OptiBarn Project Annual Meeting

November 8h – 9th 2017, Brussels, Belgium

Participants

Thomas Amon, David Janke, Dilya Willink (ATB)
Christoph Menz (PIK)
Agustin del Prado, Elena Galan (BC3)
Fernando Estelles (UPV)
Ilan Halachmi, Harel Levit (ARO)
Guoqiang Zhang, Li Rong (AU)
André Aarnik, authorised representative for Nico Ogink (WUR, Advisory Board), Mengting Zhou (WUR)
Szilard Homonnay (AGROTEL), Keld Sørensen (DXT), (Stake Holders)

Meeting agenda

Day 1 - open results workshop – OptiBarn consortium, Work Packages results, discussions

10:00 – 10:15	Welcome by Federal Representation
10:15 – 10:25	Short introduction of all participants
10:25 – 10:45	Introduction to the OptiBarn project (T. Amon, ATB)
10:45 – 11:15	Coffee break
11:15 – 12:05	**WP1**: 2 presentations • Climate Change and Climate Impact on Animal Well-being (C. Menz, PIK) • Climate Simulation (D. Janke, ATB)
12:05 – 12:55	**WP2**: 2 presentations • Monitoring and modeling of animal perceived indoor climate for livestock housing (L. Rong, AU) • Smart ventilation design and control in cattle housing – Facing Global Warming (G. Zhang, AU)
12:55 – 13:55	Lunch break
13:55 – 14:45	**WP4**: 2 presentations • Uncertainties from modeled results (F. Estelles, UPV) • Impact assessment (E. Galán, BC3)
14:45 – 15:35	**WP3**: 2 presentations • Real-time animal response to climate changes, Research and application (H. Levit, ARO) • Investigation of animal specific stress in distinct climates (T. Amon, ATB)
15:35 – 16:05	Coffee break
16:05 – 17:35	Discussion with short (5min) presentations from invited stakeholders • AGROTEL (S. Homonnay), LFA (T. Amon), WOLF System (T. Amon), DXT

17:35 – 18:00	Summary of OptiBarn results, open questions & outlook (15min & 10min discussion) (T. Amon, ATB)
18:00 Farewell	

Day 2 (internal discussion)

09:00 – 10:30	Discussion about status of publications and deliverables
10:30 – 10:45	Coffee break
10:45 – 12:15	Next steps, further collaboration (project ideas and potential funding opportunities)
12:15 – 12:30	Conclusion, outlook, farewell

Summary

WORK PACKAGE 1 was introduced by two presentations: "Climate Change and Climate Change Impact on Animal Well-being", Dr. Christoph Menz (PIK) and "Climate Simulation" from David Janke (ATB). The first presentation covered climate projections for the OptiBarn focus regions (Germany, Spain and Israel), the links between global model climate projections and indoor climate parameters (with a focus on statistical modelling). This part of the work in WP1 was pointed out on the regional aspects of climate change, characteristics near the barn in the daily and sub-daily resolutions. It was observed increasing of temperature around 1 to 1.5ºC (during the period 1980-2010) for all 4 barns, with the highest rising in Beit Dagan (Israel). Climate predictions showed that by 2100, there will be exceptionally strong warming, the temperature will rise by 4ºC in this area. The rising temperature has an affect on both the indoor climate and animal's welfare. To close the gap between indoor and outdoor climate conditions, statistical models have been used. In the process of statistically modelling, temperature and relative humidity measurements inside the barn were taken into account. The verification parameters of the model showed promising results with the exception in Beit Dagan barn, probably due to the short time records. To understand the barn climate and to investigate the complex matter of animals well–being, the temperature-humidity index (THI) was used. By that, with the statistical model, it was possible to get the cow's stress level predictions for a further 80 years under high greenhouse gas emissions (RCP8.5) without barn adaptations. It was found that the amount of hours the cows are under Mild stress is significantly and seriously increasing in Spain and Israel, mostly because of increasing number of hot days, over the thermal neutral comfort zone of the animals, during the seasons. Furthermore, the duration of mild stress events is simulated to significantly increase for these regions. However, in Germany the increase of number of mild heat-stress events and the duration is considerably lower. It was also found that in the nearest future, the duration of the heat related stress events would increase by that point when there will be no relaxation time for the animals and even at night, while animals got their release tension, heat-stress would be observed. In this case, it is necessary to accept or to develop new mitigation and adaptation strategies for the barn construction to avoid further increasing the heat-stress. By the end of the talk, it was discussed an opportunity to replace the statistical model by the physical numerical one to predict not only temperature and relative humidity, but also the wind velocity inside the barn. Now, since wind flow depends on the barn design the statistical model can't properly describe it that is why this parameter is missing in the statistical model.

Second part of the WP1 studies were the climate conditions inside the barn and answers how the climate in the barn depends on the boundary conditions. For that a free-Kalman Filtering approach was taken, which basically requires providing barn measurements, identifying boundary layer within wind tunnel experiments and providing numerical simulations. Wind velocity measurements were taken inside of all four barns (Groß Kreutz, Dummerstorf, Betera, Beit Dagan), emissions were measured only in Groß Kreutz and Dummerstorf and a large database is available on everybody request. Biosystems Engineering accepted the paper about measurements variability and uncertainty. Together with Aarhus University, the experiment in the wind tunnel was provided to identify the different impacts of opening ratios (from 18% till 100%, with the 100% meaning no wall as seen in Israel and Spain) on the discharge coefficient, the air exchange rate and flow patterns in the barn. The atmospheric boundary layer reconstruction and measurements in different parts of the wind tunnel could identify the rising of air exchange with the opening ratio. However, analysing the sample lines inside of the barn showed that depending on the opening of the sidewall, the airflow behaviour is completely different. Thus, the air exchange in the animal occupied zones can be improve or worsen by changing the opening configuration of the barn. For the investigation of the adaption strategy and tuning the inlet, the simulations in German barns were provided. Experiments without adaption (no wall) showed less deceleration through the whole barn with the more homogeneous flow. Adaptation in turn, brought bigger recirculation zone in the roof area and concentrated acceleration in the first 1/3 part of the animal occupied zone. The volume flow inside the barn was calculated and it was found that without adaptation there is a decreasing of the airflow on about 21% and within adaptation on 64%. This identifies that the design of the barn inlet is a very important factor and can be used as adaptation strategy. The influence of different boundary layer roughness length was researched through the CFD model OpenFOAM. During this research the validation dataset for transient Solvers were receive and can be published for other researches needs. For the boundary layer, the experiments with different roughness length (from z_0=1.0 till z_0=0.001) and orthogonal inflow were provided. The flow patterns and air exchange rates were investigated, it was found that with small roughness the decreasing in the total exchange rate is also small (12%), with the z_0=1.0 it is almost 100% with the same reference wind velocity. So, to sum up, in all barns it was identified a jet effect: concentrated acceleration of the flow, backflow near by the roof and deceleration of the flow due to the expansion. This work is planned to be submitted into Biosystem Engineering. During the discussion part the questions about discharge coefficients, wind profile, optimal barn design were discussed with the participants and it was concluded that the side walls and the roof geometry have to be transformed to make more sufficient air exchange and provide more homogeneous fast enough wind flow inside the barn, especially in the animal occupied zones (AOZ).

