The Effect of Climate Change Mitigation and Climate Change Adaptation Measures on Heat Stress in Retirement Homes in The Netherlands

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Abstract

This research focuses on the effect of climate change mitigation measures and climate change adaptation measures on heat stress in retirement homes. Since elderly are a high risk group for heat stress, retirements are high risk locations for heat stress. Climate change will probably increase and thus also measures that react to or prevent climate change. It is thus important to research the effects of these measures on heat stress. In this research green roofs, increased vegetation and the construction of surface water were researched as climate change mitigation measures. It was found that green roofs and vegetation, if implemented correctly, could lower the risk of heat stress. Surface waters however could increase the risk. Solar panels, heat and cold storage, solar water heaters and wall and roof insulation were researched as climate change adaptation measures in this research. It was found that solar panels, if implemented correctly, could decrease the risk on heat stress. No literature was found for heat and cold storage and solar water heaters. Wall and roof insulation could also decrease the risk of heat stress if implemented accurately. From the empirical research could be concluded that not many retirement homes implemented climate change mitigation and adaptation measures. It is however recommended that retirement homes research climate change adaptation and mitigation measures. Not only because future governance will promote these measures, but also because of pioneer status among peers, financial benefits and positive effects on the risk of heat stress.

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1. Problem Statement & Research Questions

Climate change has been noticeable around the world during the last century. Also in The Netherlands changes have been observed. The average temperature in The Netherlands for example has increased by 1.7°C in the last century and is herewith twice as high as the global average. The annual precipitation has increased with approximately 20% per year and more periods of heavy rainfall have been observed (Ligtvoet, van Minnen, & Franken, 2013). In 2014 the Royal Dutch Meteorological Institute (KNMI) predicted four climate scenarios for climate change in The Netherlands. The four scenarios predict changes for the year 2050 and 2085 in comparison to the reference period from 1981 to 2010. The scenarios are combinations of temperature rise, which could be ‘warm’ or ‘moderate’ and changes in the airflow pattern, which could be of high or low value. There are general changes that can be seen in all four scenarios. Firstly, the amount of precipitation and extreme precipitation in the winters will rise and so will the intensity of extreme rain showers in the summers. Secondly, the sea level will continue to rise, as well as the pace at which the level rises. There will thus be a quadratic relation between sea level rise and time. Thirdly, changes in wind speed are small and the amount of solar radiation near the earth’s surface rises slightly. And lastly there will be a rise in temperature, which leads to softer winters and hotter summers (Koninklijk Nederlands Meteorologisch Instituut (Klein Tank et al., 2014). Climate change comes with different side effects and also has its impact on human health. The expected hotter summers as an example, could lead to an increase in heat stress: a situation in which people are negatively affected by higher outside temperatures and in which there is an increased risk of health issues (Harbers, 2014). The higher the outside temperature and the longer the warmer period, the more people’s health will be negatively affected by the heat (de Meer et al., 2012). The impact of higher outside temperatures on human health depends on several factors that

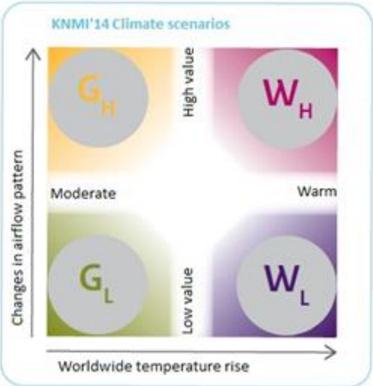

Figure 1 The ‘G stands for the scenario with moderate worldwide temperature rise, the ‘W’ for the warm scenario. The ‘H’ indicates high changes in airflow pattern and the ‘L’ low changes. Adapted figure from KNMI, 2014.

determine the severity of exposure to these higher outside temperatures. Health issues as a result from heat could range from relatively small such as fatigue and headaches to more serious issues such as breathing problems or heart failure, which could lead to hospitalization and death. One of the groups that are most vulnerable for heat stress related mortality are the elderly, since the risk of heat-related health issues or mortality rises with age. Especially elderly above 75 and elderly with respiratory diseases and cardiovascular diseases are sensitive to heat stress (Kovats and Hajat, 2008 & de Meer et al., 2013). Retirement homes are thus, seen the inhabitants, high risk locations for heat stress, which is why this research will focus on retirement homes. In Dutch retirement homes the percentage of residents with an age of 80 years or more has risen from approximately 74% to 78% of the total residents of retirement homes in 1998 and 2015 respectively (see Appendix 1, figure 1 and 2). If this number continues to rise, the risk of heat stress rises as well.

Approximately 13% more cases of death have been reported during heatwaves, where the effects are largest in urban areas because they heat up quicker and cool down slower as opposed to rural areas (Wuijts, Vros, Schets, & Braks, 2014). The guarding of residents from heat stress can be done in several ways. There are measures which are only focused on the individual and can be carried out by the personnel, such as closely watching the liquid intake and making use of cooling facilities like fans. Other measures are more focused on the building environment, such as roof isolation and thermal storage (de Meer et al., 2013). These last two examples can also be categorized as respectively a climate change adaptation measure and a climate change mitigation measure. The mentioned categories have been identified by The United Nations Framework Convention on Climate Change (UNFCCC) as two options to address climate change. Climate change adaptation measures are a response to the effects of ongoing climate change and are implemented to cope with the effects of climate change. Whereas climate change mitigation measures are focused on limiting the rate or magnitude of climate change through reduction of Greenhouse gasses (Klein, Schipper, & Dessai, 2005. Some of these climate change mitigation and adaptation measures can also be categorized under heat stress resistant building measures. Heat stress resistant building measures minimize the peak cooling demand and annual cooling energy consumption. Some climate change adaptation and mitigation measures can thus positively affect the risk of heat stress. The extent to which, and even if, climate change adaptation measures and climate change mitigation measures have an impact on heat stress has not been researched thoroughly in the Netherlands. It is important to do so however, since extra cases of deaths have been reported during heatwaves and some of them are expected to be a result of climate change ("Tackling climate change crucial to EU citizen health — ECEEE", 2016; de Meer et al., 2013). An article in a Dutch newspaper from summer 2011 mentioned that even though the weather was not extremely warm, mortality rates were rising. These were probably due to the higher temperature in houses according to the GGD (Gemeentelijke gezondheidsdienst or municipal health service), which could also be an issue even though there is no heatwave and temperatures are 22 degrees Celsius by day and 16 degrees Celsius by night (Lautenbach, 2011). Rovers, Bosch & Alber (2013) concluded that during a heatwave mortality increases with 12%, which comes down to approximately 40 extra deaths per day. Current research expects that climate change will lead to more extreme weather events and thus hotter summers. Figure 2 shows the estimated amount of days of heat stress for the future. Hotter summers lead to a higher risk of heat stress and thus a higher risk of mortality as a result of heat stress. Especially elderly people are vulnerable to heat stress, which makes retirement homes high risk locations. Apart from the newspaper, different studies concluded that there indeed is a correlation between mortality and heat stress. De Meer et al. (2012) concluded that this is also the case in the Netherlands. They found that the highest mortality occurs during extreme cold and

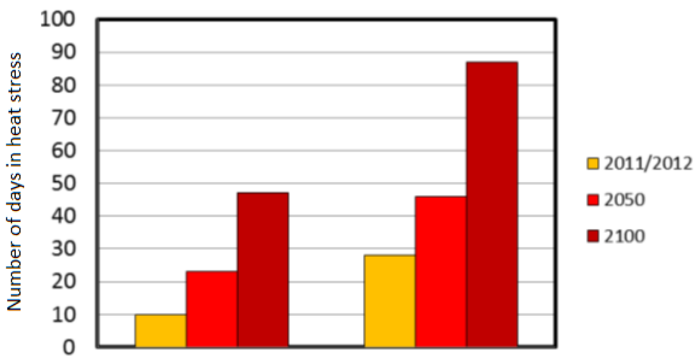

Figure 2 Measured number of days in heat stress in 2011/2012 and expected numbers for 2050 and 2100 in a rural and urban area in The Netherlands. Altered picture from De Meer et al. (2012).

extreme warm circumstances. The increased mortality during warm weather is at its highest on the day of the heat itself until 2-3 days after (Huynen et al., 2001; Baccini et al., 2008).

