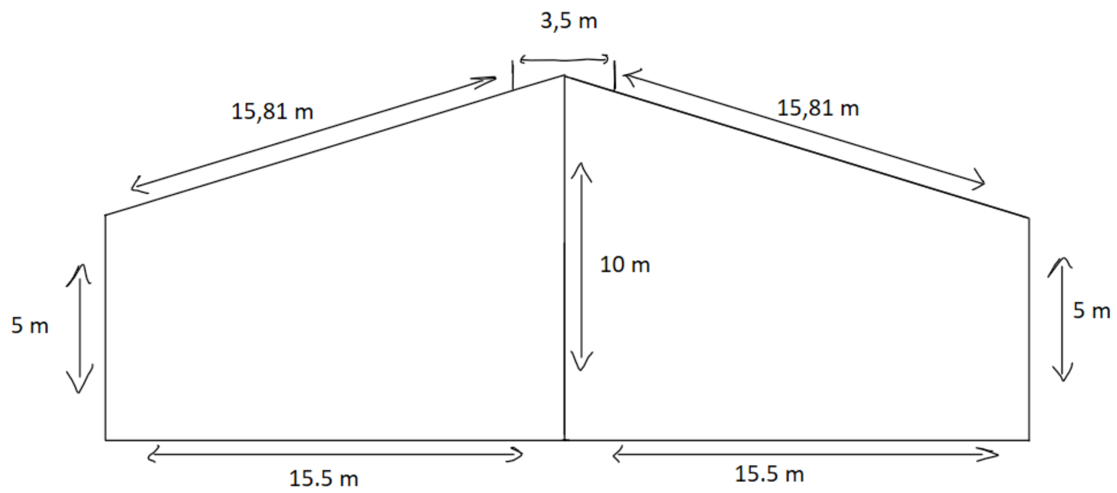


Figure 9. Front-view barn

The investment cost of Insulating the barn

As known from the preface, roof insulating is used to make sure that heat stays outside of the barn. For insulating mostly sandwich panels are used (Figure 10). These panels are a thicker piece of roof that has a higher heat resistance. That difference could be three to four degrees Celsius compared with outside temperature. Those three to four degrees could easily become the big difference in getting heat stress or not getting heat stress in the herd, depending on the outside temperature and humidity. The downside of these panels is that once the heat is inside the barn it will take longer for it to get out because it is well insulated.

Figure 10. Sandwich panel (handelsonderneming kienhuis, 2018)

Standard sandwich panel cost €30 euros per square meter (LTO Noord). The roof of this barn has a surface of 1068,6 square meters. This means that an investment in an insulated roof for a hundred cow barn will cost: **€32.000.**

The investment cost of Panel fan ventilation setup

Panel fan ventilation is standard form of mechanical ventilation. This type of fan has a 55-inch fan blade diameter and creates high velocity air patterns that helps to cool dairy cows (Figure 11). These fans are mostly put up a 2,4m height, at a 14-degree angle above the freestalls. Cross ventilating the cows, which is according to (Wang, Zhang, & Choi, 2018) is the most effective way to transfer heat. These fans reach an airflow speed of 2,5 m/s with a reach of 3,5m wide and 15m long. The only downside from these panel fans is that they can only run at 100% or at 0%, which uses a lot of energy; 0.9 kwh per fan (Fleming, 2018). For optimal ventilation this barn needs 14 panel fans, which means 12,6 kwh is used. With this setup the feeding bunks and the freestalls are ventilated. So, cows are most of the time fully ventilated, see *Figure 12: Panel fan setup*

Figure 11. Panel fan (Farmtek, 2018).

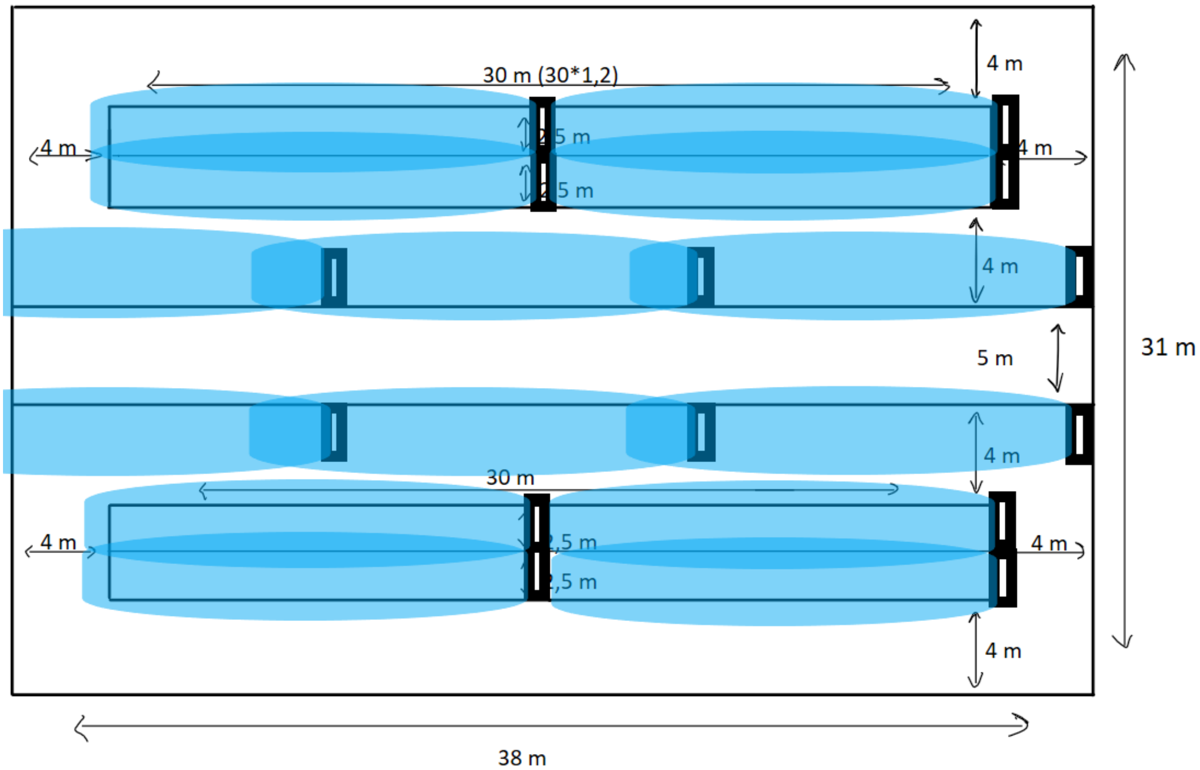


Figure 12. Panel fan setup

A setup likes this will cost **€6.800** euro's as an investment including mounts, motors and software for automatic control. The total running cost per year based on THI per day. The fans will turn on in the May to September period starting at a THI of 63 since a cow starts using more energy to cool down out of the thermal comfort zone. Fan usage is based on 24/16/12/8 hours per day. A panel fan setup will turn on 100%, 12 hours a day between a THI of 63 to 67. And after a THI of 68 will turn on 100%, 24h per day (Fleming, 2018). In *Table 4: Operation cost Panel fan setup* you can see what a yearly usage cost based on the oceanic climate data. This table is coming from *Annex V: Investment in Ventilation.* The price is 0,191 eurocents per kwh (NUON, 2018).

Table 4: Operation cost panel fan

Top 25%	Mean	Low 25%
41.126 kwh	34.927 kwh	21.017 kwh
€ 7.855	**€ 6.671**	**€ 4.014**

The investment cost of a variable speed louver fan + panel fans.
A variable speed louver fan (V.S.L. Fan) is a bigger panel fan and has a 72-inch fan blade diameter (Figure 13). But this fan has a motor system that can run on different speeds from 0% to 100% and has louvers to direct the air in several direct streams towards the cow so the air doesn't circulate to much, what sometimes is seen with panel fans. These fans will be hanging above the freestalls at a height of 2.4 m at a 30-degree angle with the louver directed at the freestalls. So, the ventilation is 100% focussed upon cross ventilation the cows. These fans have reach of 18 meters long by 6 meters wide and can reach wind speeds up to 3 m/s. Which means that in this type of barn there are only four needed to ventilate the freestalls. But to ventilate the feeding bunks six normal panel fans are needed, same as with the panel fan setup. A V.S.L. Fan uses 2.2 kwh on 100% speed but since the reach is higher than a panel fan it only must do 80% to ventilate the freestalls which equals 50% of power consumption. So, the amount will drop to 1.1 kwh (Fleming, 2018).

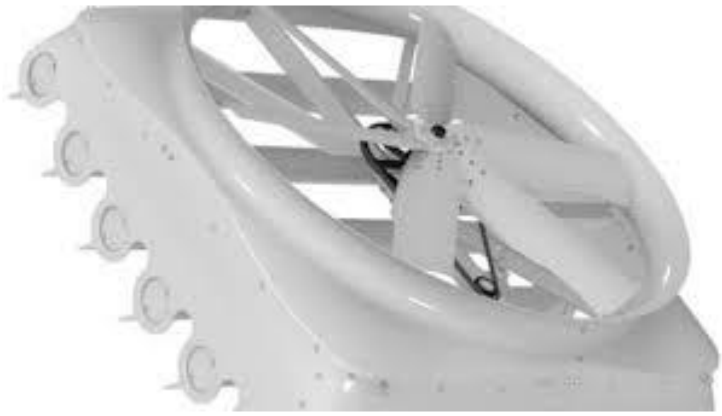


Figure 13. Variable speed louver fan (Dairy Link, 2018).

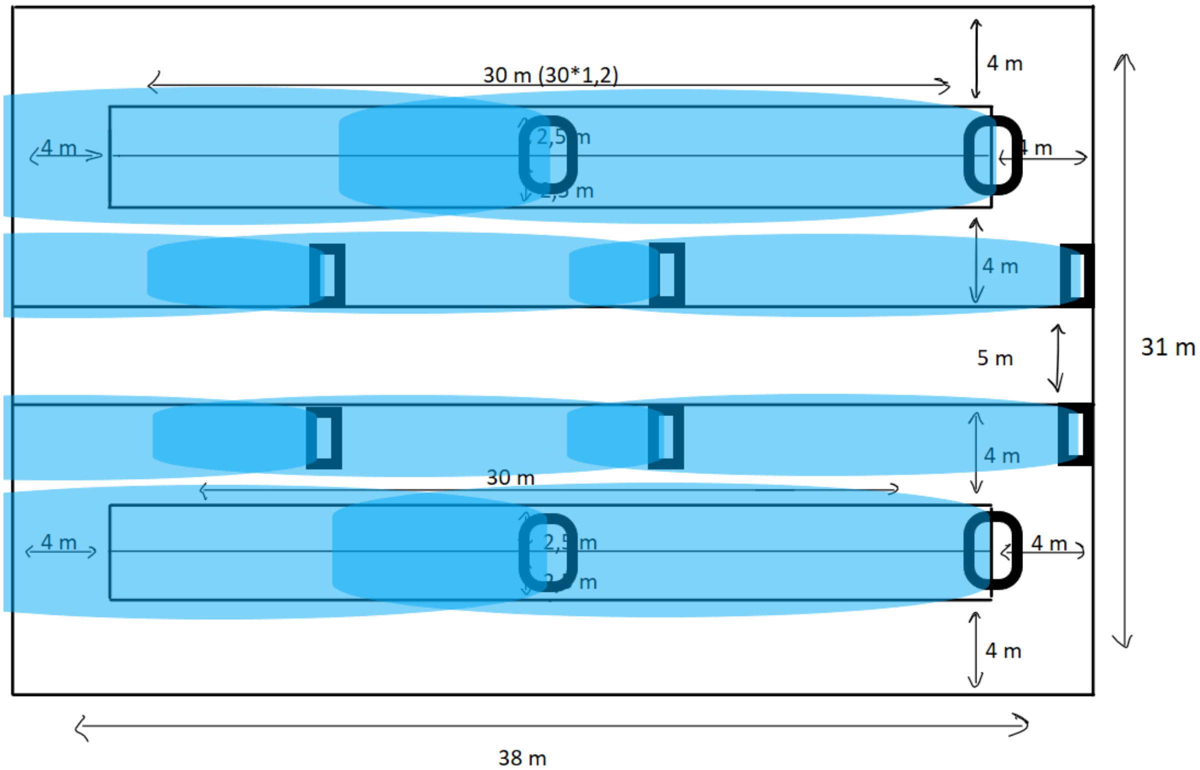


Figure 14. Variable speed louver fan setup

A setup like this (*Figure 14. Variable speed louver setup)* will have an investment price of **€11.000** euro's, including mounts, motors, software, etc. The fans will turn on in the May to September period starting at a THI of 63 since a cow starts using more energy to cool down out of the thermal comfort zone. Fan usage is based on 24/16/12/8 hours per day. The panel fan will act the same as with the panel fan setup and will turn on 100%, 12 hours a day between a THI of 63 to 67. And after a THI of 68 will turn on 100% 24h per day. The V.S.L. Fan doesn't do this. It will run 12h on 50% (0,55 kwh) between a THI of 63 to 67. With a THI of 68 to 71 the fans will run 12h on 80% (1,1 kwh) and 12h on 50%. When THI exceeds 72 to 79 the fans run 16h on 80% and 8h on 50%. With a THI of 80+ the fans will run 100% (2.2 kwh) 24h a day (Fleming, 2018). In *Table 5: Operation cost Variable speed louver fan + panel setup* you can see what yearly usage cost, based on the oceanic climate data. This table is coming from *Annex V: Investment in Ventilation.* The price is 0,191 eurocents per kwh (NUON, 2018).

Table 5: Operation cost Variable speed louver fan + panel fan setup

Top 25%	Mean	Low 25%
23.926 kwh	20.275 kwh	12.705 kwh
€ 4.570	**€ 3.873**	**€ 2.427**

3.5 What is the break-even point of an investment in heat stress prevention?

In this paragraph the break-even point of an investment in heat stress prevention was calculated. Based on the outcome of paragraph 3.2, 3.3 and 3.4.