The WP2 was presented by two presentations given by Prof. Guoqiang Zhang (AU) "Smart ventilation design and control in cattle housing – Facing Global Warming" and "Monitoring and modeling of animal perceived indoor climate for livestock housing". The first talk about smart ventilation design was presented with the objectives to display the potential of technology developments and challenges in ventilations and indoor climate control. Few methods that can be integrated in automatically controlled natural ventilation (ACNV) of cattle building were presented. These methods can increase air speed in AOZ during summer and ensure low air speed in winter, as well as pollutant source one air exhaust to ensure optimal indoor air quality and transport the most pollutant air for cleaning treatment. The air speed in the AOZ can be increased by recirculation fans, configurations of wall openings and by direct supply of fresh air to the animals. The hybrid ventilation system allowed combining all these methods and provided indoor climate and air quality control by focusing on airflow pattern and emissions control with the effective air purification units. In the mechanical ventilation buildings harmful gases and dust can be removed by using different methods (bio cleaning, chemical cleaning), whereas in the NVB it is simply impossible. Thus, to solve this problem the hybrid ventilation system was created, which can replace the original ventilation and clean the air. Experiments with the hybrid system showed that in winter time it exhausts around 80% of the emissions and sends it to the purification system, so in total 90% of emissions are reduced, in summer time the results a bit lower but still impressive. These results were published in Energy and Buildings by Li Rong. To sum up, smart ventilation design can increase the air speed in the AOZ, control the emission and air quality. It was also mentioned that before increasing the wind speed, the attention has to be paid to the air temperature, so if the temperature is too high, it's necessary to think first how to lower it down. During the discussions the questions about cooling controls systems, approaches in different climate zones and countries were discussed. On this topic one publication on earth-air heat exchange application to a zone air supply is under the preparation, Xiaoshuai Wang at AU is the leading author.

After lunch, the work of WP2 was continuing. The second talk portrayed monitoring and modelling of animal perceived indoor climate. An objective of the talk was to find an optimal thermal climate control in the animal occupied zones using either models or sensors to identify animal bio-response. Human beings can complain if climate conditions are not comfortable, however animals don't have such privilege, thus to get animals response we have to pay close to animal behavior, e. g. eating, drinking and production characteristics. When these parameters start to change, it's getting too late and animals are already suffering from heat-stress. A model or sensor that can catch the indoor climate conditions could greatly help the system regulating to avoid heat stress of animals. Since the THI has no heat convection and radiation included, it is important to find another measure for evaluation of thermal environment. An operative temperature, global temperature (involved both radiation and convection effect), can provide a part of information of convection and radiation effects to the thermal environment but can't distinguish these effects. A wet-bulb global temperature (WBGT) is one of the sensors used to estimate the effect of temperature, humidity, wind speed and sunlight radiation. For WBGT calculations, natural wet-bulb temperature, globe thermometer temperature, dry-bulb temperature are taken. When WBGT calculates indoor or neglect solar radiation, the natural wet-bulb temperature and dry-bulb temperature are taken. Depending on WBGT calculations, there are several categories identifying comfort conditions. Since the Global temperature and Operative temperature both depend on convection and radiation transfer, it was found that by effectively increasing the size of the thermometer body/bulb, the convection transfer coefficient is reduced and the effect of radiation increased accordingly. Besides sensors, models can also do the condition prediction task. Recently the Effective Temperature Model (ET) was introduced, which is a linear function of dry-bulb temperature, relative humidity, air velocity and radiation. ET could be a good indicator for thermal control to reducing animals' heat stress. As an output it is possible to see how the input parameters are interconnected and influence each other. Though many works have been done in last decades on heat stress of poultry, pigs and cows, limited data can be applied for the assessment of this ET model, since most data available are processed after analysis and are difficult to trace the independent thermal parameter as basic values. ET model needs to be further improved with experimental data from both laboratory and field measurements. During the discussion section the time resolution of input parameters was discussed.

Considering the previous talk, it was decided to present the WP 4 first and there after, the WP3. The WP4 was presented by three talks, “Uncertainties from modeled results” and “Environmental impact assessment” by Prof. Fernando Estelles, (UPV) and Impact assessment by Dr. E. Galán, (BC3).

First talk about the approach to deal with uncertainties resulting from the modelling used was presented. The farm model and data were described in order to identify sources of uncertainty and integrate them in the modelling. Second talk was focused on barn emissions. For this work different time scales were taken, leading to predictions with the confidence interval containing 95% of the data. The bibliographic review of gas emissions coming from the animals and the effect on temperature and air velocity was provided and used in the regression model. The reduction of methane production, nitrogen and volatile solids were also taken into the model. From the global accounting, heat stress reduces emissions due to reducing production and feed intake. However, temperature and wind speed affected emissions as well. The barn adaptation will change wind speed and therefore, emissions. It was found out that the adaptation strategy for improving barns and animal conditions (e.g. installing frequent fans) showed that increasing the temperature would reduce CO_2. According to emissions, it was found that ammonia positively correlated with air velocity and temperature. The influence of feeding is higher on methane production than on ammonia. Adaptation methods can help to achieve a “win-win” strategy where the temperature and emissions are both reducing. For example, the fan air-drying system can do exactly this. In the discussion session the relationships between methane - temperature, and methane – water, opportunities to reduce the methane levels were discussed.