For some of the factors that influence heat stress and possibly heat stress related mortality the causality is already known. Figure 3 visualizes some of the relationships between heat stress in retirement homes and different factors. A green arrow shows a reductive effect in the given direction. E.g. climate change mitigation measures reduce climate change. The purple arrows show an enhancing effect; an high perceived workload of personnel plus an increasing residential population of 80 years or older could lead to a lack of time for personnel to apply or keep an eye on heat stress measures. There are external and internal environmental factors that influence the heat burden on a person. Internal factors are more focused on personal lifestyle and health. Examples are so called thermal behavior such as clothing, physical exercise and cooling and factors that influence sensitivity to heat stress such as age, overweight, chronic diseases and medication. These are not the factors that this research will focus on. The factors on the left side are categorized as external and have more to with the construction of the building and are rather technical.

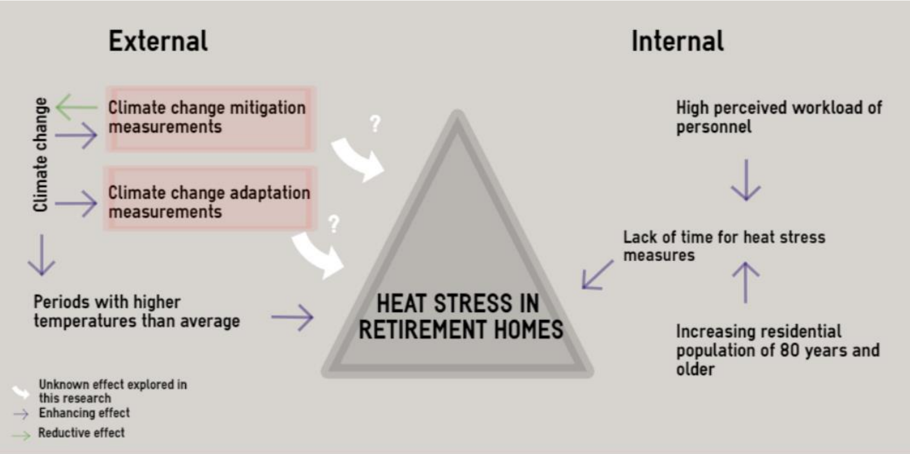

Figure 3 Visualization of several external and internal factors that could influence heat stress in retirement homes

On the external side the purple arrows show for example that due to climate change the amount of climate change mitigation measures and periods with higher temperatures than average increase. Periods with higher average temperatures in turn increase (the risk of) heat stress and thus (the risk of) heat stress induced mortality in retirement homes. The relationship between climate change mitigation measures and climate change adaptation measures and heat stress however is not yet clear and remains difficult to quantify ("Tackling climate change crucial to EU citizen health — ECEEE", 2016). The relations on the left side of the model herewith are unclear while climate change adaptation and climate change mitigation measures in the building sector are being applied more often. These adaptation measures are not intended to negatively impact human health but there is a possibility that they do, either on their own or through interaction with each other or other factors. If these measures are being applied in retirement homes, they could have an effect, either positive or negative, on the prevalence of heat stress and the risk of mortality caused by heat stress. Currently not much empirical research has been done which connects heat stress resistant buildings with health (Hatvani-Kovacs et al., 2016). Moreover, not much research has been done in The Netherlands that connects climate change adaptation measure and climate change mitigation measures with heat stress in retirement homes, even though extra mortality cases have been reported during heatwaves. It is important to research the relation between climate change mitigation and climate change adaptation measure and mortality due to health stress of residents of retirement homes and even so to determine whether or not a found relation is valid. This statement is backed up by among others Huynen & Martens (2015, p. 13312):

> “Hence, we stress that a better understanding of the impact of various plausible adaptation assumptions is required to advance future research. Future assessments of heat- and cold-related mortality should continue to explore the impacts of different adaptation options, affecting both the optimum temperature level as well as plausible developments in the sensitivity to heat and cold. More extended research is required to improve our understanding of the modulating roles of such factors as housing quality, technology, local topography, urban design and behavioral factors, and to improve assessment of adaptive capacity to current and future climates.”

This research will focus on the effect of climate change mitigation and climate change adaptation measures on heat stress in retirement homes, and regards an explorative research where a mix of methods has been used, combining empirical research with desk research to explore the set of hypotheses. The main research question reads: In what way is heat stress in retirement homes in the Netherlands affected by climate change mitigation measures and climate change adaptation measures and does it result in higher mortality rates? To answer this question, the following sub-questions have been composed:

Sub-questions
What is the correlation between mortality and heat stress?
What are the current practices regarding climate change mitigation and adaptation measures in retirement homes in The Netherlands?
What is the relation between climate change adaptation and mitigation measures and heat stress?
What are the best practices regarding climate change adaptation, climate change mitigation and heat stress measures taking into account new energy policies?

In addition to the mentioned research questions this research will also explore two hypotheses. The first hypothesis is that there is a negative correlation between climate change mitigation measures and heat stress. The second hypothesis is that there is a positive correlation between climate change adaptation measures and heat stress.

2. Method

2.1 Design and study population

The empirical research was shaped as an observational cohort research using questionnaires to obtain data. The cohort was defined as all retirement homes in The Netherlands. Retirement homes were found by using the website *Zorgkaart Nederland*. The search engine results of this website found 2334 retirement homes spread over 118 pages. The absolute number of retirement homes in The Netherlands was however lower than 2334 since some of the retirement homes showed up in the search engine results more than once and others did not exist anymore. The pages of the search engine were thoroughly researched and from each name of a retirement home, the website was visited. E-mail information and telephone numbers of the different retirement homes were acquired through their websites. All found contact information was put in an Excel sheet and if possible directly contacted. Some retirement homes belong to the same umbrella organization and thus had the same e-mail address and/or telephone number. For retirement homes or organizations where digital contact was a possibility, either through e-mail or an online form, a mail was send asking for their cooperation. In e-mails the questionnaire was also attached. Other retirement homes were approached by telephone.

2.2 Data collection

Data was collected through structured questionnaires with open and closed questions. All questionnaires were identical and formulated in the same way to all participants to allow the comparison of data. The first part of the questionnaire consisted of descriptive data of the retirement homes. The second part consisted of questions that were aimed at heat stress. The third consisted of questions regarding climate mitigation measures, the fourth part had questions about climate adaptations measures and lastly there was a question about foreign policy regarding heat stress in retirement homes. The used questionnaire can be found in appendix 2.

2.3 Data analysis

A descriptive statistics analysis was performed on the data collected through the questionnaires, using Microsoft Excel. All data collected was entered manually into a dataset.

2.4 Desk research

The desk research existed of a literature review. A theoretical framework was set up to determine what kind of knowledge was already known about heat stress and the relation between climate change mitigation measures and climate change adaptation measures. From this theoretical framework which set a base for the research. the hypotheses and research questions were explored with additional literature and empirical results.

3. Theoretical Framework

3.1 Correlation between mortality and heat stress on the physical level

To research the relation between heat stress and climate change mitigation and adaptation measures, it is important to understand the phenomenon of heat stress. Heat stress arises when the body is not able to cope with the temperature and humidity of the environment it is in. During high temperatures the body will try to release heat to its environment, but high humidity can interfere in this process. Whether or not a person experiences heat stress depends partly on the ability of the person's body to handle the heat load. The temperature of the human body consists of the core temperature and the shell temperature. The core temperature is the temperature of the abdominal, thoracic and cranial cavities and is regulated by the brain. The shell temperature refers to the temperature of the skin, subcutaneous tissue and muscles and is influenced by skin blood flow and environmental conditions. The ability of the body to regulate the internal or core temperature is called thermoregulation. In this process the body is also able to use the shell temperature to regulate the core temperature. The process of thermoregulation exists of production of heat and release of heat. Thermo-receptors throughout the body keep an eye on the overall temperature and are in contact with the brain through the nerves. The baseline core temperature lays between 36,8 and 38,7 degrees Celsius and measurement of the temperature by using the value of the pulmonary artery is seen as the golden standard. A change in core temperature reflects the amount of heat the internal circulation is exposed to and could refer to implications of homeostasis (the ability of the body to remain a relatively constant and stable internal environment). The extent and speed to which a body is capable to return to the baseline temperature differs per person (Lim, Byrne & Lee, 2008; Fulbrook, 1997). Whenever the body temperature fluctuates from the baseline, the brain is triggered and different mechanisms can be activated to bring the body back to baseline. When the temperature is too high for example, the brain brakes the sympathetic nervous system. This leads to the widening of the blood vessels. By widening the vessels the skin blood flow increases which leads to an higher shell temperature that dissipates to its surroundings. The mechanisms used by the body to alter the shell temperature are called convection, conduction, respiration and evaporation. Convection is the transport from heat from the skin to the surrounding air. Conduction is the transfer of heat through particles; e.g. standing on something cold.