With the results of the first few paragraphs we now know what the economic effects from heat stress are on a herd of a hundred cows. And we also know how much it cost to invest and operate an investment in heat stress prevention. But what is the return on revenue of these investments? That is why this break-even calculation has been made, based on business economic method. Extensive results can be found in *Annex VI: Break-even point analyses.*

The Investments

The three possible investments against heat stress are roof insulation, the panel fan setup and the variable speed louver fan setup. Roof insulation investment has a depreciation time frame of 20 years with no residual value. Both ventilation investment have a depreciation time frame of 8 years with also no residual value. Interest rates are for all 3,5% and maintenance & insurance is 2% for roof insulation and 3% for both fan setups (Wageningen University & Research, 2017). The fans also run on operational cost, there are in calculated in three different cost, this because the operational cost of the fans depend on the climate data. So, these are also divided in Top 25%, Mean and Low 25%. In *Table 6: Investment* you can see the total amounts used.

Table 6: Investment

	Roof Insulation	Panel fan	V.S.L. fan
Investment	€ 32.000	€ 6.800	€ 11.000
Variable cost (Top 25%)	€ 2.800	€ 9.028	€ 6.468
Variable cost (Mean)	€ 2.800	€ 7.844	€ 5.771
Variable cost (Low 25%)	€ 2.800	€ 5.187	€ 4.325

Costs saved with investment

The costs saved with investment from now on called profit. Are the before called losses calculated in paragraph 3.2 and 3.3. These profits are also divided in Top 25%, Mean and Low 25% just like they have been calculated in the last few paragraphs. In *Table 7: Profit* the difference between these profits has been made clear.

Table 7: Profit

	Top 25%	Mean	Low 25%
Milk production	€ 16.784	€ 8.315	€ 2.614
Non-Pregnancy loss	€ 10.212	€ 2.381	€ 0
Total	**€ 26.996**	**€ 10.696**	**€ 2.614**

Break-even point

With this data the break-even point for an investment in heat stress prevention has been calculated. The time frame for this break-even point is based on the investment year (year zero) and ten years after the investment. So, the effect of the variable cost over a longer period can also be taking into account. In total there are three charts each for each stage of climate from the past ten years: Top 25%, the Mean and the Low 25%. In *Figure 15, 16 and 17* you can see the results of the break-even calculations. In all the charts you'll see three lines: all three representing one of the investment. The investment starts in minus, for example €-32.000 for Roof insulation. The rise of the line will be calculated by the amount of rising depending on the profit and the variable cost per year. For example on the Top 25%, roof insulation will rise (26.996-2.800)= 24.196 per year. The break-even point is €0 on the figure. Once the break-even point is hit the investment will make a revenue the years after. In Figure 15 you can see that the investment in roof insulation or both mechanical ventilation systems are quickly profitable in a Top 25% season. For roof insulation there is 1,5 years needed to reach break-even and for both ventilation setups only half a year to hit break-even. From all the options is roof insulation in the long term the cheapest in cost, closely followed by the V.S.L. fan setup. The Panel fan are the most expensive.

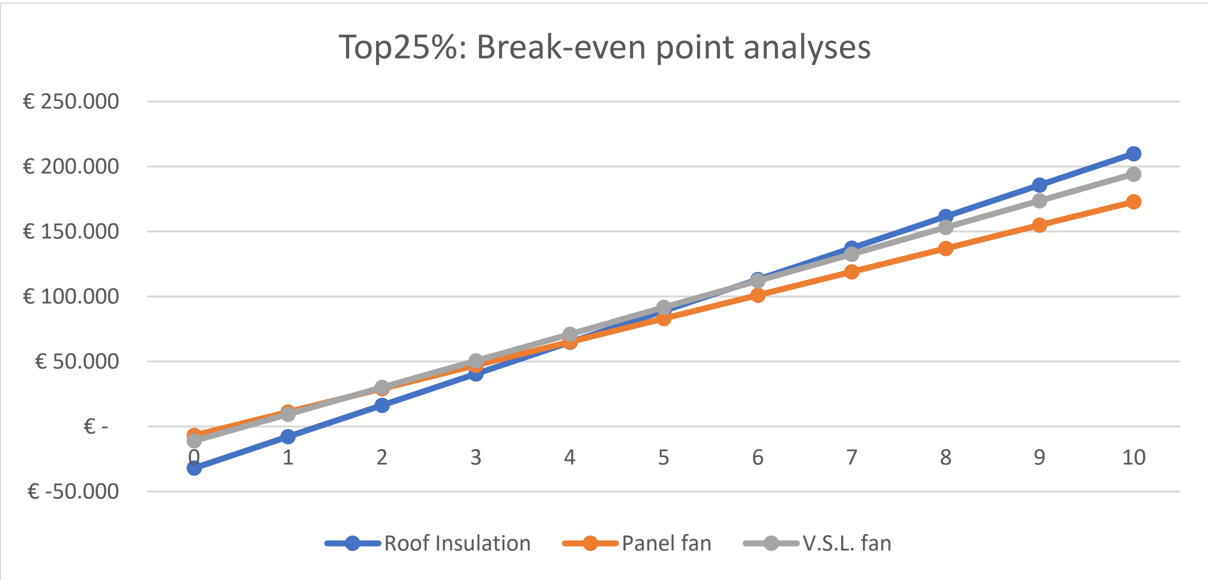


Figure 15. Top 25%, break-even point analyses

The profit in an average season is lower in *Figure 16*, but so are the cost. It will take exactly two years for both ventilation systems to be on break-even and four years for roof insulation to be break-even. In the long term V.S.L. fans are slightly cheaper in cost compared to roof insulation. The Panel fan is the most expensive of the three options.

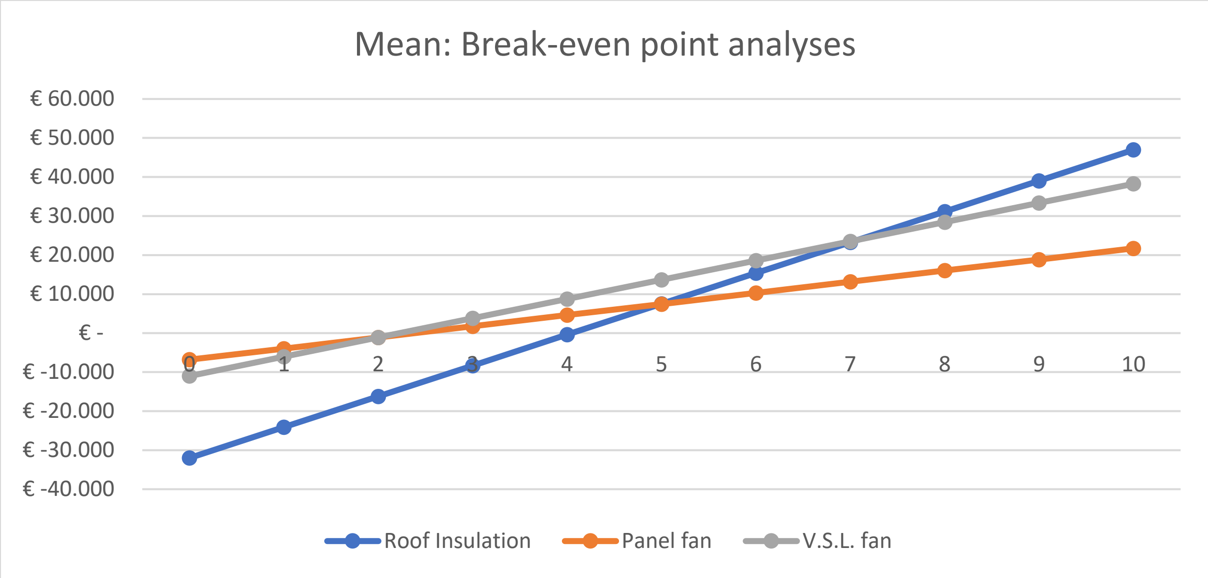


Figure 16. Mean, break-even point analyses

Figure 17 is the Low 25% chart, which has much less profit compared to the top 25% and the mean. Which can be seen within the results. None of the three investments go break-even within ten years. Which means that low temperatures will give opposite results compared to higher and average temperatures. On the low 25%, roof insulation is the most costly investment followed by panel fan setup and V.S.L. fan setup.

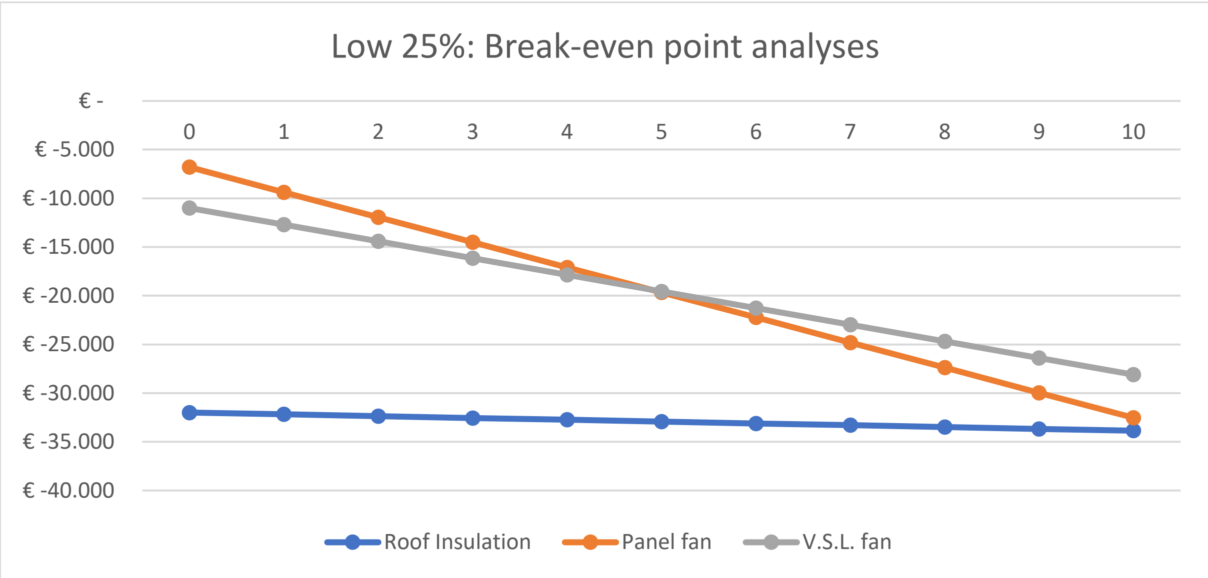


Figure 17. Low, break-even point analyses

4 Discussion

The goal of this study was to acknowledge the economic consequences of heat stress on dairy farms and how much it costs to prevent it. To answer this question, the sub-questions has been made to answer this. The process of this literature study and calculations went as planned and in the right order. The references used for answering the sub-questions were from reliable sources and most of them were also recent, so the sub-questions were correctly substantiated. Most of the research for the effects on heat stress were not researched upon an oceanic climate, which is a downside of this literature study. But since these studies have been using thermal heat index (THI) as scale of effect it was also applicable on the oceanic climate. Since THI is based on humidity and temperature and is usable on all climates because of that.

From the results we know now that in an oceanic climate it certainly is possible to get threshold, mild and moderate heat stress, some years more extreme than the other. And that the economic effects of heat stress gave a great different outcome depending on warmness of the climate, especially on milk-production and conception rates. Udder health effects of heat stress were there but more related to the somatic cell count the cow already had to generate effect. The average somatic cell count wouldn't give effect on milk loss based on the climate data. Heat stress prevention as investment is expensive, one more than the other. But depending on the climate the investments can go break-even and create a profit as seen in the break-even point analyses.

But how can this research be used for the future of dairy farming in an Oceanic climate. We know from the climate data that a warmer, average or colder season is enough to create heat stress. The highest economic consequences occur during a warmer season and because of that an investment in heat stress prevention goes break-even faster compared to an average- or colder season. But can colder seasons (low 25%) that doesn't show much economic effect nor go break-even for investment be forgotten or be less frequent to happen soon because of climate change? The Intergovernmental Panel of Climate Change predicted that temperatures will rise one to three degrees Celsius (NASA, 2018), which is for example is a THI rise from 68 to 72, which is most summer months about the difference between low 25% and the mean. So, you could say there is less chance of colder summers in the future.

The reader should also bear in mind that the studies climate data are outside temperatures. Which means it isn't hundred percent applicable to the inside of a barn. It all depends on many factors, how well is it naturally ventilated? Is it insulated? How much sunlight can come in? Is the barn hundred percent populated with cows or underpopulated or overpopulated (Fleming, 2018)? These are all examples of factors that have effect on the inside temperatures and which all could have effect on the THI level inside the barn. Which could mean that some dairy barns are worse or better compared to the outside temperature. This is why THI reduction by insulation and ventilation isn't taken into account which is a limitation of this study.

And is there a difference between dairy cow breeds? All the reference used for heat stress effects were based on Holstein-Friesian cows. But are the effects the same on other dairy cow breeds, for example a Jersey cows. The study by (Smith, Smith, Rude, & Ward, 2013) stated that Jerseys were more heat tolerant than Holstein-Friesian cows. Which could mean that a dairy farmer with a non-Holstein-Friesian herd will have different losses in terms of milk-production, health and conception rates.

5 Conclusion

Acknowledging the economic consequences of heat stress and finding out how much it would cost to prevent heat stress was the goal of this study. To answers the main question, several sub-questions have been made.

How many times a year can heat stress occur in an oceanic climate?

The results of this study indicate that there is on average a 117-day chance of threshold- and mild heat stress during the months: May to September. This based on outside temperatures of the oceanic climate data of the past ten years. The number of days could also go higher with 138 days with more mild heat stress in a warmer season (top 25%) or lower with 64 days with less mild heat stress in a colder season (low 25%). For the future above average seasons should be considered to happen more frequently because of climate change.