Second talk within WP4 was about impact assessment: modeling impacts, risks metrics and management options of heat stress. The main idea of this WP part was to identify the effectiveness and practicability of the optimization approaches. It was achieved through assessing three potential impacts of climate change at farm scale in dairy cow system such as welfare, economic costs and emissions by integrating the effects of heat stress in a farm model. The effect of temperature, air velocity, heat-stress and humidity were integrated in the model. The heat stress levels were measured by THI index. Another important part of the assessment was risk metrics. Magnitude of the impact of climate change at farm scale was measured for: milk loss, fertility performance, death risk, welfare and emissions. The idea of the risk assessments was to estimate the total costs of milk loss in order to estimate future prices. For that the representative concentration pathways (RCP) scenario from IPCC was taken, however discount rates were omitted due to the large time scale. Simulations were provided for two case studies - closed barn (Groß Kreutz) and opened barn (Betera). By reviewing the studies, it was found that conception rate in warm period is much lower than in cold periods. The welfare index (thermal-comfort index) was defined in order to integrate into already existing welfare index for SIMS dairy model. Management factors were identified affecting the welfare index, such as milk yield, diet type (depending on the season), locomotion score, cooling system (intensity) and type of breed. As a result of the region specific adaptation assessments, two special weighted matrixes for sub-optimal situation and adaptation were created. Those matrixes included all parameters explained above. From them, it was clear that for Groß Kreutz the effects of climate change are light. When implementing the adaptation, where the consumption of energy is more efficient, GHG gases decreases (mainly due to methane). In Betera barn, climate change has more severe effects, and the adaptation strategy does not have strong influence on the situation. Addressing milk price series, it was noticed that there is price seasonality, with lower values in summer time compared with higher values in October-November. The severity in monetary costs of climate change is much higher in Spain compared to Germany, with up to 50% monthly losses per cow in the long-term RCP 8.5 scenario. Implementing the adaptation strategy will help cover the milk losses in Germany whereas using the adaptation strategy in Spain is not enough and will require implementing extra methods to reduce losses. To sum up, more scenarios and combination of other management adaptations are needed to find the optimal solution for the most affected regions. Also, measures to mitigate NH_3 are required as livestock is one of the main contributors of emission gases in Europe. Optimizing solutions will require tuning the criteria, e.g. matching emissions levels in line with national reduction commitments of the Gothenburg protocol (NH3) or Kyoto protocol/Paris agreements (GHG). During the discussion part it was discussed how to improve the welfare, reduce the heat-stress and at the same time reduce ammonia.

In the afternoon, we continued with the presentations and moved into the WP3, represented by Harel Levit (ARO) “Real-time animal response to climate changes, Research and application” and by Prof. Thomas Amon (ATB) “Investigation of animal specific stress in distinct climates”. In the first talk was given by Harel Levit, two main questions were investigated: individual cow heat stress response and design of optimal cooling methods. Due to environment conditions in Israel, cooling was the only way to reduce the cow’s heat-stress. In this case, there were several methods developed with keeping this in mind. Implementing cooling methods in Israel begin in early summer and lasts till autumn. One of the common used methods is to install cooling fans with sprinkles in the cooling yard. For the first experiments, 8 and 5 cooling procedures (each procedure lasts 45 minutes and includes combinations of water spraying and drying) in the dairy barns during the day were used, with higher air temperature. It was noticed that sometimes even 8 cooling procedures (with the high air temperature days) wasn’t enough and the cow’s body temperature was above 39°C. The group with 8 cooling procedures had higher FCM (Fat corrected milk), feed consumption and spent more time in the feeding barn with superiority in lying time. The animal response to cooling strategy should be evaluated.

Room temperature was used as a predictor of animals heat-stress. Second experiment was about providing a sensor based cooling method. Similar methods for groups were taken, one was cooled down by sensor and another had pre-defined fixed in time 3 cooling procedure per day for 3 months. The cows inside the time base-cooling group suffered from the heat-stress more than the sensor-cooling group. Sensor-based cooling group changed their eating behavior, consequently their production and efficiency. Also, the sensor cooling provided better thermoregulation compared with the other group. To conclude, the sensor-cooling method was found to be an effective tool to control and reduce heat-stress. During the discussion session questions about the measured data inside the barn (temperature, thermal radiation, wind velocity) and from the cows (amount of wet cows skin, body temperature) were discussed. It was mentioned that in the cooling yard cows became completely wet, however it's still not clear how much water use for wetting cows and how fast they dry. Varying amount of water and increasing/decreasing, the period of cows drying could be a good cooling method. Another discussion was about varying amount of cooling procedures and influencing on cow's behavior and body temperature.

Prof. Dr. Thomas Amon gave the last talk before the final discussions. He spoke about investigating animal specific stress in distinct climates. Within this part of the WP3, the authors investigated the influence of barn climate on animal welfare. To identify the cow's condition, the activity behavior, respiration rate, heart variability and rumination activity were measured. The model showed that there was a high correlation between respiration frequency and THI. With increasing THI, the respiration frequency increased, too.. It was also noticed that for standing cows, less respiration frequency occurred compared with lying cows. Another parameter showed cow's condition is the milk yield. It was found that mild yield influenced respiration rate. The respiration rate increased with BPM for each kg milk produced.. Created model allowed to quantify the respiration rate according to the behavior and milk yield. Measurements showed that the respiration frequency decreased with the implementation of cooling procedures, thus the time base-cooling group was suffer less from high respiration rate, compared with time 3 cooling group. There was also an animal individual factor influencing on respiration rate, as with age the respiration decreased, however this aspect should be researched further. Experiments with THI demonstrated the connection to animal behavior, increasing THI resulted in decreasing of the daily lying duration. The physiological connection between rumination time and the THI level was found; consequently with low THI levels the duration of rumination is high. Looking in more detail, the rumination time was divided into night and day phases, so having heat stress during the day, cows tried to compensate with higher levels of rumination duration during the night. Another indicator of animal's behavior; the heart rate variability was also taken. The challenge of this indicator was to find correct parameters to interpret the heart-rate variability because of the high sensibility of this factor. . Analyzing of data was still going on. During the discussion part, questions about the way of dividing standing/lying frequencies, changing behavior while suffering from short and long time heat-stress phases, extreme changes in weather conditions, especially very quick temperature jumps in Germany especially in spring period with the high temperature variability and animals ability to fast adaptation for the new conditions were discussed. It was mentioned that the difference in respiration rate between Israel and Germany was high. Another discussed topic was the possibility of identifying different thresholds for animals' welfare response parameters (respiration rate, THI, vaginal temperature and others) depending on the regions (or even climate regions). It was considered to find absolutely independent parameters, like body temperature, respiration rate etc., to identify when exactly the heat stress begins.

After the coffee break, two stakeholders who joined the meeting presented themselves. Other stakeholders invited on the meeting couldn't come due to several large conferences taking part at the same time in different parts of Europe (like COP23 and others). The presentation, given by Mr. Homonnay (Agrotel), was about different types of agricultural goods produced by Agrotel, such as barn construction using different types of roof and construction materials, gates and automatic (remote control) doors, big storage hangers for different purposes (storing farm machinery tractors, small plains), wind break systems (including automatically controlled). Another talk was given by Mr. Sørensen (DXT), where he presented the application "StaldVent" for designers and operators of pig/chicken/cattle closed barns. Based on given design points, the software can calculate the heat balance and amount of energy needed to heat/cool the building. It also calculates the emissions that occur for set design points and animals.