Evaporation can take place through sweating or just as respiration via the lungs. The most important route to losing heat is evaporation through the skin by sweating (Havenith, 2005 & de Meer, 2012).

Certain characteristics of a person can be seen as risk factors indicating that negative effects of heat stress are more prone to occur. Age seems to be the strongest predictor of mortality during periods with higher temperatures which has to with the changes in physiological systems during aging. As such the thermoregulation of the body could be less efficient. Moreover mortality due to cardiovascular or respiratory causes increase on days with warm weather. An important note is the overall ageing of the Dutch population. Elderly are one of the most vulnerable groups regarding the effects of heat stress. It is expected that the share of elderly with an age of 65 years or more will increase from approximately 15% to 25% in 2040 and that thus the population in need of elderly care will increase (De Meer, 2012). The risk group of heat stress is thus likely to grow in the coming years, not only because of the ageing population, but also because of the increase of chronic health diseases (Hatvani-Kovacs et al., 2016).

Health effects as a result of the incapability of the body to cope with warmth can vary from slight nuisance, to life threatening situations through disturbance of physiological functions of the body. Table 1 shows a summary of the effects of heat stress (de Meer, 2012).

Effect	Symptoms	Mechanism
Nuisance	Irritable, apathy, less alert, disruption of sleep, headache, dizziness, concentration problems, stuffiness and muscle ache	Change of psychological function and social interaction with others
Disruption of sleep	Loss of concentration, tired, irritable, apathy	Decrease in quality of sleep which leads to inadequate recovery
Edema	Non painful swelling of the ankles	Withdrawal of moisture from the bloodstream as a result of widened blood vessels
Skin rash	Itchy vesicles and redness on skin	Clogging of sweat gland ducts

Heat stress, exhaustion by heat, heat syncope	Dry mouth, tired, dizzy, headache Red and sweaty skin Body temperature around 40 degrees Celsius	Moisture loss caused by transpiration and widening of the blood vessels
Heat cramps	Muscle cramps Warm and dry skin	Extreme loss of moisture and salts caused by transpiration during exercise
Heat stroke	Confused, drowsy, unconscious Body temperature more than 40 degrees Celsius Warm and dry skin	Extreme loss of moisture and salts caused by transpiration

Table 1 Effects of heat stress on the human body. Table adapted from de Meer, 2012.

There are several external factors that influence the extent to which the body is able to release heat to its environment. Firstly there is the air temperature. The higher the air temperature, the less heat the body can lose. Secondly there is the air humidity. If the moisture concentration on the skin is higher than the environment, heat loss by evaporation is facilitated if it is the other way condensation on skin will happen and a stressful situation for the body is created. Thirdly the wind speed plays a role in which a higher wind speed results in faster heat exchange. If the environment is cooler than the body, the body will be able to release heat. If the environment is warmer, the body will take up heat. As a fourth factor there is clothing insulation. The type of clothing can have a significant effect on the attraction or retention of heat. Indoors the wind chill plays a big role (Havenith, 2005). Wind chill or real feel is the perceived temperature by the human body. It is a combination of air temperature, wind speed, humidity and solar radiation and is an important predictor of heat stress. Several indices have been developed to estimate the wind chill, such as the Law Bulb Globe Temperature. In this research none of these indices will be used and the factors air temperature, humidity, wind speed and solar radiation will be reviewed separately.

3.2 Correlation between mortality and heat stress with regards to the built environment

The built environment can have a great deal of influence on the risk of heat stress. High buildings that are built close to each other for example can cause the so called Urban Heat Island effect or UHI effect. The UHI effect is the phenomenon that the temperature in urban areas higher is then the temperature in surrounding rural area as a result of warmth accumulation during the day. Another external factor is the building material. About 90% of the heat is being absorbed by building materials such as asphalt, concrete and stone. In cities where there is a large amount of these materials, a lot of heat is thus retained. At night this heat is being released to its environment, creating a higher warmth load for citizens in cities as opposed to those in rural areas. Different materials have different warmth absorption characteristics and also different albedo characteristics. White surfaces for example reflect more sunlight than black surfaces. Building materials are not only of importance on the outside of a building, but also on the inside. Proper insulation can have positive effects on the indoor climate in warm and cold periods (de Meer, 2012). Vegetation is also an external factor that can influence heat stress. Not only has it an aesthetical value, but it can also affect the temperatures around and even in buildings (Rovers, Bosch, & Albers, 2013).

4. Baseline characteristics of empirical research

In total 174 retirement homes and/or umbrella organizations were contacted. This resulted in 15 filled in questionnaires obtained from retirement homes from five provinces, namely *Zuid-Holland, Noord-Holland, Zeeland, Gelderland* and *Limburg*. Table 2 shows that most respondents were from the province of Zeeland, followed by Zuid-Holland and Limburg. Figure 4 shows the dispersion of the respondents throughout the country. The building years of the 15 retirement homes ranged from 1919 to 2015. With renovations ranging from 2007 to 2017. Three retirement homes provided numbers on mortality of which two only for August 2016 and one for August 2014, August 2015 and August 2016. The provided numbers however were not used, because no statistical analyses could be done with such few numbers.

Province	Frequency	Percentage
Gelderland	1	6.7
Limburg	2	13.3
Noord-Holland	1	6.7
Zeeland	7	46.7
Zuid-Holland	4	26.7
Totaal	15	100

Table 2 Representation of the different provinces in the filled in questionnaires

The first two questions of the questionnaire were ‘Do you see heat stress as a current problem?’ and ‘Do you see heat stress as a future problem?’. To the first question one retirement home ticket the ‘other’ box and added as explanation: “Temperature has not been above the 30 degrees [Celsius] this year and the heat protocol works fine.”. Two retirement homes ticket the ‘other’ box for the second question and answered: “heat stress can be present when one does not take any measures” and “when the heat passes de 30 degrees [Celsius] for a longer period of time”. Results can be seen in table 3. Notable is that the gross of the retirement homes do not see heat stress as a current problem, which is also affirmed by Runhaar (2012).

Question	Yes (%)	No (%)	Other (%)	No answer (%)
Do you see heat stress as a current problem?	6,7	86,6	6,7	0%
Do you see heat stress as a future problem?	23,3	60	13,3	6,7

Table 3 Answers to the question whether one sees heat stress as a current or future problem or not

All retirement homes already implemented some kind of heat stress prevention and relief. Table 4 shows which implementations where most used. Window blinds were present in all retirement homes. In 93% and 87% personnel kept an eye on respectively water intake and clothing and physical

Figure 4 Dispersion of the retirement homes that were included in the research

activity of the residents. Ventilation was only present in 67% of the retirement homes and air-condition in less than 50% of the homes. About 40% of the retirement homes looked after appliances that are turned on unnecessary and used distribution of ice to prevent heat stress. Only 4 of the 15 retirement homes specifically mentioned the use of a heat protocol. The serving of broth to prevent loss of salts due to sweating was mentioned in 20% of the retirement homes. Other implementations that were mentioned by only one of the retirement homes are the use of an air treatment system, regulation the times between which resident can go outside and swapping warm meals for cold meals.

Met opmerkingen [NT1]: ~~In the case of heat stress air-conditiniong is used to combat heat by cooling spaces. In this process however, air-conditioning also delivers heat to the environment (Rietveld, 2009).~~

Implementation	Number of retirement homes	Percentage of retirement homes
Window blinds	15	100
Water intake	14	93
Clothing	13	87
Physical activity	13	87
Ventilation	10	67
Air-conditioning	7	47
Appliances	6	40
Ice	6	40
Heat protocol	4	27
Serving broth	3	20

Table 4 Measures implemented in retirement homes in the NL, aimed at (the relieve of symptoms of) heat stress

5. Current practices in climate change mitigation and adaptation measures in retirement homes in The Netherlands

To research the current practices of climate change mitigation measures and climate change adaptation measures, question 7 and 8 of the questionnaire (Appendix 2) were used.