What are the effects and cost of heat stress on milk-production, udder-health and conception rates?

With these results and the literature results from the second and third question we know now that the heat stress affects milk-production, udder-health and conception rates based on Holstein-Friesian cows. The economic consequences of milk-production are the highest. Given an average of €8.315 loss per year on a hundred cow herd. This doubled in warmer seasons (top 25%) to €16.784 and tripled down in colder seasons to €2.614 (low 25%). Heat stress does affect udder-health but on an average somatic cell count heat stress doesn't have an economic effect in the oceanic climate. Conception rates are highly effected by mild heat stress but not on threshold heat stress. Which will give an economic loss of €2.381 to €10.212 and no loss on colder seasons.

What are the investment cost and what is the break-even point of an investment in heat stress prevention?

An investment in heat stress prevention was calculated for three different possibilities; roof insulation, panel-fans and variable speed louver fans. Roof insulation was the most expensive investment, but didn't have operational cost, which both the mechanical ventilation systems have. The variable speed louver fan had the lowest operational cost based on the climate data. With the results of the first four sub-questions the fifth sub-question could be answered. The break-even point analyses indicated that for a warmer season (top 25%) or average seasons all three investment will go break-even. But on a colder season (low 25%) all three investment will not go break-even within ten years. On warmer season mechanical ventilation investment will go break-even within half a year and roof insulation within 1,5 years. On average seasons mechanical ventilation will take two years and roof insulation will take four years. Which means that you only need two warmer seasons to make an investment in heat stress prevention profitable.

What are the economic consequences of heat stress and how much does it cost to prevent it?

With these results the main question of this study: *What are the economic consequences of heat stress and how much does it cost to prevent it?* Has been answered. This study gives dairy farmers several standardized indicators of what the economic consequences of heat stress are and what it could cost for them to prevent it.

6 Recommendations

The results of this study for dairy farmers are useful! But the climate data is based on the past and we don't know what exactly will happen in the near future. What we know now is that above average seasons are likely to happen more frequently then colder seasons because of the effects of climate change. Inside temperatures in a particular barn might also be better or worse depending on many factors as has been discussed in chapter 4. The results are also based on Holstein-Friesians cows which should be considered by dairy farmers that, that might not be a hundred percent applicable to their farm if they have another breed or cross-breeds.

That is why I recommend dairy farmers to take this study as an indicator of heat stress effects on their dairy farm. Since every dairy herd and barn is different, this study isn't hundred percent applicable for every situations. That is why dairy farmers should do the following, for short and long term:

For short term solutions dairy farmer could install sprinklers at the exit of the milking parlor to wet the cows on their backs. This is also effective as heat stress prevention as we know from the preface. But on the long-term dairy farmers should do the following:

1) Evaluate how well their barn is suited against heat.
2) Check if their herd is hundred percent Holstein-Friesian.
3) Consider the economic consequences of heat stress.
4) Ask an expert for advice on the best way to prevent heat stress.
5) Invest in heat stress prevention if needed to increase animal welfare and revenue.

Bibliography

Animal Sciences Group of WageningenUR. (2008, december). Cowel-model geeft bedrijven een welzijnscore. *V-Focus*, 34-35.

Animal Sciences group, WageningUR. (2009). *Moderne huisvesting melkvee.* Wageningen: WageningenUR.

Artex Barn Solutions. (2018). Thermal Heat Index. Abbotsford, Britisch Columbia, Canada.

Beerling, W. (2014). Licht of isolatie? Of een beetje van beide? *Veehouder techniek*, 32-35.

Bernabucci, U., Biffani, S., Buggiotti, L., Vitali, A., Lacetera, N., & Nardone, A. (2014). The Effects of Heat Stress in Italian Holstein Dairy Cattle. *Journal of Dairy Science, Volume 97, Issue 1*, 471-486.

Beunk, H. (2016). Windkracht 1: Mechanisch ventileren met HVLS. *Veehouderij Techniek*, 12-14.

Bos, B. (2012). Dierenwelzijn en milieu samen in Kwatrijn : speciale uitgave dier & welzijn. *V-focus : vakblad voor adviseurs in de dierlijke sector*, 24-26.

Bouraoui, R., Lahmar, M., Majdoub, A., Djemali, M., & Belyea, R. (2002). The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. *Animal Research, Volume 51, Issue 6*, 479-491.

Brügemann, K., Gernand, E., König von Borstel, U., & König, S. (2012). Defining and evaluating heat stress thresholds in different dairy cow production systems. *Archives of Animal Breeding, Volume 55, Issue 1*, 13-24.

CRV BV. (2018). *CRV Jaarstatistieken 2017.* Arnhem: CRV.

CRV4ALL. (2015). *Is de vruchtbaarheid van mijn veestapel goed?* Retrieved from CRV4All, Vruchtbaarheid: https://www.crv4all.nl/vruchtbaarheid/is-de-vruchtbaarheid-van-mijn-veestapel-goed/

Dairy Link. (2018, July 23). *Storm Fan*. Retrieved from Dairylink.com: http://www.dairylink.com.eg/en/storm-fan/

Europian Commission. (2017). *Animal Welfare*. Retrieved from europe.eu: https://ec.europa.eu/food/animals/welfare_en

Farmtek. (2018, July 23). *Farmtek*. Retrieved from Farmtek: https://www.farmtek.com/farm/supplies/prod1;ft_cooling_fans-ft_circulation_fans;pg105528.html

Fleming, J. (2018, June 27). Ventilation Expert. (S. v. Ooster, Interviewer)

García-Ispierto, I., López-Gatius, F., Bech-Sabat, G., Santolaria, P., Yániz, J., Nogareda, C., . . . López-Béjar, M. (2007). Climate factors affecting conception rate of high producing dairy cows in northeastern Spain. *Theriogenology, Volume 67, Issue 8*, 1379-1385.

Halasa, T., Nielen, M., De Roos, A., Van Hoorne, R., de Jong, G., Lam, T., . . . Hogeveen, H. (2009). Production loss due to new subclinical mastitis in Dutch dairy cows estimated with a test-day model. *Journal of Dairy Science, Volume 92, Issue 2*, 599-606.

handelsonderneming kienhuis. (2018, July 18). *Sandwhichpaneel wand 40mm donkergroen 4000mm*. Retrieved from handelsondernemingkienhuis: https://www.handelsondernemingkienhuis.nl/product/sandwichpaneel-wand-40mm-donkergroen-4000mm/

Idriss, S., Tancin, V., Foltys, V., Kirchnerová, K., Tancinová, D., & Vrsková, M. (2013). Relationship between mastitis causative pathogens and somatic cell counts in milk of dairy cows. *Potravinarstvo, Volume 7, Issue 1*, 207-212.

Ingraham, R., Stanley, R., & Wagner, W. (1979). Seasonal effects of tropical climate on shaded and nonshaded cows as measured by rectal temperature, adrenal cortex hormones, thyroid hormone, and milk production. *Am. J. Vet. Res., 40*, 1792-1797.

Je-In, L., & Ill-Hwa, K. (2007). Pregnancy loss in dairy cows: the contributing factors, the effects on reproductive performance and the economic impact. *Journal of Veterinary Science, Volume 8, Issue 3*, 283-288.

Jertina, J., Skorjanc, D., & Babnik, D. (2017). A new somatic cell count index to more accurately predic milk yield losses. *Archives Animal Breeding, Volume 60, Issue 4*, 373-383.

Köppen, W. (1980). *Koppen Climate classification*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification

Li, M., Zheng, N., Zhao, S., Cheng, J., Yang, Y., Zhang, Y., . . . Wang, J. (2016). Long-term heat stress induces the inflammatory response in dairy cows revealed by plasma proteome analysis. *Biochemical and Biophysical Research Communications, Volume 471, Issue 2*, 296-302.

LTO Nederland, ZuivelNL, European dairy farmers. (2017). *LTO International comparison of producer prices for milk.* Den Haag: LTO Nederland.

LTO Noord. (n.d.). Retrieved from mutifunctionelelandbouw.net: http://multifunctionelelandbouw.net/system/files/documenten/boek/warmteverlies_via_schuin_dak_beperken.pdf

NASA. (2018). *Global climate chang; Vital signs of the planet*. Retrieved from Climate.nasa.gov: https://climate.nasa.gov/effects/

Nasr, M., & El-Tarabany, M. (2017). Impact of three THI levels on somatic cell count, milk yield and composition of multiparous Holstein cows in a subtropical region. *Journal of Thermal Biology, Volume 64*, 73-77.

NUON. (2018). *Nuon tarieven 2018*. Retrieved from Overstappen.nl: https://www.overstappen.nl/energie/leveranciers/nuon-tarieven/

Olde Riekerink, R., Barkema , H., & Stryhn, H. (2007). The Effect of Season on Somatic Cell Count and the Incidence of Clinical Mastitis. *Journal of Dairy Science, Volume 90, Issue 4*, 1704-1715.

Ouweltjes, W., Dooren, H., & Ruis-Heutinck, L. (2002). Kan welzijn in ligboxenstallen nog beter? *Praktijkkompas Rundvee*, 2-3.

Pavani, K., Carvalhais, I., Faheem, M., Chaveiro, A., Vieira Reis, F., & Moreira da Silva, F. (2015). Reproductive Performance of Holstein Dairy Cows Grazing in Dry-summer Subtropical Climat Conditions: Effect of Heat Stress and Heat Schock on Meiotic Competence and In vitro Fertilization. *Asian-australasian Journal of Animal Sciences, Volume 28, Issue 3*, 334-342.

Pijnappels, E. (2007). Geïsoleerd dak voorkomt hittestress. *DLV Praktijkadvies*, 30-31.

QLIP. (2017). Celgetal zet opnieuw stap voorwaarts. *Qlip/Boerderij*, 1/1. Retrieved from https://www.qlip.nl/nl/actueel/580-celgetal-zet-opnieuw-stap-voorwaarts

Ravagnolo, O., Misztal, I., & Hoogenboom, G. (2000). Genetic component of heat stress in dairy cattle, development of heat index function. *Journal of Dairy Science, Volume 83, Issue 9*, 2120-2125.

Rejeb, M., Sadraoui, R., Najar, T., & M'rad, M. B. (2016). A Complex Interrelationship between Rectal Temperature and Dairy Cows' Performance under Heat Stress Conditions. *Open Journal of Animal Sciences*, 1-7.

Royal Netherlands Metrological Institute. (2017). *Klimatologie metingen en waarnemingen*. Retrieved from knmi.nl: https://www.knmi.nl/nederland-nu/klimatologie-metingen-en-waarnemingen

Schüller, L., Burfeind, O., & Heuwieser, W. (2014). Impact of heat stress on conception rate of dairy cows in the moderate climate considering different temperature humidity index threshold, periods relative to breeding and, heat load indices. *Theriogenology, Volume 81, Issue 8*, 1050-1057.

Shock, D., LeBlanc, S., Leslie, K., Hand, K., Godkin, M., Coe, J., & Kelton, D. (2015). Exploring the characteristics and dynamics of Ontario dairy herds experiencing increases in bulk milk somatic cell count during the summer. *Journal of Dairy Science, Volume 98, Issue 6*, 3741-3753.

Smith, D., Smith, T., Rude, B., & Ward, S. (2013). Short communication: Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. *Journal of Dairy Science, Volume 96, Issue 5*, 3028-3033.

Spiers, D., Spain, J., Sampson, J., & Rhoads, R. (2004). Use of physiological parameters to predict milk yield and feed intake in heat-stressed dairy cows. *Journal of Thermal Biology, Volume 29, Issue 7*, 759-764.

Tao et al. (2012). *Hittestress beïnvloedt vruchtbaarheid en geboortegewicht*. Retrieved from melkvee.nl: https://www.melkvee.nl/artikel/71484-hittestress-beinvloedt-vruchtbaarheid-en-geboortegewicht/

van Ginneken, R. (2010). Hittestress te lijf. *Onafhankelijk maandblad voor de Nederlandse melkveehouderij*, 12-14.

Veehouder Veearts. (2016). Hittestress ondermijnt weerstand en productie. *Veehouder Veearts*, 10.

Versteeg, D. (2016). Een fris stalklimaat. *Veeteelt*, 30.

Wageningen University & Research. (2017, December). *Agrimatie.nl*. Retrieved from BINternet, land- en tuinbouw: https://www.agrimatie.nl/binternet.aspx?ID=4&bedrijfstype=2

Wageningen University & Research. (2017). *Kwantitatieve Informatie Veehouderij 2017-2018.* Wageningen: Wageningen University & Research.

Wang, X., Zhang, G., & Choi, C. (2018). Effect of airflow speed and direction on convective heat transfer of standing and reclining cows. *Biosystems engineering, Volume 167*, 87-98.

Welfare Quality. (2009). *Welfare Quality assesment protocol for cattle.* Lelystad: Welfare Quality Consortium.

West, J., Mullinix, B., & Bernard, J. (2003). Effects of hot, humid weather on milk temperature, dry matter intake, and milk yield of lactating dairy cows. *Journal of Dairy Science, Volume 86, Issue 1*, 232-242.

ZuivelNL. (2016). *Zuivel in Cijfers.* Den Haag: ZuivelNL.

Annex

The following annex are used in this document:

Annex I: Thermal heat index
Annex II: Oceanic climate data
Annex III: Economic consequences on milk production due to heat stress
Annex IV: Cost of pregnancy loss due to heat stress
Annex V: Investment in Ventilation
Annex VI: Break-even point analyses

Annex I: Thermal heat index

Reference: (Artex Barn Solutions, 2018).