Afterwards, Prof. Thomas Amon gave the resulting talk, where he has drawn conclusions for all WP. Next day was started with discussions of milestones and deliverables together with the scientific advisory board. Some aspects of final reports preparations and deadlines were also under the discussion. The last part of the meeting was dedicated to the publication strategy. Current publication list was updated with a particular focus on cooperative papers. A list of potential topics was collected including responsible first authors and contributing institutes.

Some conclusions for the WP and further work plans:

WP1

1) Find out more regional specific optimisation strategies by using CFD models
2) It would be more sufficient to replace the statistical model by the barn circulation model, however there are some problems with the boundary conditions occurred, thus the combination of both approaches could be taken into account (take temperature and humidity from the statistical model and simulate the wind inside the barn by physical model). Having time series of temperature, humidity and wind velocity inside the barn could be used in the THI.
3) The barn management information has to be taken into account (time of opening and closing time) in the model.
4) The data sets and predictions could be separated by seasons to see if statistic model has seasonality
5) Identify the differences between models built for all 4 barns and try to build a general model for all of them.
6) Implement the results of the OptiBarn project for barn building management.

WP2

1) For checking the model conception, more measurement data (THI index, respiration rate etc., air velocity, thermal radiation data) have to be used. The possibility of combining it with production parameters was discussed.
2) Make available the respiration rate data according to temperature, humidity and wind velocity.
3) New concept of ventilation design in the barn is under development, where parts of mechanical and natural ventilations were combined together. Another task is to use the air velocity to reduce the emissions.
4) Implementing the mechanical air ventilation system to supply animals with the direct fresh and high speed cooled air.
5) The possibility of installing in Groß Kreutz a system for fresh air delivery directly to the animals inside the barn and recording animals welfare response on the system were discussed.

WP3

1) How to adapt the THI to the new thresholds.
2) Should be focused more on the direct information coming form the animals (body temperature, respiration rate) and building the models which can simulate this parameters, depending on flow characteristics and other weather parameters inside the barn
3) Animals based criteria reaction on the climate conditions changes, which parameters start to react first and are there any interactions between them were discussed.
4) When the air temperature rises, animals have different mechanisms to reduce or keep the body temperature at the same level. However when the animal's mechanisms can't cope, the heat-stress appears. That is why it is important to identify the animal's welfare heat-stress thresholds.

WP4

1) It is important that the assessment in terms of animal welfare in relation to the heat-stress has to be cooperated with new data
2) Using information about reduction of dry matter intake between controlled and experiment group for Israel farm was discussed
3) For the Northern barns need to implement in the model clearer adaptation strategy. In such way, some clear interdependencies are expected (THI with and without adaptations).
4) For correct comparison, it needs to standardize certain specific factors for all barns (Germany, Spain, Israel). Therefore, the factors have to be identified and agreed between project partners.

Discussion about status of publications and deliverables

Deliverables were finalized and discussed according to the work status and responsibilities. (Annex 1. Deliverables.xlsx). Almost all deliverables are running on schedule, by the end of the project (December 2017) they will be delivered by response authors. The opportunities for joined publications according to the topics were discussed. As a result, a list of joint publications with the timetables was created (Annex 2). The full publication list was updated (Annex 3).

Annex 2. Joined publications list (2017-2018)

N	Lead-author	Co-author	Objectives	Hypothesis	Results	Journal name	Time schedule
			WP1				
1	**The impact of roughness height on air exchange rate and particle transport in a cattle barn model by using wind tunnel test and LES simulation**						
	D. Janke	S.Hempel,M.König, L.Wiedemann D.Willink, L.Rong, C.Ammon, T.Amon, B.Amon	• To validate the numerical model with wind tunnel data • Study flow pattern of a typical cattle barn in Germany • Investigate the effect of the roughness height on the air exchange rate • Investigate the particle residence time under different roughness heights	• 2D LES can be validated with symmetrical wind tunnel setup • Different roughness heights result in different AER • Different roughness heights result in different particle residence times (equivalent to air mixing with fresh air)	• New measurement campaign in wind tunnel showed average validation results so far • Strong variations in AER due to variations in roughness heights	Biosystems Engineering (or ANIMAL	Draft will be sent by the end of 2017 year;
2	**Validating open source CFD tools with wind tunnel measurements to simulate the airflow through naturally ventilated barns**						
	D. Janke	D.Willink, O.Knoth, A.Caiazzo, L.Rong(?),T.Amon, B.Amon	• Create a dataset in the windtunnel to validate Codes • To validate different open source numerical model with tunnel data • Study the difference of the models due to: • Different turbulence modeling • Different grid generation • Different boundary layer generation • Study the efficiency of each model • Give out a dataset from wind tunnel measurements for other researchers	• Open source tools are an appropriate choice when simulating the transient flow in NVB • Each tool varies in terms of effiency and accuracy • Every tool has its strengths and weaknesses	• Simulations done so far, now analyzing the results • Wind tunnel measurements done, 16 horizontal and vertical sample lines in high resolution were measured	Computers and Electronics in agriculture (ELSEVIER)	Draft expected to be sent in January 2018
3	**Publish all measurements as datasets**						
	All participants	Birte Lindstädt	• Make the data available as open access • Learn from ZB Med about effective database generation / metadata etc • Start with using open access for future needs				
	Statistical modelling approach on indoor climate conditions						
4	C. Menz	???	• Description of the methods used • Calibration and validation	Statistical model is able to close the spatial and temporal	Statistical methods are able to close the gap, but depends on		Draft by end of Feb.

			of the model • Identification and quantification of outdoor parameters influencing different indoor parameters • Possibly impact of barn design and management on the quality of the statistical model • Impact of climate change on indoor parameters (without adaptation) • Comparison of different regions/barn designs	gap between indoor and outdoor measurements	parameter, barn desing and barn management Implementation and quantification of impact of management and barn design still to be done		2018
			Impact of climate change on dairy cows in different regions				
5	C. Menz	???	• Relate the indoor climate to animal welfare on sub-daily basis • Compare the impacts in different regions • Possibly try different Heat stress indices and classifications (haven't done this yet) • Possibly implement adaptation measures (I do not know if this will be reasonable for the statistical approach)	• Climate change will increase heat stress without adaptation Magnitude of impact will be influenced by magnitude of outdoor climate change and barn design	• Analysis done with THI only so far • Results differ by regions and anticipated climate change • Wind fields or adaptation measures (mamagement or barn design) are not considered yet •		Draft by end of Aug. 2018