5.1 Implementation of climate change adaptation measures

One of the retirement homes from the cohort indicated they had implemented a green roof. Their motivation was because of good isolation and sustainability. Aesthetics were also mentioned as the ambiance; in every season different colours. Two of the retirement homes had increased the amount of vegetation in 2010 and 2004-2006 respectively. The mentioned motives probably were of aesthetic nature; the wellbeing of the clients and simply 'during the construction of the garden' were given as reasons to implement more green in the nearby area. One of the retirement homes had constructed surface waters within a range of 5 metres. This was done in the years 2004 to 2006 and because it supposedly was a requirement for new constructions. Table 5 summarizes the outcome of the questionnaires in numbers. Notable is that not many of the questioned retirement homes implement the climate change adaptation measures mentioned in the questionnaire.

Climate change adaptation measure	Number of retirement homes with measure	Year of implementation	Reasons for implementation (# of times mentioned)		
			Financial	Climate	Other
Green roof	1	2012	-	1	1
Increased vegetation (within a 5 meter radius)	2	2010, 2004-2006	-	-	1
Construction of surface waters (within a 5 meter radius)	1	2004-2006	-	-	1

Table 5 Outcome of the questionnaire regarding the implementation of climate change adaptation measures

5.2 Implementation of climate change mitigation measures

Solar panels were implemented in two institutions. Both ticked financial motives and motives related to the climate as reasons for implementation. Two retirement homes named heat and cold storage as being implemented. Reasons were financial incentives, climate focused and 'other', but the last one was not clarified. Even though solar water heaters are subsidized until 2021, it was implemented in only one retirement home, which mentioned financial and climate as reasons behind the implementation. Wall insulation was implemented in 9 retirement homes. Both financial and climate motives were mentioned for implementation. Three of the retirement homes implemented it during the building of the retirement homes and were relatively new. The reason they implemented wall insulation also had to do with the changed construction standards over the years. Nine retirement had implemented roof insulation. The same reasons for implementing wall insulation were mentioned. In the questionnaires two extra additions were made by respondents that were by them seen as climate change mitigation measures, namely 1) switching to LED lighting and 2) automatic lighting in the day and during the night. Both were installed in the year 2015 and were because of financial and climate reasons. Table 6 summarizes the outcome of the questionnaires in numbers. The implementation of solar panels, heat and cold storage and solar water heaters are not common. The insulation of walls and of the roof however is more common, but still not 100%. The retirement homes that did not tick the box for having wall insulation were built in 2015, 2014, 1921 and 1919. The last two had renovations in

Climate change mitigation measure	Number of retirement homes with measure	Year of implementation	Reasons for implementation (# of times mentioned)		
			Financial	Climate	Other
Solar panels	2	2016, 2014	2	2	-
Heat and cold storage	2	2011, 2013	1	2	1
Solar water heater	1	2014	1	1	-
Insulation of the walls	11	2011, 2011-2012, 2007-2008, 2013, 2009, 2000, 2004-2006, 2010, 2014, 2002, 1964	5	3	2
Insulation of the roof	9	2011, 2011-2012, 2007-2008, 2013, 2009, 2004-2006, 2010, 2014, 2016	6	3	2

Table 6 Outcome of the questionnaire regarding the implementation of climate change mitigation measures

respectively 2016 and 2007. Three of the retirement homes did not provide any information regarding climate change mitigation and adaptation measures at all. It is very probable that these retirement homes do have wall insulation, but simply did not mention it, since there a very few buildings that are not isolated after the year 2000. One of the retirement homes did not tick the box for wall insulation, but did have wall insulation, solar panels and heat and cold storage. In this case it is also very probable that there is wall insulation. With these assumptions, the implementation of wall insulation comes down to 100% of the questioned retirement homes.

6. Heat stress and climate change adaptation and climate change mitigation measures in retirement homes

6.1 The relationship between heat stress and the absence or presence of climate change adaptation measures

Climate change adaptation measures are, as mentioned before, measures that are a reaction to and a way to cope with the changing climate. In this research the focus will be on green roofs, increased vegetation in the near surroundings (within a 5 meter radius), construction of surface waters in the near surroundings (within a 5 meter radius). As mentioned in the theoretical framework the inside wind chill is a main factor that influences heat stress. Wind chill is determined by air temperature, wind speed, humidity and solar radiation.

Green roofs

Different researches have been done regarding the temperature of green roofs in comparison to other roofs and have concluded that green roofs have a cooling effect on the inside temperature of a building during warm temperatures (Klimaat voor Ruimte, n.d.; Simmons et al. 2008; Ascione et al. 2013; Ouldboukhitine, Belarbi, & Sailor, 2014; Park & Hawkins, 2015; Ahmadi, Arabi, & Fatahi, 2015). Simmons et al. (2008) did research in Texas in a subtropical climate by monitoring 24 constructed roof platforms which represented black, non-reflective roofs and white, reflective roofs next to six green roof platforms. They found that the green roofs had a temperature of 31 to 38 degrees Celsius when the outside temperature reached 35 degrees Celsius, as opposed to black and white coloured roofs which reached about respectively 68 and 42 degrees Celsius. The lower temperature on the green roofs transmitted to the internal space in a lower temperature up to 18 degrees Celsius in comparison to the black and white roofs. Ascione et al. (2013) found that green roofs do not only contribute to a reduction in energy use for the cooling of spaces, but also for the heating of spaces in colder months. Locations in Amsterdam and London have proven to save 4 to 7 percent on their energy demand on an annual basis. Three physical phenomena of a green roof were mentioned that contribute to the energy savings. The first is the heat storage function of the inertial mass of the roof. Secondly there are processes of the vegetation on the roof that absorb thermal energy through photosynthesis leading to less solar radiation flowing indoors. Lastly there is the evaporative cooling function of the soil and vegetative layers. These effects and thus also energy demand, retention of heat and cooling properties differ per type of roof. The amount of layers, the type and thickness of the construction material and the vegetation are some of the parameters that are of influence (Ouldboukhitine, Belarbi, & Sailor, 2014; Ahmadi, Arabi, & Fatahi, 2015). Green roofs can also increase the outside air humidity through the photosynthesis of the roof plants (Klimaat voor Ruimte, n.d.). Research on the effects of green roofs on the inside air humidity however is missing. Table 7 shows a summary of the effect of a green roof on the four different components of wind chill. From the table it becomes clear that green roofs most probably decrease the risk of heat stress.

Wind chill component	Effect of a green roof
Air temperature	Lower indoor temperature
Wind speed	Not found
Humidity	Increase outside air humidity. Effect on inside air humidity not found
Solar radiation	Lower incoming solar radiation

Table 7 Effect of a green roof on wind chill components

Increased vegetation

Vegetation does not only carry an aesthetic value, but dependant of the type of vegetation, can also influence the inside and outside temperature of buildings. Large vegetation such as trees can provide shade and shielding from the wind, but can also increase the intensity of the Urban Heat Island. By providing shade vegetation can influence the heat gain within buildings. The heat gain will reduce as a result of a lower surface temperature of the surroundings. Increased vegetation can decrease the temperature at ground level with 5 to 20 degrees Celsius (Klimaat voor Ruimte, n.d.). Evapotranspiration also plays it role in lowering ambient temperatures. Evapotranspiration is the evaporation and transpiration of water from vegetation and surrounding soils. If there is a significant amount of trees in an urban area, the so called “oasis effect” could take place, in which ambient temperatures are significantly lowered. Another result of evapotranspiration is (in some cases) extra addition of moisture to the air and thus increase in inside and outside humidity. The effect of increased humidity on human comfort depends on the region and its climate (E.g. dry or humid). By shielding buildings from the wind, large vegetation can have different effects, partly dependant of the type of building. A lower wind speed on an uninsulated building lowers the dissipation of heat from surfaces exposed to sunlight. The temperature of these surfaces then raised and have a higher heat gain through the building shell as a result. A lower wind speed also means lower air infiltration. The cooling of buildings by opening windows could thus be less effective with lower wind speed and lower air infiltration. However, this could also be a protecting factor, since the infiltration of hot summer winds is also lessened. (Akbari, 2002; van Praag, 2011; Wang, Bakker, de Groot, & Wörtche, 2014; Rovers, Bosch, & Albers, 2013). Table 8 summarizes the effect of increased vegeation on the different wind chill components.