THI Index

Temp		% Humidity																				
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
73	23	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72	73	73
74	23	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
75	24	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
76	24	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
77	25	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
78	26	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
79	26	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	78	79
80	27	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
81	27	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80	80	81
82	28	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	28	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
84	29	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	29	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
86	30	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	31	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
88	31	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	32	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	32	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	33	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	33	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	34	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	92	93
94	34	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	35	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	36	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
97	36	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	37	76	77	78	79	80	82	83	84	85	86	87	88	89	90	91	93	94	95	96	97	98
99	37	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	96	97	98	99
100	38	77	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	100
101	38	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	97	99	100	101
102	39	78	79	80	81	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
103	39	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101	102	103
104	40	79	80	81	82	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
105	41	79	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99	100	101	102	104	105
106	41	80	81	82	84	85	86	88	89	90	91	93	94	95	97	98	99	101	102	103	105	106
107	42	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104	106	107
108	42	81	82	83	85	86	87	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
109	43	81	82	84	85	87	88	89	91	92	94	95	96	98	99	101	102	103	105	106	108	109
110	43	81	83	84	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110
111	44	82	83	85	86	88	89	91	92	94	95	96	98	99	101	102	104	105	107	108	110	111
112	44	82	84	85	87	88	90	91	93	94	96	97	99	100	102	103	105	106	108	109	111	112
113	45	83	84	86	87	89	90	92	93	95	96	98	99	101	102	104	105	107	108	110	111	113
114	46	83	85	86	88	89	91	92	94	96	97	99	100	102	103	105	106	108	109	111	112	114
115	46	84	85	87	88	90	91	93	95	96	98	99	101	102	104	106	107	109	110	112	113	115
116	47	84	86	87	89	90	92	94	95	97	98	100	102	103	105	106	108	110	111	113	114	116

Annex II: Oceanic climate data

REFERENCE: Royal Netherlands Metrological Institute

Mean temperature in Celcius

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	6,5	5,1	5,9	8,9	15,7	16,5	18,1	17,4	13,6	10,1	6,9	2,4
2009	8	3,3	6,3	12,2	13,9	15,6	18,1	18,5	15	10,7	9,5	2,2
2010	-5	1,6	6,4	9,7	10,5	16,4	19,9	16,8	13,6	10,4	5,8	-1,1
2011	3,5	4,6	6	13,1	14	16,1	15,9	16,9	15,6	11,4	7,2	6,5
2012	4,9	8	8,3	8,4	14,5	14,9	17,3	18,5	14,2	10,5	6,8	5
2013	2	1,7	2,5	8,1	11,5	15,3	19,2	18,1	14,4	12,2	6,7	5,9
2014	5,7	6,5	8,4	12,1	13,2	16,2	19,8	16,1	15,9	13,4	8,2	4,8
2015	4	3,5	6,2	9	12,4	15,6	18,4	18,5	13,4	9,9	9,9	9,6
2016	4,8	4,6	5,4	8,7	14,5	16,8	18,4	17,9	17,3	9,9	5,4	4,7
2017	1,7	5,1	8,6	8,6	15	18	17,9	17,2	13,7	13,3	7,3	4,9
Mean	**3,6**	**4,4**	**6,4**	**9,9**	**13,5**	**16,1**	**18,3**	**17,6**	**14,7**	**11,2**	**7,4**	**4,5**

Maximum temperature in Celcius

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	8,8	9,2	9,4	13,8	21,2	21,6	22,7	21,8	18,2	13,9	9,2	5,1
2009	3,7	5,9	10	17,9	18,9	20,3	22,8	24	19,7	14,5	11,9	4,4
2010	1,7	4,3	10,2	15,1	14,7	22	25,2	21	17,8	14,3	8,1	1
2011	5,9	7,2	11,1	19,1	19	20,6	19,9	21,3	20,4	15,9	10,7	8,5
2012	7,4	3,9	12,8	12,5	19,2	18,9	21,6	23,7	19	14,5	9,8	7,3
2013	4,2	4,3	6	13,1	15,7	19,9	24,3	23,4	18,9	15,8	9,5	8,6
2014	8	9,7	13,8	17,1	17,7	20,9	24,6	20,4	21	17	10,8	7,1
2015	6,4	7	10,2	14,3	17	20,3	23,2	23,6	17,8	13,8	12,8	11,9
2016	7,2	7,7	9,5	13	19,2	21,2	22,8	22,7	23	13,9	8,7	7,3
2017	4,5	7,6	13,3	13,2	20,3	22,9	22,5	22,2	18,2	16,5	10,1	7
Mean	**5,8**	**6,7**	**10,6**	**14,9**	**18,3**	**20,9**	**23,0**	**22,4**	**19,4**	**15,0**	**10,2**	**6,8**

Humidity

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	86	81	81	75	66	75	79	82	83	86	90	89
2009	86	88	81	75	72	75	76	75	82	85	87	87
2010	87	85	76	68	76	70	70	80	84	86	90	90
2011	90	86	80	70	68	76	78	82	83	84	91	83
2012	84	81	82	79	76	76	77	78	81	85	89	89
2013	85	82	69	70	76	75	76	77	84	86	89	87
2014	86	81	75	76	76	74	78	82	84	88	88	85
2015	85	84	78	72	70	70	75	78	84	88	86	85
2016	87	82	81	76	71	81	78	79	79	86	88	90
2017	87	85	77	73	73	71	77	79	86	83	87	89
Mean	**86**	**84**	**78**	**73**	**72**	**74**	**76**	**79**	**83**	**86**	**89**	**87**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean C	4	4	6	10	14	16	18	18	15	11	7	4
Max Mean C	6	7	11	15	18	21	23	22	19	15	10	7
HS line	22	22	22	22	22	22	22	22	22	22	22	22
Humidity%	86	84	78	73	72	74	76	79	83	86	89	87

May 2008 - 2017

Maximum temperature ***All yearly data is writen times x10***

Day	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean	Top25%	Low25%
1	149	223	149	185	192	174	183	133	141	137	**16,7**	**18,5**	**14,3**
2	165	187	87	148	198	170	122	158	179	152	**15,7**	**17,7**	**14,9**
3	198	144	75	141	143	190	137	170	140	152	**14,9**	**16,6**	**14,0**
4	217	147	112	141	120	174	137	194	160	133	**15,4**	**17,1**	**13,4**
5	220	132	132	184	101	188	184	222	188	111	**16,6**	**18,8**	**13,2**
6	238	161	139	223	118	231	178	155	236	188	**18,7**	**22,9**	**15,7**
7	255	175	94	278	151	232	162	162	258	162	**19,3**	**24,9**	**16,2**
8	251	177	109	269	176	219	134	194	252	153	**19,3**	**24,3**	**15,9**
9	263	168	118	204	189	170	161	161	253	138	**18,3**	**20,0**	**16,1**
10	274	204	110	232	218	158	156	191	221	159	**19,2**	**22,0**	**15,8**
11	263	174	115	209	174	137	117	256	255	228	**19,3**	**24,8**	**14,6**
12	269	178	77	174	131	131	146	175	251	212	**17,4**	**20,4**	**13,5**
13	260	214	92	187	143	137	150	181	222	190	**17,8**	**20,8**	**14,5**

14	266	212	128	155	166	120	139	167	121	199	**16,7**	**19,1**	**13,1**
15	234	174	146	154	124	172	150	144	121	212	**16,3**	**17,4**	**14,5**
16	152	171	155	150	120	112	183	149	136	262	**15,9**	**16,7**	**13,9**
17	123	163	159	168	150	104	207	162	181	284	**17,0**	**17,8**	**15,2**
18	155	183	157	169	191	128	231	140	187	211	**17,5**	**19,0**	**15,6**
19	145	201	171	160	206	151	243	137	173	167	**17,5**	**19,4**	**15,3**
20	168	202	207	212	227	126	271	147	186	173	**19,2**	**21,1**	**16,9**
21	195	194	201	221	247	115	215	174	234	202	**20,0**	**22,0**	**19,4**
22	213	177	198	186	284	123	230	199	190	246	**20,5**	**22,6**	**18,7**
23	229	213	237	214	288	104	207	157	133	210	**19,9**	**22,5**	**17,0**
24	233	224	225	162	283	125	196	199	146	223	**20,2**	**22,5**	**17,1**
25	181	253	181	215	257	139	213	153	145	230	**19,7**	**22,6**	**16,0**
26	156	192	130	179	256	124	223	158	193	266	**18,8**	**21,6**	**15,7**
27	220	152	154	152	266	195	174	189	209	319	**20,3**	**21,7**	**15,9**
28	258	186	172	165	243	216	146	165	227	266	**20,4**	**23,9**	**16,7**
29	212	207	210	217	185	124	118	158	205	286	**19,2**	**21,2**	**16,5**
30	203	221	159	281	223	168	169	154	180	212	**19,7**	**21,9**	**16,8**
31	195	239	172	167	184	206	194	165	226	222	**19,7**	**21,8**	**17,5**

Humidity

Days	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Mean**
1	79	75	83	42	81	60	80	65	69	70	**70,4**
2	77	78	93	48	86	60	72	60	68	87	**72,9**
3	65	81	91	51	88	64	69	77	72	85	**74,3**
4	51	68	69	71	85	68	73	72	69	78	**70,4**
5	50	90	74	62	76	68	61	72	56	81	**69,0**
6	60	81	71	53	69	64	71	67	65	73	**67,4**
7	56	80	82	47	68	72	78	74	52	79	**68,8**
8	51	72	87	49	82	82	88	67	46	72	**69,6**
9	50	69	79	87	88	65	81	75	49	71	**71,4**
10	46	65	69	77	87	70	87	72	62	68	**70,3**
11	44	67	75	72	77	82	88	64	58	62	**68,9**
12	46	50	89	74	73	78	84	67	50	82	**69,3**
13	58	54	88	71	73	79	76	67	61	87	**71,4**
14	63	62	76	70	69	83	76	65	63	77	**70,4**
15	77	92	72	71	83	70	72	70	68	69	**74,4**
16	93	78	66	86	70	91	65	78	73	65	**76,5**
17	91	83	73	81	64	94	72	61	69	61	**74,9**
18	69	71	73	83	74	85	73	77	74	82	**76,1**
19	72	74	62	85	74	82	65	76	81	77	**74,8**
20	63	70	64	76	88	94	65	72	80	77	**74,9**
21	60	73	73	71	80	95	78	71	71	68	**74,0**
22	62	72	76	74	74	76	67	67	87	65	**72,0**
23	51	68	73	64	82	80	71	76	91	69	**72,5**
24	52	69	71	58	65	75	72	68	75	75	**68,0**
25	78	69	67	59	50	80	70	72	88	73	**70,6**
26	86	88	65	61	50	82	83	66	78	60	**71,9**
27	79	78	72	75	61	59	94	66	77	57	**71,8**
28	72	77	74	78	74	58	96	70	80	64	**74,3**
29	89	60	68	75	84	91	91	75	83	71	**78,7**
30	89	61	88	67	73	82	74	66	92	76	**76,8**
31	85	65	83	81	93	77	71	84	79	69	**78,7**

Days	**Top25%**	**Mean**	**Low25%**	**Humidity**	**Top25% THI**	**Mean THI**	**Low25% THI**	Threshold	Mild	Moderate	Severe
1	18	17	14	70	64	54	58	66	72	80	90
2	18	16	15	73	63	60	59	66	72	80	90
3	17	15	14	74	61	59	57	66	72	80	90
4	17	15	13	70	62	59	56	66	72	80	90
5	19	17	13	69	65	61	56	66	72	80	90
6	23	19	16	67	70	64	60	66	72	80	90
7	25	19	16	69	74	65	61	66	72	80	90
8	24	19	16	70	73	65	60	66	72	80	90
9	20	18	16	71	66	64	61	66	72	80	90
10	22	19	16	70	69	65	60	66	72	80	90
11	25	19	15	69	73	65	58	66	72	80	90
12	20	17	13	69	67	62	57	66	72	80	90
13	21	18	14	71	68	63	58	66	72	80	90
14	19	17	13	70	65	61	56	66	72	80	90
15	17	16	14	74	62	61	58	66	72	80	90
16	17	16	14	77	62	60	57	66	72	80	90
17	18	17	15	75	63	62	59	66	72	80	90
18	19	18	16	76	65	63	60	66	72	80	90

19	19	18	15	75	66	63	59	66	72	80	90
20	21	19	17	75	68	65	62	66	72	80	90
21	22	20	19	74	70	67	66	66	72	80	90
22	23	20	19	72	70	67	64	66	72	80	90
23	23	20	17	73	70	66	62	66	72	80	90
24	22	20	17	68	70	66	62	66	72	80	90
25	23	20	16	71	70	66	60	66	72	80	90
26	22	19	16	72	69	65	60	66	72	80	90
27	22	20	16	72	69	67	60	66	72	80	90
28	24	20	17	74	73	67	61	66	72	80	90
29	21	19	16	79	69	66	61	66	72	80	90
30	22	20	17	77	70	66	62	66	72	80	90
31	22	20	18	79	70	66	63	66	72	80	90