WP2

1			**Review of heat stress indices for cattle**				
	Xiaoshuai Wang.	Guoqiang Zhang; Bjarne Bjerg; Chao Zong	To get an overview of the current thermal index used for cow heat stress estimation				Draft expected at the end of the year 2017
2			**Effective temperature model for thermal control of dairy cattle housing**				
	Xiaoshuai Wang.	Guoqiang Zhang; Bjarne Bjerg	To present an integrated thermal index and validation using data available				Draft expected at the end of the year 2017
3			**Effect of airflow on convective heat release from standing and reclining cows**				
	Xiaoshuai Wang.	Guoqiang Zhang; Christopher Choi	To investigate the ventilation airflow on heat removal from cow in varied positions			Biosystems Engineering	Submitted. Now under revision
			Numerical Assess of a Precision Air Supply System (PASS) Targeting for a Single Cow				
4	Xiaoshuai Wang	Guoqiang Zhang; Christopher Choi	To assess the effects of a precision zone air supply on convective heat removal of cow			Biosystems Engineering	It is expected to be submitted in Dec.

WP3

1	**The presence of critical periods using the temperature-humidity index in a moderate climate zone and resulting changes in the activity behavior of lactating dairy cows**						
	J. Heinicke	G.Hoffmann, C.Ammon, B.Amon, A.Römer, T.Amon, I.Halachmi	• to measure the duration (hours and minutes) of exceeding of different THI thresholds in a moderate climate zone • to estimate the risk of heat stress by contrasting the amount of time above the THI threshold of 68 on animal based activity measurements	• dairy cows are exposed to THI ≥ 68 during long periods in summer (June to August) • increasing accumulation of duration of heat stress has an influence on activity behavior	• THI values inside the barn achieved up to 86 and down to 8.6 • highest average monthly THI values / highest amount of time above the THI threshold in July and August duration of exceeding of the THI thresholds of 68 influences the activity behavior	Journal of Thermal Biology	Draft expected to be sent in May 2018
2	**Quantification of cow individual heat stress under seasonal barn climate conditions in moderate zone using time series analysis**						
	J. Heinicke	V.Belik, M.Sieg, B.Amon, T.Amon, I.Halachmi	• to recognize heat stress situations on the basis of behavior changes with the help of time-series comparison • forecasting of heat stress situations by learning processes based on knowledge of previous activity data	there are regularities/ structures on the activity behavior regarding climate changes	• in process • data collection (activity, climate) finished • time series analysis is still in progress	Applied Animal Behaviour Science	Draft expected to be sent in April 2018
3	**Preferred lying places of abode in the barn under different climate conditions**						
	J. Heinicke	A. Ott, M.Sieg, I.Halachmi B. Amon, T. Amon	• to analyse the preference of lying places inside the barn under different climate conditions	• increasing THI influences the occupancy of the lying places • lying boxes with lower THI inside the barn are preferred	• in process • data collection (video, climate) finished • video analyses are still in progress	?	Draft expected to be sent in May 2018
3	**Influence of barn climate on respiration rate of dairy cows considering cow-related factors**						
	S. Pinto	G. Hoffmann, C. Ammon, B. Amon, W. Heuwieser, I. Halachmi, T. Banhazi, T. Amon	evaluation of the effects of THI on RR of lactating dairy cows considering cow-related factors, specifically body posture as standing or lying and daily milk yield	Lying cows would show higher RR than standing cows, and cows with higher milk yield would lead to an increase in RR regardless of THI.	Respiration rate increased with increasing THI. The values of RR in lying cows in THI < 68, 68 ≤ THI < 72 and 72 ≤ THI < 80 categories (37, 46, and 53 BPM, respectively) were greater than in standing cows in the same THI categories (30, 38 and 45 BPM). The RR response showed a significant increase in cows with	International Journal of Biometeorology SPRINGE	Draft expected to be sent in December 2017

					increasing milk yield.		
4	**Critical THI thresholds on respiration rate and milk yield of lactating dairy cows considering different cow-related factors**						
	S. Pinto	G. Hoffmann, C. Ammon, W. Heuwieser, I. Halachmi, T. Amon	• Examination of the effects of heat stress on respiration rate and milk yield of high production dairy cows in moderate climate • Determination of a critical THI threshold to respiration rate and milk yield, demonstrating the period of accumulation temperature for each significant THI level	• respiration rate increases before the milk yield decreases in hot conditions • critical THI value for milk yield decrease is less than 68 • period of temperature accumulation to decrease the milk yield is longer than to increase the respiration rate		Journal of Dairy Science ELSEVIER	Draft expected to be sent in August 2018
5	**Influence of temperature and relative humidity on rumination activity of lactating dairy cows in a moderate climate**						
	T. Siemens	Gundula Hoffmann, Christian Ammon, Severino Pinto, Julia Heinicke, Ilan Halachmi, Thomas Amon, Barbara Amon	• automatic, long-time investigations of rumination activity (RA) in a moderate climate considering cow-individual factors • determination of a critical THI threshold for a decrease in rumination activity	• RA is influenced by environmental conditions • RA decreases with increasing THI / critical THI threshold is above 68 • RA is more influenced by environmental conditions during the daytime than during the night		Journal of Dairy Science ELSEVIER	Draft expected to be sent in December 2018
6	**Influence of cooling on rumination activity in lactating dairy cows under hot climate conditions in Israel**						
	T. Siemens	Gundula Hoffmann, Christian Ammon, Severino Pinto, Julia Heinicke, Ilan Halachmi, Thomas Amon, Barbara Amon	• RA is influenced by cooling	• RA increases during cooling time? • effectiveness of cooling (How long is the impact of cooling? What is the peak? What is the lag? Is it wet / windy enough?)		Journal of Dairy Science ELSEVIER	Draft expected to be sent in March 2018
7	**Heart rate variability under heat stress conditions in Israel**						
	S. Strutzke	G. Hoffmann, C. Ammon, T. Amon, B. Amon, I. Halachmi (?)	• The aim of this study is to investigate the effect of heat stress and cooling on heart rate variability of dairy cows.	• heat stress results in a decrease of HRV • cooling under heat stress conditions results in a increase of heart rate variability			Draft expected to be sent in 2018

8	Animal-related, non-invasive indicators for determining heat stress in dairy cows: A review				
	G.Hoffmann			in Vet Res Commun ?	Draft expected to be sent in 2018
9	Standardized bolus temperature based on vaginal temperature				
	S.Goldshtein			Journal of Dairy Science ELSEVIER	Draft expected to be sent in December 2017
10	Real-time animal response to climate changes; research and application				
	Harel Levit			Journal of Dairy Science ELSEVIER	Draft expected to be sent in December 2017