Wind chill component	Effect of increased vegetation
Air temperature	Lowers temperature
Wind speed	Lowers windspeed
Humidity	Increases humidity if presence is significant
Solar radiation	Lower incoming solar radiation

Table 8 Effects of increased vegetation on the differend wind chill components

Construction of surface water

Water absorbs solar energy in the form of heat. It therefore has a lowering effect on the UHI effect during the day. After sunset however, the absorbed heat is released and the UHI effect is increased. Having surface waters nearby a retirement home could thus bring relieve when the sun is up, but could enhance heat stress at night (Kleis & Lenzholzer, 2015). Additionally surface waters could increase the humidity outside, which could reflect back on the humidity indoors.

Due to climate change The Netherlands were confronted with several periods of heavy rainfall, in which they could not handle the large amounts of water (KNMI, 2014). With the expected climate changes ahead, incorporating more blue (water) and green (vegetation) into the built environment has been a trend in The Netherlands. The climate change adaptation measures which are focused on in this research are also part of this so called climate proof building and can help cope with excessive rainwater and prevent climate change (Weima, 2015; Belzen van, 2015; ("Aantal groene daken met subsidie in Utrecht | Tuin en Balkon", 2013; Gemeente Rotterdam, 2013). Even though the increase in climate proof building can be seen in the increase of green roofs, green roofs are not that common on Dutch retirement homes. This is possibly because of the cuts the government has done on the health sector, which leaves the health sector in constant shortage of finances ("Gevolgen bezuinigingen voor de zorg", n.d.). Applying a green roof would mean input of more finances for most of the retirement homes. Additionally only a few municipalities give subsidies for green roofs. Another reason could be that some retirement homes were built in earlier years when green roofs were not known or not deviated from the standard. It is expected however that the implementation of a green roof would have higher health advantages than on most other buildings. Green roofs proved to have a positive effect on the indoor climate, even in very warm weather. If retirement homes would implement green roofs, extreme temperatures in summer would have less effect on the indoor temperature and could thus possibly lower the chance on heat stress among residents. Increased vegetation surrounding a retirement home is difficult to measure. The advantages of placing more vegetation nearby a retirement home are not only aesthetic, but could also affect temperature in summer periods by providing shade and blocking warm winds. It could therefore decrease the risk of heat stress. A disadvantage however could be during heavy storms; trees could fall and form a risk. The last adaptation measure, increased surface water, could be very useful to store excessive rainwater. It however does not seem to be a good measure to prevent heat stress, since it enhances the UHI effect at night and could affect the humidity indoor. One of the retirement homes had constructed surface waters within a range of 5 metres. Even though the surface water could increase the risk of heat stress at night by enhancing the UHI effect, the retirement home did not see heat stress as a current nor a future problem.

Wind chill component	Effect of surface waters
Air temperature	Lowers temperature
Wind speed	Not found
Humidity	Could increase indoor humidity
Solar radiation	Lowers solar radiation

Table 9 Effects of surface waters on the different wind chill components

6.2 The relationship between heat stress and the absence or presence of climate change mitigation measures

This research focuses on five main mitigation measures: solar panels, heat and cold storage, solar water heater, wall isolation and roof isolation. As mentioned in the theoretical framework the inside wind chill is a main factor that influences heat stress. Wind chill is determined by air temperature and humidity.

Solar Panels

Applying solar panels on roofs can alter the indoor climate. Lith, Entrop, & Halman (2016) concluded that if solar panels are installed above the roof horizontally, solar radiation will be blocked. Additionally a cavity is created in which the convection of heat can take place. They compared five different types of roofs with a conventional roof. Research showed that a roof with solar panels, during a Dutch summer, could lower the amount of hours in which the indoor temperature is more than 23 degrees Celsius up to 95%. The maximum indoor temperature during the summer season was 23.8 degrees, which means an exceedance of the set temperature with only 0.8 degrees Celsius. These calculations are based on a roof with a thermal resistance of 3.5 m^2 K/W. The thermal resistance is the difference in temperature across a material or structure when a unit of heat energy flow through it. It indicates the ability of a material to conduct heat. In comparison to a roof with a lower thermal resistance (1.1 m^2 K/W), a roof with solar panels had 84% less hours hotter than 23 degrees Celsius and the maximum indoor temperature measured was 24.4 degrees Celsius. Even though the second roof had a lower thermal resistance, it still had a positive impact on the indoor temperature.

Wind chill component	Effect of solar panels
Air temperature	Lowers temperature
Wind speed	Not found
Humidity	Not found
Solar radiation	Lower incoming solar radiation

Table 10 Effects of solar panels on the different wind chill components

Heat and Cold storage

Heat and cold storage is a method to store energy as heat or cold in the water-bearing sand layers (aquifers). To cool a building cold water from the cold aquifers will be pumped up and led to the building. The warmed water that comes back afterwards will be pumped into the warm aquifers. To warm a building, the reversed processed is used. There are three different types of mechanisms, but for each of them a technical space is needed for the pumps and the storage tanks. Additionally pipelines are needed to transfer de warmth or cold to the individual pumps (Agentschap NL Energie en

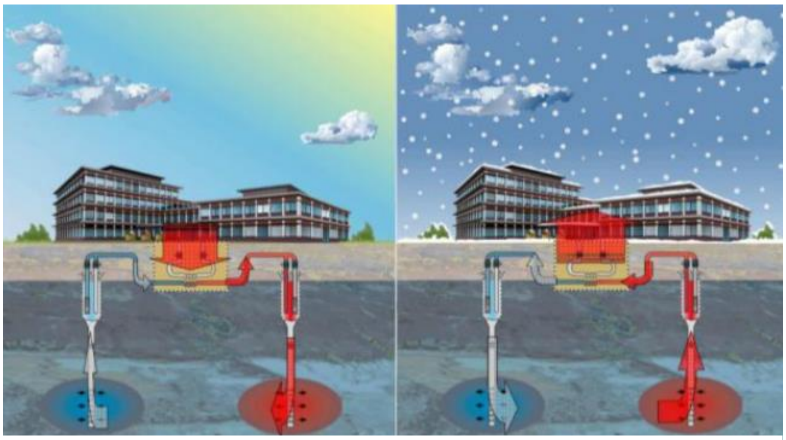

Figure 2 Visualization of an heat and cold storage installation for cooling (left) and warming (right) the buidling. Figure from van de Maas, 2013.

Klimaat, 2010). No literature has been found regarding the effects of heat and cold pumps on the indoor climate. Expected is that the indoor temperature could be influenced by the pumps, storage tanks and pipelines. Depending on the type of material and its isolation properties, it could radiate heat or cold to its surroundings.

Wind chill component	Effect of Hot and cold storage
Air temperature	Not found
Wind speed	Not found
Humidity	Not found
Solar radiation	Not found

Table 11 Effects of hot and cold storage on the different wind chill components

Solar water heater

There are two types of solar water heaters: active and passive systems. Both of them exist of solar collectors and storage tanks and are placed on top of the building, on the roof (see figure 6 and 7) ("Solar Water Heaters | Department of Energy", n.d.). As with the heat and cold storage, no research has been found regarding the influence of solar water heaters on the indoor climate. One could however reason that biggest influence on the indoor climate would be through the storage tanks which are placed inside the building. Again, the type of material used for construction of the solar water heater would influence the heat or could the installation would radiate to its surroundings. Additionally the space in which it is stored also plays a role. If the heat dispersion from that room is low to non-existent, the storage tank will not influence the wind chill within a building and will thus not increase the risk of heat stress within a retirement home.

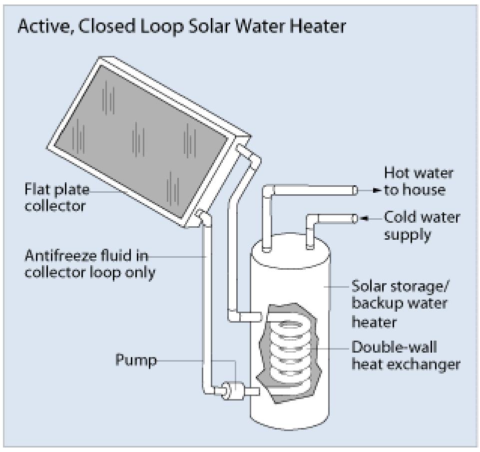

Figure 3 Visualization of an active, closed loop solar water heater. Figure taken from "Solar Water Heaters | Department of Energy", n.d...