June 2008-2017

Maximum temperature ***All yearly data is writen times x10***

Days	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Mean**	**Top25%**	**Low25%**
1	224	252	185	200	161	154	187	161	243	234	**20,0**	**23,2**	**16,7**
2	288	213	214	222	164	177	206	177	172	266	**21,0**	**22,0**	**17,7**
3	237	158	216	251	110	148	210	177	214	237	**19,6**	**23,2**	**16,3**
4	211	138	233	277	114	210	178	220	275	195	**20,5**	**23,0**	**18,2**
5	178	132	265	215	157	219	178	318	256	229	**21,5**	**24,9**	**17,8**
6	251	170	261	213	187	252	229	189	256	174	**21,8**	**25,2**	**18,8**
7	230	163	188	195	209	247	276	189	265	174	**21,4**	**24,3**	**18,8**
8	267	189	230	184	192	198	248	172	216	232	**21,3**	**23,2**	**19,0**
9	265	196	201	186	159	169	271	150	203	196	**20,0**	**20,3**	**17,3**
10	233	178	217	198	201	172	258	208	212	239	**21,2**	**22,9**	**19,9**
11	186	164	201	163	200	216	219	240	208	271	**20,7**	**21,8**	**19,0**
12	145	178	191	183	165	218	229	274	211	178	**19,7**	**21,6**	**17,8**
13	160	216	166	196	153	187	222	213	190	208	**19,1**	**21,2**	**17,1**
14	163	207	215	208	180	191	189	195	191	244	**19,8**	**20,8**	**19,0**
15	177	191	168	233	193	189	201	175	187	264	**19,8**	**19,9**	**18,0**
16	178	189	220	177	199	189	178	177	211	180	**19,0**	**19,7**	**17,8**
17	211	226	231	175	195	240	193	227	195	232	**21,3**	**23,0**	**19,5**
18	203	208	159	172	187	304	200	166	171	278	**20,5**	**20,7**	**17,1**
19	203	176	157	166	209	264	161	153	189	309	**19,9**	**20,8**	**16,2**
20	204	181	140	191	218	228	180	163	168	274	**19,5**	**21,5**	**17,1**
21	226	184	182	211	219	195	209	185	201	291	**21,0**	**21,7**	**18,8**
22	266	188	209	176	184	192	206	153	249	308	**21,3**	**23,9**	**18,5**
23	187	217	259	190	193	184	213	151	284	232	**21,1**	**22,8**	**18,8**
24	225	242	270	182	167	161	213	215	227	179	**20,8**	**22,7**	**18,0**
25	245	265	246	167	173	174	192	240	193	190	**20,9**	**24,4**	**17,8**
26	224	247	255	237	225	176	222	250	183	206	**22,3**	**24,5**	**21,0**
27	209	254	284	302	209	153	215	218	189	218	**22,5**	**24,5**	**20,9**
28	227	238	298	322	279	171	210	232	218	219	**24,1**	**26,9**	**21,8**
29	222	267	266	196	223	175	192	242	202	217	**22,0**	**23,7**	**19,8**
30	228	257	270	197	242	222	186	273	192	208	**22,8**	**25,3**	**20,0**

Humidity

Days	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Mean**
1	90	69	79	66	78	83	73	63	84	61	**74,6**
2	75	68	69	65	67	69	72	76	91	62	**71,4**
3	88	64	62	71	89	74	75	71	90	76	**76,0**
4	88	69	62	65	87	68	89	63	79	68	**73,8**
5	92	72	60	87	70	65	74	68	70	58	**71,6**
6	68	66	73	91	85	69	63	59	68	75	**71,7**
7	85	84	79	78	82	70	67	64	68	71	**74,8**
8	79	72	85	69	68	73	75	67	78	73	**73,9**
9	63	81	90	68	67	74	81	69	68	76	**73,7**
10	74	82	90	78	68	73	79	64	65	70	**74,3**
11	71	81	85	78	81	71	65	54	77	66	**72,9**
12	85	70	76	61	81	79	68	56	84	69	**72,9**
13	75	72	76	79	70	80	70	75	87	70	**75,4**
14	82	83	67	68	65	70	68	82	89	65	**73,9**
15	78	79	62	74	84	65	68	62	87	65	**72,4**
16	73	83	67	88	69	68	76	72	77	68	**74,1**
17	67	71	65	78	71	66	77	73	87	74	**72,9**
18	72	65	75	80	81	69	82	75	83	72	**75,4**
19	76	68	71	87	74	80	81	83	69	64	**75,3**
20	69	72	72	78	74	90	76	77	91	68	**76,7**
21	69	75	67	76	82	89	73	85	92	61	**76,9**

22	68	72	67	70	71	81	72	84	79	67	**73,1**
23	73	69	67	73	68	83	74	83	87	67	**74,4**
24	60	71	64	73	84	83	75	70	85	90	**75,5**
25	61	66	67	93	79	73	70	68	86	84	**74,7**
26	66	78	64	83	72	77	68	63	83	65	**71,9**
27	70	87	57	69	88	78	72	74	86	69	**75,0**
28	79	90	62	72	77	90	74	74	76	91	**78,5**
29	73	83	69	83	69	77	74	72	80	80	**76,0**
30	71	80	73	69	71	77	75	61	87	84	**74,8**

Days	Top25%	Mean	Low25%	Humidity	Top25% THI	Mean THI	Low25% THI	Threshold	Mild	Moderate	Severe
1	23	20	17	75	71	67	61	66	72	80	90
2	22	21	18	71	69	68	63	66	72	80	90
3	23	20	16	76	72	66	61	66	72	80	90
4	23	21	18	74	71	67	64	66	72	80	90
5	25	21	18	72	74	69	63	66	72	80	90
6	25	22	19	72	74	69	65	66	72	80	90
7	24	21	19	75	73	69	65	66	72	80	90
8	23	21	19	74	71	69	65	66	72	80	90
9	20	20	17	74	67	66	62	66	72	80	90
10	23	21	20	74	71	68	66	66	72	80	90
11	22	21	19	73	69	68	65	66	72	80	90
12	22	20	18	73	69	66	63	66	72	80	90
13	21	19	17	75	68	65	62	66	72	80	90
14	21	20	19	74	68	66	65	66	72	80	90
15	20	20	18	72	66	66	63	66	72	80	90
16	20	19	18	74	66	65	63	66	72	80	90
17	23	21	20	73	71	68	66	66	72	80	90
18	21	20	17	75	68	67	62	66	72	80	90
19	21	20	16	75	68	66	61	66	72	80	90
20	21	19	17	77	69	66	62	66	72	80	90
21	22	21	19	77	69	68	65	66	72	80	90
22	24	21	19	73	73	69	64	66	72	80	90
23	23	21	19	74	71	68	65	66	72	80	90
24	23	21	18	76	71	68	63	66	72	80	90
25	24	21	18	75	73	68	63	66	72	80	90
26	24	22	21	72	73	70	68	66	72	80	90
27	25	23	21	75	74	71	68	66	72	80	90
28	27	24	22	79	78	73	70	66	72	80	90
29	24	22	20	76	72	70	66	66	72	80	90
30	25	23	20	75	75	71	67	66	72	80	90

July 2008-2017

Maximum temperature *All yearly data is writen times x10*

Days	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean	Top25%	Low25%
1	277	264	284	184	191	193	193	331	198	210	**23,3**	**27,4**	**19,3**
2	312	297	336	176	213	208	209	331	187	196	**24,7**	**30,8**	**19,9**
3	200	289	278	190	235	191	262	291	198	220	**23,5**	**27,4**	**19,9**
4	218	249	258	205	265	225	289	327	228	232	**25,0**	**26,3**	**22,6**
5	244	277	236	243	274	235	228	282	181	248	**24,5**	**26,8**	**23,5**
6	233	231	209	212	229	252	244	238	194	265	**23,1**	**24,3**	**21,6**
7	194	185	257	221	240	251	235	258	221	260	**23,2**	**25,6**	**22,1**
8	187	191	289	215	197	251	170	196	212	245	**21,5**	**23,8**	**19,2**
9	192	181	344	208	194	234	178	176	236	232	**21,8**	**23,4**	**18,4**
10	199	172	327	225	196	195	276	226	274	259	**23,5**	**27,0**	**19,7**
11	209	202	293	237	192	182	238	287	217	207	**22,6**	**23,8**	**20,3**
12	190	215	258	238	186	194	245	204	203	182	**21,2**	**23,2**	**19,1**
13	196	231	265	141	205	218	231	196	183	205	**20,7**	**22,8**	**19,6**
14	230	253	286	163	178	225	227	213	192	186	**21,5**	**22,9**	**18,8**
15	205	239	225	222	185	260	224	211	213	215	**22,0**	**22,5**	**21,2**
16	202	251	241	211	177	260	258	251	226	221	**23,0**	**25,1**	**21,4**
17	175	226	211	192	195	263	283	256	238	231	**22,7**	**25,2**	**19,9**
18	206	196	233	173	192	271	311	221	265	252	**23,2**	**26,2**	**19,9**
19	199	195	275	208	181	257	329	205	295	294	**24,4**	**28,9**	**20,1**
20	176	209	293	226	191	226	272	214	329	242	**23,8**	**26,5**	**21,0**
21	159	266	259	202	184	304	212	254	274	227	**23,4**	**26,4**	**20,5**
22	205	244	235	186	209	326	272	231	261	242	**24,1**	**25,7**	**21,5**
23	232	210	226	170	256	316	284	217	253	191	**23,6**	**25,5**	**21,2**

24	260	204	204	133	289	269	263	233	255	202	**23,1**	**26,2**	**20,4**
25	281	206	198	197	287	290	221	183	224	200	**22,9**	**26,7**	**19,9**
26	288	234	206	186	270	269	251	209	234	236	**23,8**	**26,5**	**21,5**
27	282	249	212	217	287	254	262	197	213	214	**23,9**	**26,0**	**21,3**
28	279	217	223	243	221	234	235	189	235	210	**22,9**	**23,5**	**21,8**
29	249	251	207	189	207	243	259	176	212	205	**22,0**	**24,8**	**20,6**
30	272	208	227	168	195	205	235	181	209	229	**21,3**	**22,9**	**19,8**
31	298	214	215	181	179	225	244	194	205	228	**21,8**	**22,7**	**19,7**

Humidity

Days	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Mean**
1	58	77	67	71	70	79	71	49	85	87	**71,4**
2	75	70	54	72	64	74	68	66	71	78	**69,2**
3	87	73	78	71	72	89	65	76	80	76	**76,7**
4	71	70	65	74	71	84	62	66	75	72	**71,0**
5	76	71	66	69	75	79	81	75	83	73	**74,8**
6	75	73	61	72	82	73	84	71	75	76	**74,2**
7	81	85	61	68	74	72	72	68	74	80	**73,5**
8	86	82	65	67	89	70	92	81	82	81	**79,5**
9	85	69	60	75	83	68	95	71	76	69	**75,1**
10	95	78	64	72	79	76	84	65	72	73	**75,8**
11	85	74	78	70	75	72	87	60	69	81	**75,1**
12	76	84	77	76	76	84	83	80	82	84	**80,2**
13	75	73	71	94	83	78	84	92	81	75	**80,6**
14	70	73	75	95	85	83	80	88	74	82	**80,5**
15	85	68	66	77	75	70	85	91	69	72	**75,8**
16	72	64	73	86	89	69	76	70	80	85	**76,4**
17	87	69	74	80	83	74	72	73	78	71	**76,1**
18	86	81	70	83	80	70	62	72	70	66	**74,0**
19	89	76	65	74	82	69	61	82	64	67	**72,9**
20	79	70	59	81	73	78	81	86	61	84	**75,2**
21	88	80	62	81	76	68	95	66	77	63	**75,6**
22	79	83	73	71	74	63	73	67	82	75	**74,0**
23	81	86	76	78	68	69	62	66	82	85	**75,3**
24	65	81	64	94	66	76	63	74	82	82	**74,7**
25	67	77	80	80	67	75	80	86	85	86	**78,3**
26	85	72	84	87	71	84	82	80	77	77	**79,9**
27	81	79	82	84	76	86	79	85	87	69	**80,8**
28	86	78	75	82	84	79	90	84	83	78	**81,9**
29	83	70	78	81	73	73	84	77	83	87	**78,9**
30	71	77	73	78	72	82	77	75	89	76	**77,0**
31	70	77	84	75	84	82	78	69	79	73	**77,1**

Days	**Top25%**	**Mean**	**Low25%**	**Humidity**	**Top25% THI**	**Mean THI**	**Low25% THI**	Threshold	Mild	Moderate	Severe
1	27	23	19	71	78	71	65	66	72	80	90
2	31	25	20	69	82	73	66	66	72	80	90
3	27	24	20	77	78	72	66	66	72	80	90
4	26	25	23	71	76	74	70	66	72	80	90
5	27	24	24	75	77	74	72	66	72	80	90
6	24	23	22	74	73	71	69	66	72	80	90
7	26	23	22	74	75	71	70	66	72	80	90
8	24	22	19	80	73	69	66	66	72	80	90
9	23	22	18	75	72	69	64	66	72	80	90
10	27	23	20	76	78	72	66	66	72	80	90
11	24	23	20	75	72	71	67	66	72	80	90
12	23	21	19	80	72	69	65	66	72	80	90
13	23	21	20	81	71	68	66	66	72	80	90
14	23	22	19	81	72	69	65	66	72	80	90
15	22	22	21	76	71	70	68	66	72	80	90
16	25	23	21	76	75	71	69	66	72	80	90
17	25	23	20	76	75	71	67	66	72	80	90
18	26	23	20	74	76	72	66	66	72	80	90
19	29	24	20	73	80	73	67	66	72	80	90
20	26	24	21	75	77	73	68	66	72	80	90
21	26	23	20	76	77	72	67	66	72	80	90
22	26	24	21	74	75	73	69	66	72	80	90
23	26	24	21	75	75	72	68	66	72	80	90
24	26	23	20	75	76	71	67	66	72	80	90
25	27	23	20	78	77	71	67	66	72	80	90
26	26	24	22	80	77	73	69	66	72	80	90
27	26	24	21	81	77	73	69	66	72	80	90

28	24	23	22	82	73	72	70	66	72	80	90
29	25	22	21	79	74	70	68	66	72	80	90
30	23	21	20	77	71	69	66	66	72	80	90
31	23	22	20	77	71	70	66	66	72	80	90