WP4

1	Modelling ammonia emissions in a dairy cattle barn for future according to climate change scenarios			
	Elena Sanchis	E.Sanchis, S.Calvet, A. Prado, E. Galán, C.Menz, S.Hempel, B. Amon, F. Estellés	Based on the SIMSDairy modelling framework (Del Prado et al., 2011), we have developed a model that describes dairy cattle performances and environmental loads according to farm management and environmental conditions. This model has been used to predict future variations in NH3 emissions based on temperature projections until the year 2100 for a dairy cattle farm located in Eastern Spain (Valencia). NH3 emission factors are expected to increase (considering 2005 emissions as a reference) from 2 to 9% for 2050 and from 7 to 24% for 2100 under moderate and high emissions scenarios respectively. The uncertainty of these results is high, mainly due to emission factor uncertainty (about 25%), but clear tendencies are shown	Draft expected to be sent in December 2017/January 2018
2	A meta-analysis of environmental factor effects on ammonia emissions from dairy cattle houses			
	Elena Sanchis	Elena Sanchis, Salvador Calvet, Agustín del Prado, Fernando Estellés	A literature survey was performed and works published until September 2016 were reviewed. A total of 26 peer-reviewed papers were considered and 371 values of NH_3 emission rates were obtained. Results showed that NH_3 emissions increased linearly with increasing air temperature inside the barn (ºC) at a rate of 1.5 $g{\cdot}cow^{-1}{\cdot}d^{-1}$ for every temperature ºC rise. When these results are expressed as a percentage of excreted TAN emitted as NH_3, emissions increased 0.007 g $N\text{-}NH_3{\cdot}g$ TAN $excreted^{-1}$ for every temperature ºC rise. For ventilation rate, NH_3 emissions increased by 33% when ventilation rate rose from 700 to 1,000 $m^3{\cdot}cow^{-1}{\cdot}h^{-1}$. Our equations to predict NH_3 emissions by using climate information will be very helpful to assist on the development of mitigation strategies as a consequence of the increase in gaseous emissions expected in the future due to the climate change.	Draft expected to be sent in December 2017/ January 2018
3	Risks associated with sub-optimal housing design			
	Elena Galán	Agustin del Prado,	Literature review on effects of heat stress of dairy cows in milk yield, fat, protein, reproductive performance and death risk.	Draft expected by February 2018

		Fernando Estellés, Elena Sanchís, Guillermo Pardo			
4			**Systematic review on heat stress in the welfare of dairy cattle**		
	Elena Galán	Pol Llonch, Arantxa Villagrá, Agustin del Prado, Fernando Estellés, Elena Sanchís, Guillermo Pardo	Systematic review on the welfare effects of heat stress on dairy cattle was performed. We assess the main differences among the studies.	Animal	Draft expected by February 2018

Annex 3. Full publication list, including already published and submitted papers (2015-2018)

№	Type / Journal	Lead author	Contributing OptiBarn partner	Topic	Title	Status
1.	Review article	Li Rong	AU	Natural ventilation	Mechanisms of natural ventilation in livestock buildings: Perspectives on past achievements and futurze challenges	Published in November in journal of Biosystems Engineering Published online September 2016, doi= http://dx.doi.org/10.1016/j.biosystemseng.2016.09.004
2.	Research article	Li Rong	AU, ARO, ATB	Heat transfer out of cow	Uncertainties of input to model the heat transfer between animals and the environment	Draft is planned for next year (depends on the input)
3.	Proceeding PLF-Asia, Beijing, September 2015	Guoqiang Zhang	AU	Zone ventilation	Precision control of ventilation in Livestock Housing	Published in proceedings of PLF-Asia
4.	Research article	Q. Yi	AU, ATB	Discharge coefficient and ventilation rate estimation	Investigation of discharge coefficient for wind-driven naturally ventilated dairy barns	It has been submitted in Energy and Buildings – re-submitted in revised version in Nov 15, 2017.
5.	Review article	Xiaoshuai Wang	AU	Integrated thermal sensing index	Review of heat stress indices for cattle	Draft expected at the end of the year 2017
6.	Research article	Xiaoshuai Wang	AU	New model analysis and validation	Effective temperature model for thermal control of dairy cattle housing	Draft expected at the end of the year 2017
7.	Research article	Xiaoshuai Wang	AU	Convective heat transfer	Effect of airflow on convective heat release from standing and reclining cows	It has been submitted to Biosystems Engineering – now under revision.
8.	Research article	Xiaoshuai Wang	AU	Precision Zone air supply ventilation	**Numerical Assess of a Precision Air Supply System (PASS) Targeting for a Cow in a cubicle**	Manuscript will be ready for a journal submission in December 2017
9.	Proceeding BTU 2015, Freising, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Air flow pattern, modelling and long-term measurements	Determine the through-flow characteristics of naturally ventilated dairy barns to optimise barn climate	Published in: 12. Tagung: Bau, Technik und Umwelt 2015 in der landwirtschaftlichen Nutztierhaltung. 12. Tagung: Bau, Technik und Umwelt 92015. KTBL, Darmstadt, (978-3-945088-09-8), p. 346-351.
10.	Proceeding RAMIRAN 2015, Hamburg, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Variability of air velocity, temperature, humidity and gas concentrations (long-term measurements and the OptiBarn	OptiBarn – Optimized animal specific barn climatisation facing temperature rise and increased climate variability	Published in: 16th International Conference Rural-Urban Symbiosis (RAMIRAN), p. 141-145. http://ramiran2015.de/wp-content/uploads/2016/05/RAMIRAN_2015-Proceedings-