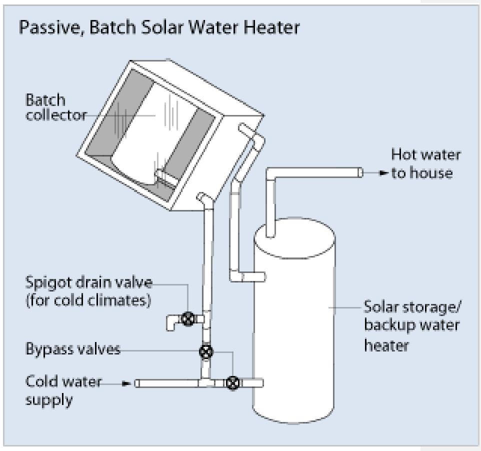

Figure 4 Visualization of a passive, batch solar water heater. Figure taken from "Solar Water Heaters | Department of Energy", n.d.

Wind chill component	Effect of a solar water heater
Air temperature	Not found
Wind speed	Not found
Humidity	Not found
Solar radiation	Not found

Table 12 Effects of a solar water heater on the different wind chill components

Wall insulation

Insulation of buildings is directed at retaining heat. The heat and moisture transport and storage parameters of insulation materials depend on the temperature and humidity of the surroundings. Heat and moist transport parameters generally rise with temperature, but the effect of moist and humidity was reported to be larger. The values of the thermal conductivity of thermal insulations materials when saturated with water were several times larger than the same material in a dry state. The heat storage parameter of insulation material typically rises with the moisture content of the material. Insulated buildings with high moist levels and high humidity thus retain heat easier than in dry conditions (Jerman & Černý, 2012). Well insulated buildings are known to retain heat and cool down slowly. A risk could be that the cooling process is to slow in warmer periods. It is thus important that there are options for ventilation, since building with high air-tightness as a result of high insulation, can foster overheating in warmer periods (de Meer, 2012; Hatvani-Kovacs et al., 2016).

Met opmerkingen [NT2]: Protectie insulation from sun

Wind chill component	Effect of wall insulation
Air temperature	Prevents heat loss, stabilizes temperature
Wind speed	Not found
Humidity	Depends on used material
Solar radiation	Lower incoming solar radiation

Table 13 Effects of wall insulation on the different wind chill components

Roof insulation

There are different techniques for roof insulation, of which a green roof is one. The goal of roof insulation has mostly to do with energy saving: decreasing the use of energy by preventing the loss of heat or excessive influx of heat. The roof typically has the highest surface temperature compared to other surfaces on a building. Insulating the roof could therefore have significant effect on the reduction of heat gain in hot climates and can improve the indoor climate (Ran et al., 2017). If roof insulation is implemented with wall insulation, it is of great importance that there are enough options to ventilate the building at night, so warm air can get out and temperature can fall (de Meer, 2012).

Wind chill component	Effect of roof insulation
Air temperature	Prevents heat loss, stabilizes temperature
Wind speed	Not found
Humidity	Not found
Solar radiation	Lower incoming solar radiation

Table 14 Effects of roof insulation on the different wind chill components

The implementation of solar panels has been rising (Simons, 2014). Only two of the questioned retirement homes had solar panels implemented. This is possibly because of the same reasons as the low implementation of green roofs: lack of finance and older buildings. The implementation of solar panels on retirement homes could lead to a decrease in the risk of heat stress and have a positive effect on the indoor climate – if installed horizontally above the roof. Whether or not this would be lucrative for a retirement home would depend on several factors, such as the location of the building, the investment and the payback time. The effect of heat and cold storage and solar water heater installations on heat stress still needs to be researched. By looking at the sketches of the installations however, it could be that heat radiates from the tanks that are stored indoor. In what way this influences the indoor climate cannot be estimated and depends on for example the placement of the tank and the isolation of the space where it is located. Roof and wall insulation were implemented at 60% of the questioned retirement homes. It is however remarkable that this is not 100% since roof and wall insulation both retain heat, but also prevent the influx of heat. This lowers the use of energy and could thus lead to savings. A building with good insulation can also be beneficial to heat stress when the influx of heat is minimalized and ventilation is present (le Grand et al., 2014). The reason that implementation of wall insulation in this research did not count to 100% is probably because of missing information. Retirement homes also mentioned the switch to LED lighting. This could have a positive effect on heat stress, because LED lights release less heat than conventional lighting. If this decrease in release of heat has a significant effect on heat stress has yet to be researched. Another measure that a retirement home considered to be a mitigation measure was the implementation of automatic lighting.

7. Best practices in climate change adaptation, climate change mitigation and heat stress for the future

With regards to the future it is important to take into account rules and regulations that are connected to climate change. The '*Energieakkoord´* or energy agreement, initiated in 2013, is an important regulation since it is aimed to limit the global temperature rise as a result of climate change to a maximum of 1,5 degree Celsius. The energy agreement offers a long-term perspective to reach this goal up to the year 2023. To limit the temperature rise to a maximum of 1,5 degrees Celsius the CO2 emission should be lowered drastically. The Dutch government plans to do so partly through reduction of conventional energy resources. All electricity should be from renewable resources by 2050 and buildings should be warmed by electricity and geothermal heat. Big investments in the insulation of buildings is also mentioned. To reach the energy goals the government is responsible for a policy which includes both stimulating and mandatory or normative measures, which should also be cost-effective and expedient in regarding to lowering the CO2 emission. The '*Energieagenda'* or energy agenda describes the way in which The Netherlands excpects to reach the climate goals that are a result of the recent COP21 (United Nations Conference on Climate Change) in Paris. It is expected that the government will either put to use mandatory or normative agreements for the most economically viable measures, followed by stimulation of further CO2 emission reduction measures.

Energy reduction is one of the main pillars of the goal for CO2 reduction. The reduction of energy can be promoted through three channels: setting an obligatory minimum, stimulating wins beyond the set minimum and where necessary, remove bottlenecks for implementing certain techniques. Rules and regulations regarding the reduction in CO2 will be different for the buying sector, rental sector, commercial and social real estate sectors. In the buying sector a mix of methods will be used to stimulate owners to take energy reductive measures. For example, a three year nationwide campaign has started in 2016 to provide information and create awareness. Additionally the '*Stimuleringsregeling Energiebesparing Eigen Huis'* was put into force to create an incentive for owners to implement energy reductive measures. In the rental sector a goal has been set to have all buildings at energy label B by 2020. It is expected that this goal will not be reached and thus the government will prepare legally binding measures for phasing out buildings with a label lower than C.

Renovated buildings that are very energy efficient have been receiving an energy performance fee from September 2016. Companies with real estate are obliged to take all energy saving measures which have a payback time of maximum 5 years. If possible, other requirements will also be obligated, such as a minimum energy label of C. Starting from 2019 all newly built offices for the government should be energy-neutral and existing governmental buildings should have energy label A.

Currently about 27% of the total energy use has its origin from natural gas. To limit the CO2 emission paired with its use, the use of natural gas will be discouraged in the coming years. It is expected that there will be a shift from energy taxes from electricity to natural gas. The most important pillar however is to lower the demand for heat and thus the demand for energy and the use of natural gas. Additionally more sustainable sources for electricity and heat should be stimulated, adapted and researched. With the current techniques a CO2 neutral society cannot be realized. It is thus also necessary to innovate (Ministerie van Economische Zaken, 2016).