August 2008 - 2017

Maximum temperature ***All yearly data is writen times x10***

Day	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean	Top25%	Low25%
1	234	254	228	217	269	307	259	220	210	227	**24,3**	**25,8**	**22,2**
2	244	192	201	267	214	340	276	242	186	220	**23,8**	**26,1**	**20,4**
3	208	224	221	234	230	234	253	300	217	225	**23,5**	**23,4**	**22,2**
4	213	254	201	253	237	262	233	215	208	218	**22,9**	**24,9**	**21,4**
5	236	271	202	229	238	292	243	250	216	204	**23,8**	**24,8**	**21,9**
6	270	289	233	246	204	222	213	284	224	217	**24,0**	**26,4**	**21,8**
7	216	283	208	205	192	171	230	270	228	226	**22,3**	**23,0**	**20,6**
8	206	228	209	191	207	219	223	230	205	196	**21,1**	**22,2**	**20,5**
9	226	220	223	173	219	232	231	243	185	213	**21,7**	**23,0**	**21,5**
10	227	245	225	201	219	199	225	252	168	205	**21,7**	**22,7**	**20,2**
11	216	224	213	211	213	219	207	254	163	203	**21,2**	**21,8**	**20,8**
12	228	197	203	211	241	211	202	230	226	216	**21,7**	**22,8**	**20,5**
13	212	221	210	200	245	197	217	284	215	215	**22,2**	**22,0**	**21,1**
14	206	223	242	212	262	218	203	254	217	241	**22,8**	**24,2**	**21,3**
15	212	279	202	211	288	207	197	221	217	218	**22,5**	**22,0**	**20,8**
16	228	237	223	218	241	269	187	166	210	233	**22,1**	**23,6**	**21,2**
17	218	229	180	222	270	229	167	152	234	199	**21,0**	**22,9**	**18,5**
18	191	250	199	194	320	226	173	168	242	201	**21,6**	**23,8**	**19,2**
19	220	296	210	197	330	211	159	225	243	196	**22,9**	**23,9**	**20,0**
20	193	338	276	231	270	212	178	249	229	198	**23,7**	**26,5**	**20,2**
21	206	222	259	274	267	240	182	253	198	208	**23,1**	**25,8**	**20,7**
22	199	221	225	234	221	216	171	265	227	235	**22,1**	**23,2**	**21,7**
23	195	255	214	242	231	262	174	259	269	250	**23,5**	**25,8**	**21,8**
24	201	273	199	209	239	235	177	231	302	222	**22,9**	**23,8**	**20,3**
25	220	211	205	242	218	224	169	199	310	234	**22,3**	**23,2**	**20,7**
26	193	240	204	212	196	240	165	252	262	250	**22,1**	**24,8**	**19,8**
27	181	234	172	183	218	242	207	185	265	247	**21,3**	**24,0**	**18,4**
28	197	205	184	166	228	241	214	209	246	268	**21,6**	**23,8**	**19,9**
29	232	188	167	165	241	242	212	236	214	290	**21,9**	**24,0**	**19,4**
30	249	187	179	181	210	233	186	253	238	225	**21,4**	**23,7**	**18,6**
31	275	256	187	179	171	211	190	265	254	197	**21,9**	**25,6**	**18,8**

Humidity

Days	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
1	76	72	77	77	77	68	75	69	78	76	**74,5**
2	77	84	89	74	85	65	84	65	95	78	**79,6**
3	90	76	75	84	79	73	77	67	88	72	**78,1**
4	78	70	82	83	78	68	74	77	79	71	**76,0**
5	82	67	79	79	84	70	76	63	79	79	**75,8**
6	77	69	70	87	80	76	84	73	82	75	**77,3**
7	91	75	82	79	86	93	89	76	82	72	**82,5**
8	87	76	86	79	87	78	91	71	74	87	**81,6**
9	78	84	76	75	75	77	77	77	77	78	**77,4**
10	80	77	84	73	72	73	86	79	77	86	**78,7**
11	81	83	76	84	77	76	73	81	94	75	**80,0**
12	78	87	83	88	63	76	76	79	84	88	**80,2**
13	75	79	78	92	78	77	75	77	84	79	**79,4**
14	82	75	71	83	87	74	84	86	79	77	**79,8**
15	81	68	82	77	72	91	82	88	76	88	**80,5**
16	72	80	84	70	75	81	75	88	75	82	**78,2**
17	79	82	90	78	67	80	88	96	67	89	**81,6**
18	93	76	78	90	70	82	85	89	71	82	**81,6**
19	82	72	77	81	71	80	86	78	80	78	**78,5**
20	88	68	67	76	78	79	81	76	76	75	**76,4**
21	83	73	78	81	78	76	75	80	85	80	**78,9**
22	94	77	84	87	72	83	84	63	82	70	**79,6**
23	84	66	83	91	73	72	80	65	72	72	**75,8**
24	84	62	67	89	75	78	80	85	73	78	**77,1**
25	80	87	76	85	81	88	89	81	74	79	**82,0**
26	86	74	95	85	90	63	91	80	78	77	**81,9**
27	90	79	87	85	75	65	80	89	77	74	**80,1**
28	85	74	82	90	80	76	85	82	80	76	**81,0**
29	84	74	88	77	74	77	79	73	80	79	**78,5**

30	77	80	80	87	86	82	88	87	79	93	**83,9**
31	78	68	81	84	82	76	86	88	76	83	**80,2**

Days	Top25%	Mean	Low25%	Humidity	Top25% THI	Mean THI	Low25% THI	Threshold	Mild	Moderate	Severe
1	26	24	22	75	76	73	70	66	72	80	90
2	26	24	20	80	77	73	68	66	72	80	90
3	23	23	22	78	72	72	70	66	72	80	90
4	25	23	21	76	74	71	69	66	72	80	90
5	25	24	22	76	74	73	70	66	72	80	90
6	26	24	22	77	77	73	70	66	72	80	90
7	23	22	21	83	72	71	68	66	72	80	90
8	22	21	21	82	71	69	68	66	72	80	90
9	23	22	21	77	71	69	69	66	72	80	90
10	23	22	20	79	71	69	67	66	72	80	90
11	22	21	21	80	70	69	68	66	72	80	90
12	23	22	21	80	71	70	68	66	72	80	90
13	22	22	21	79	70	70	69	66	72	80	90
14	24	23	21	80	74	71	69	66	72	80	90
15	22	23	21	81	70	71	68	66	72	80	90
16	24	22	21	78	73	70	69	66	72	80	90
17	23	21	18	82	72	69	65	66	72	80	90
18	24	22	19	82	73	70	66	66	72	80	90
19	24	23	20	79	73	71	67	66	72	80	90
20	26	24	20	76	77	73	67	66	72	80	90
21	26	23	21	79	76	72	68	66	72	80	90
22	23	22	22	80	72	70	70	66	72	80	90
23	26	24	22	76	76	72	70	66	72	80	90
24	24	23	20	77	73	71	67	66	72	80	90
25	23	22	21	82	72	71	68	66	72	80	90
26	25	22	20	82	75	70	67	66	72	80	90
27	24	21	18	80	73	69	64	66	72	80	90
28	24	22	20	81	73	70	67	66	72	80	90
29	24	22	19	79	73	70	66	66	72	80	90
30	24	21	19	84	73	69	65	66	72	80	90
31	26	22	19	80	76	70	65	66	72	80	90

September 2008-2017

Maximum temperature ***All yearly data is writen times x10***

Days	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean	Top25%	Low25%
1	204	211	185	191	193	179	212	195	229	193	**19,9**	**20,9**	**19,2**
2	186	212	177	251	196	196	212	188	217	194	**20,3**	**21,2**	**19,0**
3	173	183	196	279	230	236	212	171	229	200	**21,1**	**23,0**	**18,6**
4	193	181	195	221	247	260	235	166	213	216	**21,3**	**23,2**	**19,4**
5	193	183	197	190	201	303	228	169	228	217	**21,1**	**22,5**	**19,1**
6	206	181	205	166	196	279	205	170	242	183	**20,3**	**20,6**	**18,2**
7	169	242	150	177	232	198	216	169	268	185	**20,1**	**22,8**	**17,1**
8	182	276	210	166	254	186	205	169	276	158	**20,8**	**24,3**	**17,2**
9	233	190	208	200	281	178	178	185	229	177	**20,6**	**22,4**	**18,0**
10	226	200	183	254	233	159	184	196	257	177	**20,7**	**23,1**	**18,3**
11	264	182	233	201	182	194	204	201	217	174	**20,5**	**21,4**	**18,5**
12	200	196	191	210	169	196	216	202	281	183	**20,4**	**20,8**	**19,2**
13	164	171	191	187	171	178	211	194	312	176	**19,6**	**19,3**	**17,2**
14	174	191	167	179	175	179	209	198	314	144	**19,3**	**19,6**	**17,4**
15	167	166	171	187	191	172	228	159	290	164	**19,0**	**19,0**	**16,6**
16	165	201	172	192	193	157	246	192	212	129	**18,6**	**19,9**	**16,7**
17	160	180	150	173	199	143	252	164	216	172	**18,1**	**19,4**	**16,1**
18	166	212	167	166	174	157	253	184	207	162	**18,5**	**20,1**	**16,6**
19	172	249	162	179	150	153	244	175	198	174	**18,6**	**19,3**	**16,5**
20	181	209	181	187	157	168	240	181	200	175	**18,8**	**19,7**	**17,7**
21	176	198	186	186	162	177	192	186	207	186	**18,6**	**19,1**	**17,9**
22	167	208	225	178	161	211	175	174	213	192	**19,0**	**21,0**	**17,4**
23	155	197	208	185	136	200	177	173	203	183	**18,2**	**19,9**	**17,4**
24	164	195	178	209	216	182	165	157	236	204	**19,1**	**20,8**	**16,8**
25	176	176	150	227	168	186	178	168	243	181	**18,5**	**18,5**	**17,0**
26	184	197	144	231	161	164	194	168	191	172	**18,1**	**19,3**	**16,5**
27	196	196	127	206	166	167	202	175	204	202	**18,4**	**20,2**	**16,9**
28	186	189	150	238	171	174	220	160	216	206	**19,1**	**21,4**	**17,2**
29	142	172	142	252	158	179	193	174	177	227	**18,2**	**19,0**	**16,2**
30	137	164	149	241	165	165	209	175	187	157	**17,5**	**18,4**	**15,9**

Humidity

Days	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean

1	78	78	83	78	72	73	81	78	83	81	**78,5**
2	90	74	86	81	80	82	83	81	82	81	**82,0**
3	86	80	82	79	82	85	80	82	79	83	**81,8**
4	75	81	76	91	80	78	82	91	82	79	**81,5**
5	87	75	72	79	74	72	87	82	81	86	**79,5**
6	75	78	63	87	72	77	92	78	87	79	**78,8**
7	89	78	87	80	81	87	84	88	78	78	**83,0**
8	92	79	91	91	83	83	79	84	77	93	**85,2**
9	79	83	83	93	75	89	83	81	83	91	**84,0**
10	86	76	90	89	81	93	80	73	74	82	**82,4**
11	81	80	77	86	80	86	81	76	89	83	**81,9**
12	95	81	88	82	72	89	83	85	78	75	**82,8**
13	85	84	77	77	77	91	84	80	70	78	**80,3**
14	73	80	94	74	82	93	87	87	71	90	**83,1**
15	76	91	73	79	83	81	84	79	67	82	**79,5**
16	79	81	86	80	85	79	86	89	84	94	**84,3**
17	85	78	86	84	81	89	82	90	86	87	**84,8**
18	76	80	74	85	85	88	80	85	81	87	**82,1**
19	76	85	80	82	88	85	91	88	82	87	**84,4**
20	81	90	83	82	83	89	89	83	77	83	**84,0**
21	85	81	94	79	76	84	77	81	74	82	**81,3**
22	79	82	85	75	82	93	70	89	84	91	**83,0**
23	89	80	88	87	85	92	80	90	80	82	**85,3**
24	86	81	85	85	86	90	89	92	77	87	**85,8**
25	82	87	76	82	81	91	79	89	76	89	**83,2**
26	83	84	93	86	84	79	92	85	84	92	**86,2**
27	84	83	98	91	90	81	88	86	71	88	**86,0**
28	86	86	94	86	83	70	88	86	71	91	**84,1**
29	89	91	84	84	78	68	93	77	86	91	**84,1**
30	92	94	96	83	77	71	90	73	79	94	**84,9**

Days	**Top25%**	**Mean**	**Low25%**	**Humidity**	**Top25% THI**	**Mean THI**	**Low25% THI**	Threshold	Mild	Moderate	Severe
1	21	20	19	79	68	67	65	66	72	80	90
2	21	20	19	82	69	67	65	66	72	80	90
3	23	21	19	82	72	69	65	66	72	80	90
4	23	21	19	82	72	69	66	66	72	80	90
5	23	21	19	80	71	69	65	66	72	80	90
6	21	20	18	79	68	67	64	66	72	80	90
7	23	20	17	83	72	67	62	66	72	80	90
8	24	21	17	85	74	69	63	66	72	80	90
9	22	21	18	84	71	68	64	66	72	80	90
10	23	21	18	82	72	68	64	66	72	80	90
11	21	21	19	82	69	68	65	66	72	80	90
12	21	20	19	83	68	68	66	66	72	80	90
13	19	20	17	80	66	66	62	66	72	80	90
14	20	19	17	83	66	66	63	66	72	80	90
15	19	19	17	80	65	65	61	66	72	80	90
16	20	19	17	84	67	65	62	66	72	80	90
17	19	18	16	85	66	64	61	66	72	80	90
18	20	18	17	82	67	65	61	66	72	80	90
19	19	19	16	84	66	65	61	66	72	80	90
20	20	19	18	84	67	65	63	66	72	80	90
21	19	19	18	81	65	65	64	66	72	80	90
22	21	19	17	83	69	65	63	66	72	80	90
23	20	18	17	85	67	64	63	66	72	80	90
24	21	19	17	86	69	66	62	66	72	80	90
25	18	19	17	83	65	65	62	66	72	80	90
26	19	18	17	86	66	64	61	66	72	80	90
27	20	18	17	86	68	65	62	66	72	80	90
28	21	19	17	84	69	66	62	66	72	80	90
29	19	18	16	84	65	64	61	66	72	80	90
30	18	17	16	85	65	63	60	66	72	80	90