				project)		Book.pdf
11.	Review article	Şeyda Özkan (MACSUR)	ATB	Modelling related to animal health and climate change	Challenges and priorities for modelling livestock health and pathogens in the context of climate change	Publication expected in November 2016 in Environmental Research Published online September 2016, doi = http://dx.doi.org/10.1016/j.envres.2016.07.033
12.	Proceeding MACSUR LIVEM Conference, June 2016, Potsdam, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Modelling in OptiBarn	Integrated modelling to assess optimisation potentials for cattle housing climate	Published in November 2016 in Advances in Animal Biosciences DOI: https://doi.org/10.1017/S2040470016000352
13.	Research article	Sabrina Hempel	ATB, PIK, UPV, USQ	THI measurement uncertainty	Uncertainty in the measurement of indoor temperature and humidity in naturally ventilated dairy buildings as influenced by measurement technique and data variability	Resubmission to Biosystems Engineering until end of October 2017 under open access license
14.	Research article	Sabrina Hempel	ATB,UPV, PIK, USQ	Predicting the temporal evolution of THI		Planned for end of 2018
15.	Research article	David Janke	ATB, AU, WIAS, TROPOS	Air flow modelling, comparison of tools and approaches	Validating open source CFD tools with wind tunnel measurements to simulate the airflow through naturally ventilated barns	Draft expected to be sent in January 2018; plan to submit in Computers and electronics in agriculture
16.	Research article	David Janke	ATB, AU	Simulation of airflow patterns inside a barn model	The impact of roughness height on air exchange rate and particle transport in a scaled cattle barn by using wind tunnel test and LES simulation	Draft will be sent at the end of the year; plan to submit in Biosystems engineering
17.	Research article	Dilya Willink	ATB, PIK	Simulation of microclimate in NVB		Planned for 2018
18.	Proceeding BTU, September 2017, Stuttgart, Germany	Julia Heinicke / Sabrina Hempel / Severino Pinto	ATB	Animal welfare, behavior, vitality, microclimate	Effect of heat stress on behaviour and vitality parameters of dairy cows	Published in 13. Tagung: Bau, Technik und Umwelt 2017 in der landwirtschaftlichen Nutztierhaltung. 13th Conference – Construction, Engineering and Environment in Livestock Farming 2017. KTBL, Darmstadt (978-3-945088-46-3), p. 64-69
19.	Research article	Julia Heinicke	ATB, ARO	Heat stress in moderate climate zones	The presence of critical periods using the temperature-humidity index in a moderate climate zone	Submitted: May 2017 Review with major revisions: August 2017 Planned resubmission:

					and resulting changes in the activity behavior of lactating dairy cows	November 2017
20.	Research article	Julia Heinicke	ATB, ARO	Activity behaviour under different climate conditions	Quantification of cow individual heat stress under seasonal barn climate conditions in moderate zone using time series analysis	Planned submission: April 2018
21.	Research article Short communication	Julia Heinicke	ATB, ARO	Activity behaviour and position in the barn	Preferred lying places of abode in the barn under different climate conditions	Planned for 2018
22.	Proceeding BTU, September 2017, Stuttgart, Germany	Theresa Siemens	ATB	Rumination activity	Effect of heat stress on rumination activity in lactating dairy cows	Published in 13. Tagung: Bau, Technik und Umwelt 2017 in der landwirtschaftlichen Nutztierhaltung. 13th Conference – Construction, Engineering and Environment in Livestock Farming 2017. KTBL, Darmstadt (978-3-945088-46-3), p. 182-186
23.	Research article	Theresa Siemens	ATB, ARO	Rumination activity	Influence of environmental climate conditions on rumination activity of lactating dairy cows in a moderate climate	Draft expected in December 2017 (Journal of Dairy Science)
24.	Research article	Theresa Siemens	ATB, ARO	Rumination activity	Influence of cooling on rumination activity in lactating dairy cows under hot climate conditions in Israel	Draft expected in March 2018
25.	Research article	Severino Pinto	ATB, ARO	Respiration rate	Influence of barn climate on respiration rate of dairy cows considering different cow-related factors	Resubmitted in a new journal (Journal of thermal Biometerology),December 2017
26.	Research article	Severino Pinto	ATB, ARO	Respiration rate	A critical THI level for respiration and milk yield of high producing dairy cows under hot temperature	Draft expected in March 2018
27.	Research article	Severino Pinto	ATB, ARO, UPV	Respiration rate	Cooling influences on respiration rate of lactating dairy cows in different environmental conditions and barn management	Draft expected in February 2018
28.	Research article	Severino Pinto	ATB, ?	Respiration rate	Respiration rate of Holstein dairy cows under thermal neutral conditions	Draft expected at the beginning of 2018
29.	Review article	Gundula Hoffmann	ATB, ARO	Review on physiological parameters changing under heat stress	Animal-related, non-invasive indicators for determining heat stress in dairy cows: A review	Drafting, submission planned for next year (in Vet Res Commun?)
30.	Research article	Marcel König	ATB	Air exchange rates – uncertainties in	Variabilities in determining air exchange rates in naturally ventilated dairy	Resubmitted to Biosystems Engineering at 17.10.2017.

				CO_2-balance method (long-term measurement)	buildings using the CO2 production model	
31.	Research article	Shlomi Goldshtein	ARO, ATB	Vaginal vs. rumen bolus logger	Standardized bolus temperature based on vaginal temperature	Drafting, draft expected to be send around December 2017; Journal of Dairy Science
32.	Research article	Harel Levit	ARO, ATB	Sensor based cooling management	Real-time animal response to climate changes; research and application	Drafting, draft expected for December 2017; Journal of Dairy Science
33.	Proceeding MACSUR LIVEM Conference, June 2016, Potsdam, Germany	Elena Galan	BC3, UPV	Economic impacts of heat stress / management strategies	Heat stress effects in milk yield and milk traits at farm scale	Published in November 2016 in Advances in Animal Biosciences DOI: https://doi.org/10.1017/S2040470016000261
34.	Review article	Elena Galan	BC3, UPV	Review about general effects of heat on animal + model of climate parameters affecting milk yield in two farms, Betera and GK	Modelling heat stress effects at farm level	The review part is done. Draft expected end of this year
35.	Review article	Elena Galan	BC3, UPV, ARO, ATB	Welfare effects of heat stress	Systematic review on welfare effects of heat stress	Submitting at the end of the year
36.	Research article	Augustin del Prado	BC3, UPV, ARO, PIK	Modelling the effect of climate change adaptations to heat stress in two barn types, open and closed under climate change scenarios. With welfare and economic assessment. Corresponds to (D.4.6)		Draft expected in March 2018
37.	Review article	Fernando Estelles	UPV, BC3	Ammonia emissions and climatic factors	A meta-analysis of environmental factor effects on ammonia emissions from dairy cattle houses	Draft expected to be sent in December 2017/ January 2018
38.	Research article	Elena Sanchis	UPV, BC3, PIK, ATB	Emission modelling in OptiBarn	Modelling ammonia emissions in a dairy cattle barn for future according to climate change scenarios	Resubmitting in a new journal is planned for Jan- feb 2018
39.	Research article	Elena Galán	BC3, UPV, PIK	Modelling heat stress effects in milk yield in two farm typologies		Draft expected in 2018