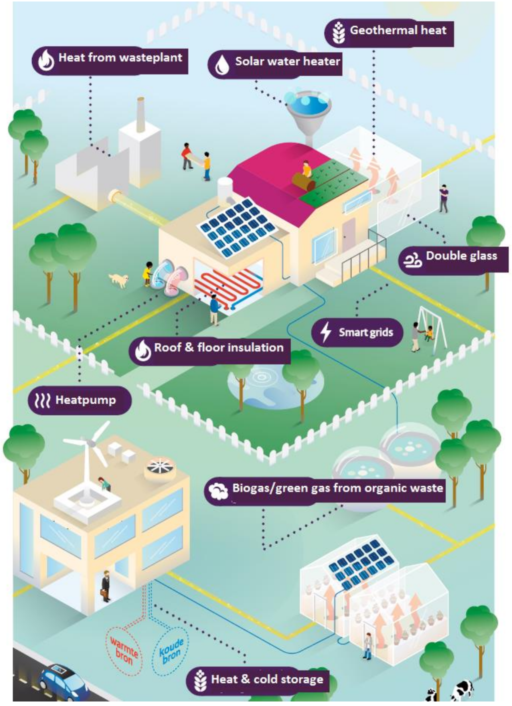

Figure 8 Vision of the Dutch government on how to lower the consumption and demand of natural gas. Altered figure from Ministerie van Economische Zaken, 2016.

Energy reduction is one of the main pillars for CO2 reduction in the built environment and figure 8 shows some of the options to reduce energy use. Retirement homes can see energy reduction as an opportunity in several ways. First of all there is the savings of energy and thus financial savings. Applying solar panels on the roof or install a green roof, could lead to decrease in temperature in hot summers which can lead to a significant lower effect of heat stress in the future. Local energy production is likely to be stimulated by the government. Larger retirement homes can seek opportunities by using their property to produce energy and distribute the energy which is not used themselves, which could lead to financial benefits. Next to technical and financial opportunities, implementing climate change mitigation and adaptation measures could bring societal opportunities. If retirement homes lead by example, they could be of interest and use for people interested in adaptation and mitigation measures. This could lead to positive attention, which could be used in different ways. One could use this positive attention to strengthen the image, but one could also organize in-house days. This could increase the social contact of the residents if, for example, residents are schooled on the measures and give tours to e.g. school children.

Another initiative that could influence climate change mitigation and adaptation measures in the future is the in September 2016 proposed 'Klimaatwet' or climate law. Currently the law is not yet operative, but the majority of the house of representatives is currently in favor of the law. Its goal is to connect long term goals with short term policies with the vigor of a law instead of a directive. The content of the law is just like the above mentioned energy agreement focused on the reduction of exhaustion of greenhouse gases. The difference however is that the this proposal will be legally binding. Since the majority of the house of representatives is already in favor of this law, it is likely that it will be implemented (Reijn & van Raaij, 2017).

Klimaatwet

- Reduction of exhaustion greenhouse gasses of 55 percent in 2030, with 1990 as a baseline. And a reduction of 95 percent in 2050;
- Entire energy supply should be from renewable sources in 2050;
- Every year the government should present a climate budget in which they state what the challenges are for the coming year and how the different ministeries will overcome and achieve these challenges. This budget will have the vigor of a law;

- A climate-plan should be written every 5 years. Agreements on CO2 reduction, renewable energy and energy reduction will be in the plan;
- Coordination regarding the implementation of the climate law is a task for the Prime Minister;
- Added by the Council if State: set up an indepent 'Climate comission' which advises the government on the progress of the climate law and its effect on the job market and other affairs.

Figure 5 The content of the climate law summarized in bullet points. Table derived from the article from FluxEnergie 2017.

The energy agreement and climate law are two recent initiatives coming from the government. They show that manners to reduce climate change and thus reduce the exhaustion of greenhouse gasses are high priorities. Even though measures aimed at the reduction of climate change are mostly steering instead of obligatory, it is very likely that they will become obligatory in the future. It would thus be wise for households, companies and in this case retirement homes to closely look into climate change adaptation and mitigation measures that could now be implemented with the support of the government. Solar water heaters for example will only be subsidized until the year 2021 ("Subsidie zonneboilers 2017", 2017). By already researching the opportunities regarding climate change mitigation measures and climate change adaptation measures, retirement homes could be ahead of their peers, save on finances and positively influence the current and future risk on heat stress casualties (Hatvani-Kovacs et al., 2016).

8. Conclusion

Heat stress arises when a body is not able to ward of heat or release it to its environment. The results can differ from small physical disturbances such as rash to severe complications such as a heat stroke. Heat stress can also lead to cases of mortality, most often with people of an older age. This makes retirement homes high risk locations for heat stress.

The collected questionnaires in this research showed that regarding climate change adaptation measures in retirement homes in The Netherlands green roofs, increased vegetation and construction of surface waters were implemented. Green roofs can have a positive effect on heat stress as it lowers the temperature within a building as opposed no roofs without vegetation. The effects differs per green roof, as a green roof can exist of different layers and different types vegetation. The effect of increased vegetation is also dependant of the type of vegetation. Large trees and bushes can provide shadow and prevent the heat gain in buildings. If there is a significant amount of trees, the so called “oasis effect” can take place, in which ambient temperature is lowered as a result of evapotranspiration of the vegetation. Increased vegetation could also block the wind. This would mean less ventilation through open windows, but also protection from hot summer winds. Surface waters can absorb solar energy in the form of heat throughout the day, but releases this heat in the night. It can thus bring relieve to heat stress during daytime, but could enhance heat stress at night. The mentioned climate change adaptation measures have positive effects on heat stress, but the extent to which these positive effects reach, are dependant of different factors. There are also not only positive effects of climate change mitigation measures; construction of surface waters could worsen heat stress at night. The first hypothesis that there is a negative correlation between climate change mitigation measures and heat stress can thus only be confirmed partially.

Regarding climate change mitigation measures solar panels, heat and cold storage, solar water heater and insulation of walls and roofs were implemented. Solar panels can decrease indoor temperature in summer and thus positively affect heat stress. This is only if they are placed in such a way that they block out the sun that would otherwise fall on the roof. No information could be found on the effect of heat and cold storage and solar water heaters on heat stress. They both could influence the indoor temperature of there is heat or cold exchange between the storage tanks and its surroundings, but research is lacking. Wall and roof insulation both retain warmth and prevent heat from entering. It is therefore important that there are options for ventilation to let the accumulated warm air out. If a building is well ventilated and the influx of heat is minimalized, a steady temperature can be maintained, which could have a positive effect on heat stress. There is thus not necessarily a negative correlation between climate change mitigation measures and heat stress. On the contrary: if implemented correctly, some climate change mitigation could have a positive effect on heat stress. The second hypothesis that there is a positive correlation between climate change adaptation measures and heat stress can thus only be confirmed partially.

Notable from the questionnaires was that not many retirement homes had climate change mitigation and adaptations measures implemented. It would definitely be valuable to research this. Reasons are expected to be mainly financial, since the Dutch government has cut back on the health sector for some years.

With the recent energy agreement and the proposed climate law, the Dutch government has set goals to lower the emission of greenhouse gasses. One important tool to do so is to make the Dutch society as energy neutral as possible. It is very probably that retirement homes will be obligated in the future to suffice to certain requirements regarding energy. It is thus recommended to research ways to lower their CO2 emission and reduce energy use. Advantages could be a pioneer status among peers, financial savings and a positive influence on the current and future risk on heat stress and potential related casualties. With proper instalment of the different climate change adaptation and mitigation measures mortality as a result of heat stress could thus be prevented.

9. Discussion

The research proposal was thought out thoroughly and seemed to cover all that was needed to research the relation between heat stress and climate change mitigation and adaptation measures in retirement homes. The research focused only on a the climate change mitigation and adaptation measures which were frequently mentioned in literature. Even though the most common measures were researched, it is probable that some measures that could have an influence on the heat stress in retirement homes were not mentioned in this research. Specifically linking climate change adaptation measures and climate change mitigation measures with heat stress in retirement homes is not common. This research is therefore quite unique and brings to the attention a correlation which is worth further research. The questionnaires were put together with a lot of care and would provide all data necessary if filled in correctly in completely. Not all questionnaires were filled in entirely however, leading to a gap of data which was not foreseen in the research proposal. Additionally relatively few retirement homes were willing to commit to the research; only 15 of the 174 contacted retirement homes were willing to participate. The total research population was thus too small to make any valid conclusions. The results of the data however can be seen as useful exploratory data. The pitfalls regarding heat stress and climate change mitigation and adaptation measures in retirement homes have been identified, providing interesting views for future research. The same goes for gaps in the literature research; on certain measures no existing literature and information could be found regarding the effect on the indoor temperature or humidity of a building. However, due to these information gaps in which were encountered during the literature study, this research contributed to reveal areas in which more research can be done.