Annex III: Economic consequences on milk production due to heat stress

Top 25% Temperatures

THI	Decrease per day	Total days	Production loss	
69	0,41	14	5,7	
70	0,82	11	9,0	
71	1,23	17	20,9	
72	1,64	15	24,6	
73	2,05	18	36,9	
74	2,46	9	22,1	
75	2,87	7	20,1	
76	3,28	7	23,0	
77	3,69	9	33,2	
78	4,10	4	16,4	
79	4,51	0	0,0	
80	4,92	1	4,9	
81	5,33	0	0,0	
82	6,43	1	6,4	
83	7,53	0	0,0	
84	8,63	0	0,0	
85	9,73	0	0,0	
	Total	**113**	**223,3**	kg Milk
Lag Days	THI: 72+ Production	121	121,0	kg Milk
	THI: 69+ Protein yield	148	5,9	kg Protein
	THI: 72+ Fat yield	134	6,7	kg Fat
Total Loss	**Milk-production**	**344,3**	**kg**	
	Protein yield	**5,9**	**kg**	
	Fat yield	**6,7**	**kg**	

Milk price					
Protein p/100kg	€	630			
Fat p/100kg	€	250			

The average Cow					
Milkprod. (305 d)	8500	kg			
3,5% Protein	297,5	kg	€	1.874	
4,4% Fat	374	kg	€	935	+
			€	**2.809**	

The average Cow with heatstress					
Milkprod. (305 d)	8156	kg			
3,5% Protein	285,4	kg			
4,4% Fat	358,8	kg			
- Protein loss	**279,5**	kg	€	1.761	
- Fat loss	**352,1**	**kg**	€	880	+
			€	**2.641**	

Total economic loss			
	€	**168**	**p/cow**
	€	**16.784**	**p/100 cow**

Annex III: Economic consequences on milk production due to heat stress

Mean Temperatures

THI	Decrease per day	Total days	Production loss	
69	0,41	21	8,6	
70	0,82	14	11,5	
71	1,23	17	20,9	
72	1,64	9	14,8	
73	2,05	12	24,6	
74	2,46	2	4,9	
75	2,87	0	0,0	
76	3,28	0	0,0	
77	3,69	0	0,0	
78	4,10	0	0,0	
79	4,51	0	0,0	
80	4,92	0	0,0	
81	5,33	0	0,0	
82	6,43	0	0,0	
83	7,53	0	0,0	
84	8,63	0	0,0	
85	9,73	0	0,0	
	Total	**75**	**85,3**	kg Milk
Lag Days	THI: 72+ Production	59	59,0	kg Milk
	THI: 69+ Protein yield	107	4,3	kg Protein
	THI: 72+ Fat yield	68	3,4	kg Fat
Total Loss	**Milk-production**	**144,3**	**kg**	
	Protein yield	**4,3**	**kg**	
	Fat yield	**3,4**	**kg**	

Milk price					
Protein p/100kg	€	630			
Fat p/100kg	€	250			
The average Cow					
Milkprod. (305 d)		8500	kg		
3,5% Protein		297,5	kg	€	1.874
4,4% Fat		374	kg	€	935 +
				€	**2.809**
The average Cow with heatstress					
Milkprod. (305 d)		8356	kg		
3,5% Protein		292,5	kg		
4,4% Fat		367,7	kg		
- Protein loss		**288,2**	kg	€	1.815
- Fat loss		**364,3**	**kg**	€	911 +
				€	**2.726**
Total economic loss					
	€	**83**	**p/cow**		
	€	**8.315**	**p/100 cow**		

Annex III: Economic consequences on milk production due to heat stress

Low 25% Temperatures

THI	Decrease per day	Total days	Production loss	
69	0,41	10	4,1	
70	0,82	10	8,2	
71	1,23	0	0,0	
72	1,64	1	1,6	
73	2,05	0	0,0	
74	2,46	0	0,0	
75	2,87	0	0,0	
76	3,28	0	0,0	
77	3,69	0	0,0	
78	4,10	0	0,0	
79	4,51	0	0,0	
80	4,92	0	0,0	
81	5,33	0	0,0	
82	6,43	0	0,0	
83	7,53	0	0,0	
84	8,63	0	0,0	
85	9,73	0	0,0	
	Total	**21**	**13,9**	kg Milk
Lag Days	THI: 72+ Production	8	8,0	kg Milk
	THI: 69+ Protein yield	69	2,8	kg Protein
	THI: 72+ Fat yield	12	0,6	kg Fat
Total Loss	**Milk-production**	**21,9**	**kg**	
	Protein yield	**2,8**	**kg**	
	Fat yield	**0,6**	**kg**	

Milk price					
Protein p/100kg	€	630			
Fat p/100kg	€	250			

The average Cow					
Milkprod. (305 d)	8500	kg			
3,5% Protein	297,5	kg	€	1.874	
4,4% Fat	374	kg	€	935	+
			€	**2.809**	

The average Cow with heatstress					
Milkprod. (305 d)	8478	kg			
3,5% Protein	296,7	kg			
4,4% Fat	373,0	kg			
- Protein loss	**294,0**	kg	€	1.852	
- Fat loss	**372,4**	**kg**	€	931	+
			€	**2.783**	

Total economic loss			
	€	**26**	**p/cow**
	€	**2.614**	**p/100 cow**

Annex IV: Cost of pregnancy loss due to heat stress

Calculations

Amount of cows	**100**	
Calving Interval	**415**	**days**
Percentage not pregnant	**26%**	1 day of THI 73+
	39%	2 day+ of THI 73+
	61%	21 days+ of THI 73+

	Top25%	Mean	Low25%
Amount of Days			
1 day of THI 73+	5	4	0
2 day+ of THI 73+	51	10	0
21 days+ of THI 73+	0	0	0
Total	**56**	**14**	**0**
Amount of cows			
1 day of THI 73+	1,20	0,96	0,00
2 day+ of THI 73+	12,29	2,41	0,00
21 days+ of THI 73+	0,00	0,00	0,00
Total	**13,49**	**3,37**	**0,00**
Amount of Cows effected			
1 day of THI 73+	0,31	0,25	0,00
2 day+ of THI 73+	4,79	0,94	0,00
21 days+ of THI 73+	0,00	0,00	0,00
Total	**5,11**	**1,19**	**0,00**
Economic loss	**€ 10.212**	**€ 2.381**	**€ -**

Annex V: Investment in Ventilation

Panel fan setup

Investment cost	Quantity	Total price
Panel fan	14	€ 5.000
Mounts	14	€ 1.000
Software	1	€ 2.000 +
		€ 8.000

Operation cost

Fullspeed energy consumtpion	0,9 kwh

Louver Fan speed time per day

Hours per day	24h	16h	12h	8h
THI 63 to 67	0%	0%	100%	0%
THI 68 to 71	100%	0%	0%	0%
THI 72 to 79	100%	0%	0%	0%
THI 80+	100%	0%	0%	0%

Power consumption per day (14 panel fans)

Hours per day	24h	16h	12h	8h	**Total**	
THI 63 to 67	0	0	151	0	**151**	kwh
THI 68 to 71	302	0	0	0	**302**	kwh
THI 72 to 79	302	0	0	0	**302**	kwh
THI 80+	302	0	0	0	**302**	kwh

Power consumption per season

	Total days			**Total power consumption**			
	Top25%	**Mean**	**Low25%**	**Top25%**	**Mean**	**Low25%**	
THI 63 to 67	26	55	69	3.931	8.316	10.433	kwh
THI 68 to 71	52	65	34	15.725	19.656	10.282	kwh
THI 72 to 79	69	23	1	20.866	6.955	302	kwh
THI 80+	2	0	0	605	0	0	kwh
Total	149	143	104	**41.126**	**34.927**	**21.017**	kwh
kwh price	**0,191**			**€ 7.855**	**€ 6.671**	**€ 4.014**	

Annex V: Investment in Ventilation

Variable speed louver fan setup

Investment cost	Quantity	Total price
Variable speed louver fan	4	€ 6.000
Panel fan	6	€ 2.200
Mounts	6	€ 400
Software	1	€ 2.000 +
		€ 10.600

Operation cost

Fullspeed energy consumtpion	
Variable speed louver fan	2,2 kwh
Panel fan	0,9 kwh

Louver Fan speed time per day

Hours per day	24h	16h	12h/12h	8h
THI 63 to 67	50%	0%	0%	0%
THI 68 to 71	0%	0%	80%/50%	0%
THI 72 to 79	0%	80%	0%	50%
THI 80+	100%	0%	0%	0%

Power consumption per day (4 Louver fans)

Hours per day	24h	16h	12h/12H	8h	**Total**	
THI 63 to 67	0	35	0	0	**35**	kwh
THI 68 to 71	0	0	79	0	**79**	kwh
THI 72 to 79	0	70	0	18	**88**	kwh
THI 80+	211	0	0	0	**211**	kwh

Power consumption per day (6 panel fans)

	24h	16h	12h	8h	**Total**	
THI 63 to 67	0	0	65	0	**65**	kwh
THI 68 to 71	0	86	0	0	**86**	kwh
THI 72 to 79	0	86	0	0	**86**	kwh
THI 80+	130	0	0	0	**130**	kwh

Power consumption per season

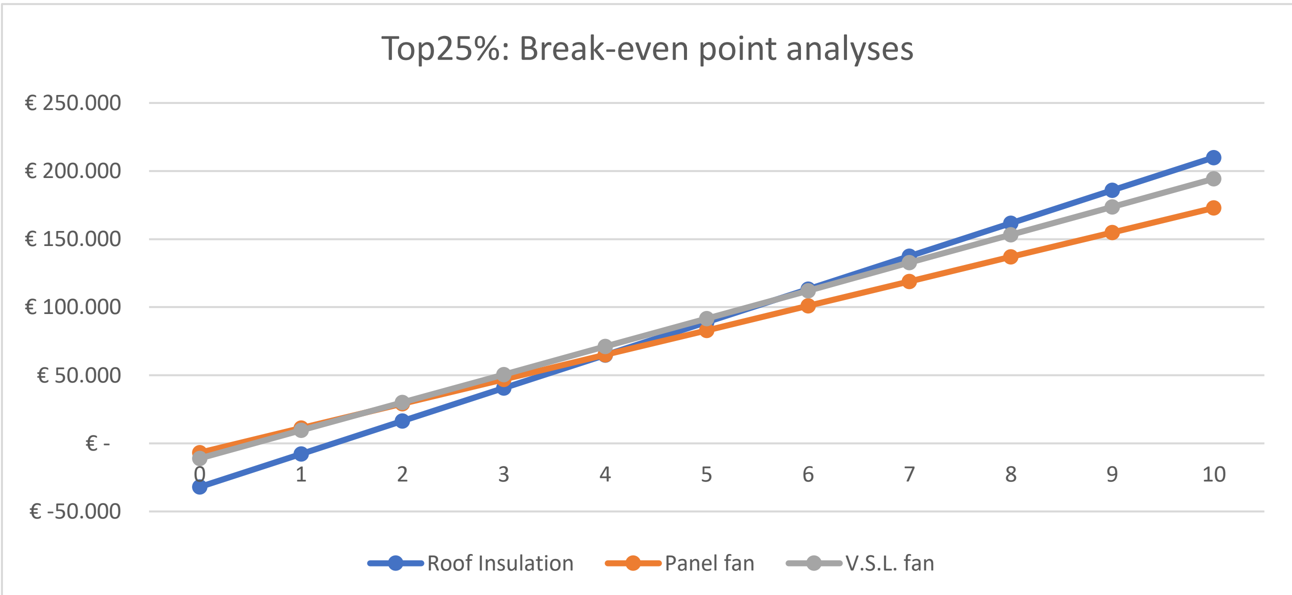
	Total days			**Total power consumption**			
	Top25%	**Mean**	**Low25%**	**Top25%**	**Mean**	**Low25%**	
THI 63 to 68	26	55	69	2.600	5.500	6.900	kwh
THI 68 to 71	52	65	34	8.611	10.764	5.630	kwh
THI 72 to 79	69	23	1	12.034	4.011	174	kwh
THI 80+	2	0	0	682	0	0	kwh
Total	149	143	104	**23.926**	**20.275**	**12.705**	kwh
kwh price	**0,191**			**€ 4.570**	**€ 3.873**	**€ 2.427**	

Annex VI: Break-even point analyses

Top 25%

	Roof Insulation	Panel fan	V.S.L. fan	*reference*
Investment	**€ 32.000**	**€ 6.800**	**€ 11.000**	
Depreciation in Years	20	8	8	(KWIN, 2018)
Residual value	€ -	€ -	€ -	(KWIN, 2018)
Interest	3,50%	3,50%	3,50%	(KWIN, 2018)
Maintenance + Insurance	2,00%	3,00%	3,00%	(KWIN, 2018)
Depreciation	€ 1.600	€ 850	€ 1.375	
Interest	€ 560	€ 119	€ 193	
Maintenance + Insurance	€ 640	€ 204	€ 330	
Operational cost	€ -	€ 7.855	€ 4.570	
Variabel cost	**€ 2.800**	**€ 9.028**	**€ 6.468**	
Average profit				
Milk production	€ 16.784			
Non Pregnancy loss	€ 10.212			
Total	**€ 26.996**			

Ten year time frame	Roof Insulation	Panel fan	V.S.L. fan
0	€ -32.000	€ -6.800	€ -11.000
1	€ -7.804	€ 11.168	€ 9.529
2	€ 16.392	€ 29.136	€ 30.057
3	€ 40.588	€ 47.104	€ 50.586
4	€ 64.784	€ 65.072	€ 71.114
5	€ 88.980	€ 83.040	€ 91.643
6	€ 113.176	€ 101.008	€ 112.171
7	€ 137.372	€ 118.976	€ 132.700
8	€ 161.568	€ 136.944	€ 153.228
9	€ 185.764	€ 154.912	€ 173.757
10	€ 209.960	€ 172.880	€ 194.285