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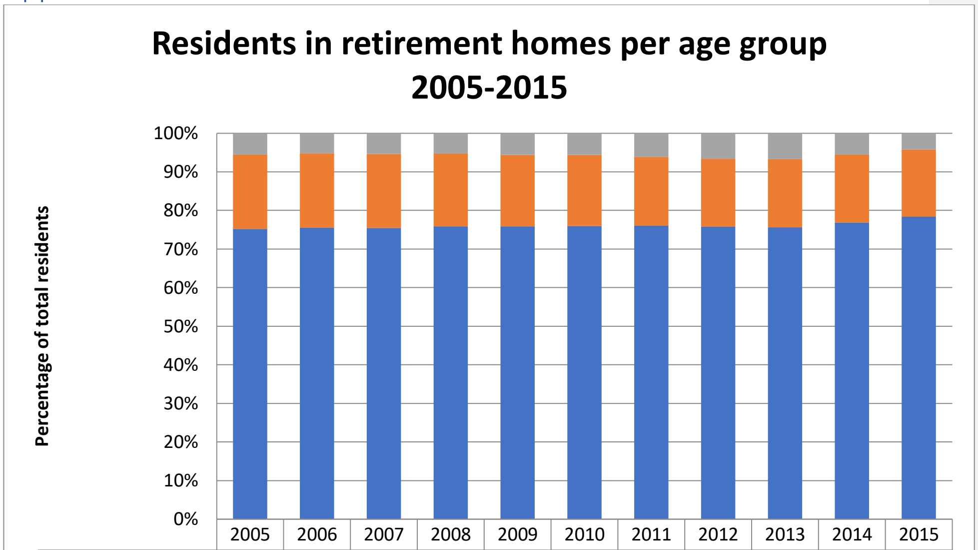
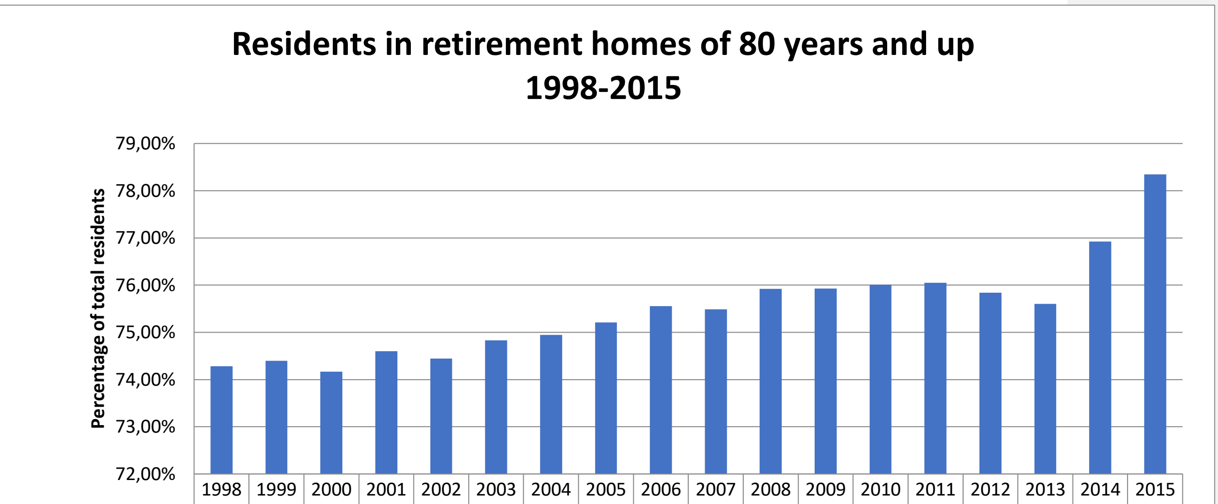
Appendix 1



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
below 65 years	5,48%	5,20%	5,38%	5,24%	5,56%	5,62%	6,09%	6,55%	6,72%	5,51%	4,16%
65 to 80 years	19,31%	19,24%	19,14%	18,84%	18,51%	18,37%	17,86%	17,60%	17,68%	17,57%	17,49%
80 years and older	75,21%	75,56%	75,49%	75,92%	75,92%	76,01%	76,05%	75,84%	75,60%	76,92%	78,34%



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
80 years and older	74,28	74,40	74,17	74,60	74,44	74,83	74,94	75,21	75,56	75,49	75,92	75,92	76,01	76,05	75,84	75,60	76,92	78,34

Appendix 2

QUESTIONNAIRE

Gegevens betreffende zorginstelling:

Stad zorginstelling: ____________________

Bouwjaar: ____________________

In welk jaar is de instelling voor het laatst verbouwd? ____________________

(indien van toepassing) ____________________

Aantal bewoners en aantal zorgverleners

OF

Ratio personeel/bewoners ____________________

HITTESTRESS

1. Ziet u hittestress als een huidig probleem?

☐ Ja

☐ Nee

☐ Anders:

---

2. Ziet u hittestress als een probleem in de toekomst?

☐ Ja

☐ Nee

☐ Anders:

---

3. Wat voor maatregelen worden er momenteel in uw verzorgingstehuis genomen met betrekking tot hittestress?

   ☐ Inzet (extra) ventilatoren

☐ Inzet airconditioning

☐ Gebruik zonwering

☐ Extra aandacht aan de kleding van bewoners

☐ Extra aandacht aan de waterinname van bewoners

☐ Extra aandacht aan de fysieke inspanning van bewoners

☐ Extra aandacht aan het al dan niet aanstaan van apparaten (computers, lampen enzovoorts)

Overig, namelijk:

4. Welke maatregelen neemt u momenteel niet, maar gaat u **in de toekomst zeker toepassen?**

5. Welke maatregelen neemt u momenteel niet, maar zou u wel **willen** toepassen?

6. Waarom worden bovenstaande maatregelen niet toegepast?

KLIMAAT-MITIGATIE MAATREGELEN

7. Kunt u in onderstaande table aankruisen welke klimaat-mitigatie maatregelen* er in uw zorginstelling(en) zijn geïmplementeerd en wat de reden voor implementatie was (meerdere opties mogelijk)? In de lege vakken kunt u eventueel zelf klimaat-mitigatie maatregelen toevoegen die niet in de tabel staan.

Klimaat-mitigatie maatregel	**Jaar van implementatie**	**Reden voor implementatie**		
		Financiële beweegredenen	*Klimaats-overwegingen*	*Anders, namelijk;*
Zonnepanelen				
Warmte- koudeopslag				
Zonneboiler				
Isolatie van de muren				
Isolatie van de daken				

Klimaat-mitigatie betekent het tegengaan van verdere klimaatsverandering. De klimaat-mitigatie maatregelen waar in dit onderzoek naar gekeken wordt, zijn maatregelen die in het teken staan van* ***economisch en efficiënt gebruik van gas en stroom* *(en hiermee de uitstoot van broeikasgassen verminderen).*

KLIMAAT-ADAPTATIE MAATREGELEN

8. Kunt u in onderstaande Table aangeven welke klimaat-adaptatie maatregelen er in uw zorginstelling zijn geïmplementeerd en wat de reden voor implementatie was (meerdere opties mogelijk)? In de lege vakken kunt u eventueel zelf klimaat-adaptatie maatregelen toevoegen die niet in de Table staan.

Klimaat-adaptatie maatregel	**Jaar van implementatie**	**Reden voor implementatie**		
		Financiële beweegredenen	*Klimaatsoverwegingen*	*Anders, namelijk;*
Groen dak				
Meer vegetatie in de nabije omgeving (binnen een straal van ~5 meter)				
Aanleg oppervlaktewateren in de nabije omgeving (binnen een straal van ~5 meter)				

**Klimaat-adaptatie betekent het aanpassen aan klimaatsverandering. De klimaat-adaptatie maatregelen waar in dit onderzoek naar gekeken wordt, zijn maatregelen waarmee geanticipeerd wordt op het veranderende klimaat.*

Het kan zijn dat er in andere verzorgingstehuizen anders om wordt gegaan met hittestress.

9. Zijn er maatregelen in andere verzorgingstehuizen (al dan niet in het buiteland) die u graag toegepast zou willen zien?