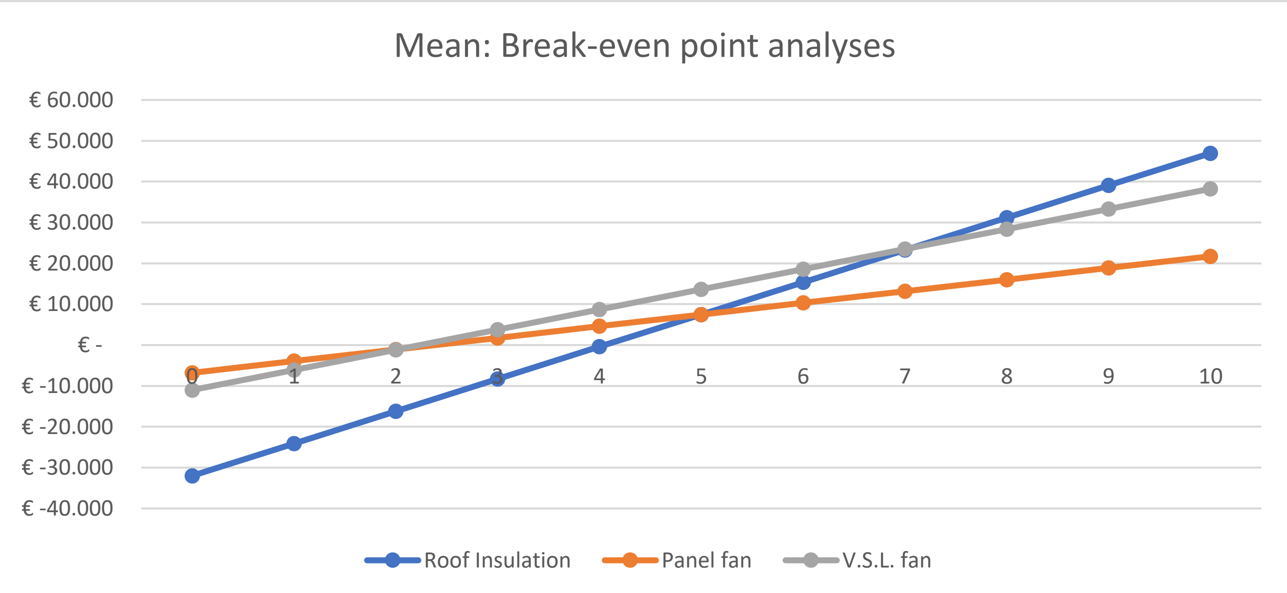


Annex VI: Break-even point analyses

Mean

	Roof Insulation	Panel fan	V.S.L. fan	*reference*
Investment	**€ 32.000**	**€ 6.800**	**€ 11.000**	
Depreciation in Years	20	8	8	(KWIN, 2018)
Residual value	€ -	€ -	€ -	(KWIN, 2018)
Interest	3,50%	3,50%	3,50%	(KWIN, 2018)
Maintenance + Insurance	2,00%	3,00%	3,00%	(KWIN, 2018)
Depreciation	€ 1.600	€ 850	€ 1.375	
Interest	€ 560	€ 119	€ 193	
Maintenance + Insurance	€ 640	€ 204	€ 330	
Operational cost	€ -	€ 6.671	€ 3.873	
Variabel cost	**€ 2.800**	**€ 7.844**	**€ 5.771**	
Average profit				
Milk production	€ 8.315			
Non Pregnancy loss	€ 2.381			
Total	**€ 10.696**			

Ten year time frame	Roof Insulation	Panel fan	V.S.L. fan
0	€ -32.000	€ -6.800	€ -11.000
1	€ -24.104	€ -3.948	€ -6.075
2	€ -16.208	€ -1.096	€ -1.149
3	€ -8.312	€ 1.756	€ 3.777
4	€ -416	€ 4.608	€ 8.702
5	€ 7.480	€ 7.460	€ 13.628
6	€ 15.376	€ 10.312	€ 18.553
7	€ 23.272	€ 13.164	€ 23.479
8	€ 31.168	€ 16.016	€ 28.404
9	€ 39.064	€ 18.868	€ 33.330
10	€ 46.960	€ 21.720	€ 38.255

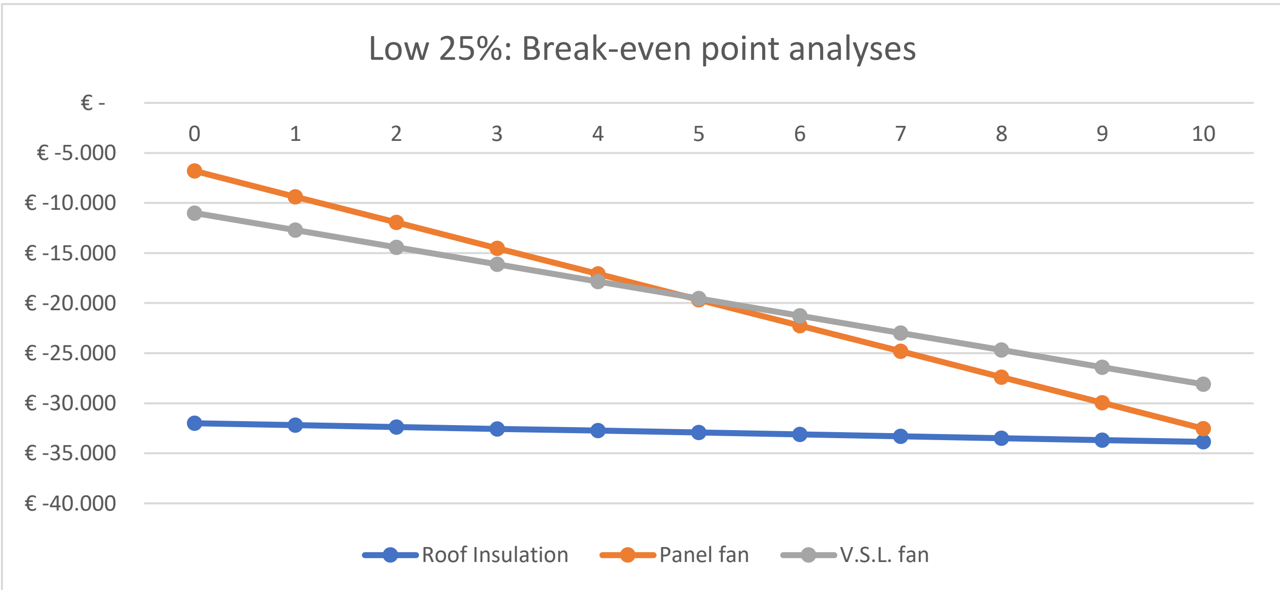


Annex VI: Break-even point analyses

Low 25%

	Roof Insulation	Panel fan	V.S.L. fan	*reference*
Investment	**€ 32.000**	**€ 6.800**	**€ 11.000**	
Depreciation in Years	20	8	8	(KWIN, 2018)
Residual value	€ -	€ -	€ -	(KWIN, 2018)
Interest	3,50%	3,50%	3,50%	(KWIN, 2018)
Maintenance + Insurance	2,00%	3,00%	3,00%	(KWIN, 2018)
Depreciation	€ 1.600	€ 850	€ 1.375	
Interest	€ 560	€ 119	€ 193	
Maintenance + Insurance	€ 640	€ 204	€ 330	
Operational cost	€ -	€ 4.014	€ 2.427	
Variabel cost	**€ 2.800**	**€ 5.187**	**€ 4.325**	
Average profit				
Milk production	€ 2.614			
Non Pregnancy loss	€ -			
Total	**€ 2.614**			

Ten year time frame	Roof Insulation	Panel fan	V.S.L. fan
0	€ -32.000	€ -6.800	€ -11.000
1	€ -32.186	€ -9.373	€ -12.711
2	€ -32.372	€ -11.946	€ -14.421
3	€ -32.558	€ -14.519	€ -16.132
4	€ -32.744	€ -17.092	€ -17.842
5	€ -32.930	€ -19.665	€ -19.553
6	€ -33.116	€ -22.238	€ -21.263
7	€ -33.302	€ -24.811	€ -22.974
8	€ -33.488	€ -27.384	€ -24.684
9	€ -33.674	€ -29.957	€ -26.395
10	€ -33.860	€ -32.530	€ -28.105



Checklist Schriftelijk Rapporteren

Naam: Stefan van 't Ooster Klas: 4DvoB Datum: 23 Augustus 2018

Titel verslag/rapport: What are the economic consequences of heat stress and how much does it cost to prevent it?

Nadat **jij** je verslag/rapport hebt gecontroleerd met behulp van deze checklist, voeg je deze toe als bijlage. Zonder de ingevulde checklist vindt er geen beoordeling plaats. De assessor controleert met deze checklist je rapport/verslag. De beoordelingscriteria die met een * zijn aangegeven, zijn de zogenaamde *'killing points'*. Indien de assessor meer dan vijf *'killing points'* heeft aangekruist, dien je het rapport/verslag op alle onvoldoende onderdelen te verbeteren. Voor de herbeoordeling moet je ook de oude versie inleveren. In het afstudeerwerkstuk zijn geen *'killing points'* toegestaan! AANVINKEN WAT NIET IN ORDE IS!

1. Het taalgebruik:
- ☐ Bevat niet meer dan drie grammaticale, spel- en typefouten per duizend woorden*
  Bij meer dan drie fouten per duizend woorden is het rapport/verslag afgekeurd!
- ☐ Heeft een adequate interpunctie*
- ☐ Is afgestemd op de gekozen doelgroep (juiste stijl)*
- ☐ Laat een zakelijke en actieve schrijfstijl zien*
- ☐ Bevat geen persoonlijke voornaamwoorden*

2. Het rapport/verslag:
- ☐ Is ingebonden (hard copy)*
- ☐ Is vrij van plagiaat* (zie onderwijsexamenregeling)

3. De omslag:
- ☐ Bevat de titel
- ☐ Vermeldt de auteur(s)

4. De titelpagina/het titelblad:
- ☐ Heeft een specifieke titel*
- ☐ Vermeldt de auteur(s)*
- ☐ Vermeldt de plaats en de datum*
- ☐ Vermeldt de opdrachtgever(s)*

5. Het voorwoord:
- ☐ Bevat de persoonlijke aanleiding tot het schrijven van het rapport/verslag
- ☐ Bevat persoonlijke bedankjes (persoonlijke voornaamwoorden toegestaan)

6. De inhoudsopgave:
- ☐ Vermeldt alle genummerde onderdelen van het rapport/verslag*
- ☐ Vermeldt de samenvatting en de bijlage(n)
- ☐ Is overzichtelijk
- ☐ Heeft een correcte paginaverwijzing

7. De samenvatting:
- ☐ Is een verkorte versie van het gehele rapport/verslag
- ☐ Bevat conclusies
- ☐ Bevat geen persoonlijke mening
- ☐ Is gestructureerd
- ☐ Is zakelijk geschreven
- ☐ Staat direct na de inhoudsopgave

8. De inleiding (toelichting op intranet):
- ☐ Is hoofdstuk 1*
- ☐ Beschrijft het grotere kader en aanleiding
- ☐ Beschrijft inhoudelijke achtergrondinformatie*
- ☐ Formuleert het probleem/de onderzoeksvraag*
- ☐ Vermeldt het doel*
- ☐ Bevat een leeswijzer voor het rapport/verslag*

9. Materiaal en methode:
- ☐ Beschrijft de gevolgde onderzoeksmethode
- ☐ Past bij de onderzoeksvraag/vragen*
- ☐ Beschrijft de variabelen/eenheden
- ☐ Beschrijft de methode van data-analyse

10. De (opmaak van de) kern:
- ☐ Bestaat uit genummerde hoofdstukken en (sub)paragrafen (maximaal drie niveaus)*
- ☐ Deze zijn verschillend in opmaak*
- ☐ De hoofdstukken en (sub)paragrafen hebben een passende titel
- ☐ Een hoofdstuk beslaat ten minste één pagina
- ☐ Een nieuw hoofdstuk begint op een nieuwe pagina
- ☐ De zinnen lopen door (geen 'enter' binnen een alinea gebruiken)
- ☐ De figuren zijn (door)genummerd en hebben een passende titel (onder de figuur)*
- ☐ De tabellen zijn (door) genummerd en hebben een passende titel (boven de tabel)*
- ☐ Tabellen en figuren zijn zelfstandig te begrijpen
- ☐ In de tekst zijn er verwijzingen naar figuren en/of tabellen*
- ☐ De tekst bevat verwijzing naar de desbetreffende bijlage(n)
- ☐ De tekst is ook zonder verwijzingen te begrijpen
- ☐ De pagina's zijn genummerd*

11. De discussie:
- ☐ Bevat een vergelijking met relevante literatuur
- ☐ Geeft de valide argumentatie weer
- ☐ Evalueert de gebruikte onderzoeksmethode
- ☐ Bevat een kritische reflectie op de eigen bevindingen (zie toelichting op intranet)

12. De conclusies en aanbevelingen:
- ☐ De conclusies zijn gebaseerd op relevante feiten
- ☐ De aanbevelingen zijn gebaseerd op relevante feiten
- ☐ Bevatten geen nieuwe informatie*

13. De bronvermelding:
- ☐ In de tekst is conform de geldende APA-normen* (zie intranet Mediatheek)

14. De literatuurlijst:
- ☐ Is opgesteld conform de geldende APA-normen* (zie intranet Mediatheek)

15. De bijlagen:
- ☐ Zijn genummerd
- ☐ Zijn voorzien van een passende titel
- ☐ Bevatten geen eigen analyse