- Green = planned
- Black = drafting

Conferences

1	Proceeding PLF-Asia, Beijing, September 2015	Guoqiang Zhang	AU	Zone ventilation	Precision control of ventilation in Livestock Housing	Published in proceedings of PLF-Asia
2	Proceeding BTU 2015, Freising, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Air flow pattern, modelling and long-term measurements	Determine the through-flow characteristics of naturally ventilated dairy barns to optimise barn climate	Published in: 12. Tagung: Bau, Technik und Umwelt 2015 in der landwirtschaftlichen Nutztierhaltung. 12. Tagung: Bau, Technik und Umwelt 2015. KTBL, Darmstadt, (978-3-945088-09-8), p. 346-351.
3	Proceeding RAMIRAN 2015, Hamburg, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Variability of air velocity, temperature, humidity and gas concentrations (long-term measurements and the OptiBarn project)	OptiBarn – Optimized animal specific barn climatisation facing temperature rise and increased climate variability	Published in: 16th International Conference Rural-Urban Symbiosis (RAMIRAN), p. 141-145. http://ramiran2015.de/wp-content/uploads/2016/05/RAMIRAN_2015-Proceedings-Book.pdf
4	Proceeding MACSUR LIVEM Conference, June 2016, Potsdam, Germany	Sabrina Hempel	ATB, PIK, AU, ARO, BC3, UPV	Modelling in OptiBarn	Integrated modelling to assess optimisation potentials for cattle housing climate	Published in November 2016 in Advances in Animal Biosciences DOI: https://doi.org/10.1017/S2040470016000352
5	Proceeding MACSUR LIVEM Conference, June 2016, Potsdam, Germany	Elena Galan	BC3, UPV	Economic impacts of heat stress / management strategies	Heat stress effects in milk yield and milk traits at farm scale	Published in November 2016 in Advances in Animal Biosciences DOI: https://doi.org/10.1017/S2040470016000261
6	Proceeding Precision Dairy Farming Conference, June 2016, Leuwaarden	Severino Pinto	ATB	Respiration rate	Influence of cow-related factors on respiration rate of dairy cows under hot climate conditions	Published in Book of Abstracts
7	Proceeding	Xiaoshuai Wang	AU	Zone ventilation	Optimal design of precision air supply in a natural	Published on website: CFD Symposium, CIGR/AgENg 2016,

					ventilated cattle barn using Computational Fluid Dynamics (CFD) method	Aarhus, Denmark
8	Proceeding CIGR Ag-Eng Conference, June 26-29 2016, Aarhus, Denmark	Elena Sanchis	UPV, BC3	Gaseous emissions	Meta-analysis of environmental effects on gaseous emissions	Published in Book of Abstracts
9	Proceeding REMEDIA V Workshop, March 2017, Caldes de Montbui, Spain	Elena Sanchis	UPV, BC3, PIK, ATB	Gaseous emissions and climatic factors	Ammonia and nitrous oxide emissions depending on temperature variations	Published in Book of Abstracts
10	Proceeding EMILI 2017, 3rd International Symposium on Emissions of Gas and Dust from Livestock, May 2017, Saint-Malo, France	Elena Sanchis	UPV, BC3, PIK, ATB	Ammonia emissions and climatic factors	A model to predict ammonia emissions from dairy cattle barns depending on temperature variations	Published in Book of Abstracts
11	Proceeding MACSUR Scientific Conference, May 2017, Berlin, Germany	Theresa Siemens	ATB	Heat stress and animal welfare	Influence of environmental climate conditions on animal welfare criteria of lactating dairy cows	Published in Book of Abstracts
12	Proceeding ECCA, 3rd European Climate Change Adaptation Conference, June 2017, Glasgow, UK/Scotland	Severino Pinto / Sabrina Hempel	ATB	Microclimate, animal welfare	Climate and animal monitoring for adapted smart dairy barns	Presented in June 9, 2017. Abstract is in the proceedings
13	Proceeding BTU, September 2017, Stuttgart,	Julia Heinicke / Sabrina Hempel / Severino Pinto	ATB	Animal welfare, behavior, vitality, microclimate	Effect of heat stress on behaviour and vitality parameters of dairy cows	Published in 13. Tagung: Bau, Technik und Umwelt 2017 in der landwirtschaftlichen Nutztierhaltung. 13th Conference – Construction, Engineering and Environment in

	Germany					Livestock Farming 2017. KTBL, Darmstadt (978-3-945088-46-3), p. 64-69
14	Proceeding EAAP, 68th Annual Meeting of the European Federation of Animal Science, August / September 2017, Tallinn, Estonia	Sabrina Hempel / David Janke	ATB	Microclimate	Microclimate monitoring as basis for smart cattle barns	Presented in August 30, 2017. Abstract is in the proceedings
15	Proceeding EAAP, 68th Annual Meeting of the European Federation of Animal Science, August / September 2017, Tallinn, Estonia	Theresa Siemens / David Janke	ATB, ARO	Animal welfare	Influence of environmental climate conditions on animal welfare criteria of lactating dairy cows	Presented in August 30, 2017. Abstract is in the proceedings
16	Proceeding EAAP, 68th Annual Meeting of the European Federation of Animal Science, August / September 2017, Tallinn, Estonia	X. Wang/G. Zhang	AU	Potential application of Erath-Air heat exchange for integrated Mechanical Ventilation in OptiBarn	Assessments of earth-air heat exchanger (EAHE) for precision zone cooling in dairy housing	Presented in August 30, 2017. Abstract is in the proceedings
17	Proceeding EAAP, 68th Annual Meeting of the European Federation of Animal Science, August / September 2017, Tallinn, Estonia	G. Zhang; Xiaoshuai Wang; Li Rong; Chao Zong	AU	Precision ventilation control	Future cattle housing with smart ventilation design and control	Presented in August 30, 2017. Abstract is in the proceedings
18	Proceeding	Theresa	ATB	Rumination	Effect of heat stress on	Published in 13. Tagung: Bau,

	BTU, September 2017, Stuttgart, Germany	Siemens		activity	rumination activity in lactating dairy cows	Technik und Umwelt 2017 in der landwirtschaftlichen Nutztierhaltung. 13th Conference – Construction, Engineering and Environment in Livestock Farming 2017. KTBL, Darmstadt (978-3-945088-46-3), p. 182-186
19	Proceeding REMEDIA V Workshop, March 2017, Caldes de Montbui, Spain	Elena Galán	UPV, BC3	Modelling heat stress at farm level	Modelización de los efectos del estrés por calor a nivel de granja	Published in Book of Abstracts
20	Proceeding ECCA, 3rd European Climate Change Adaptation Conference, June 2017, Glasgow, UK/Scotland	Elena Galán	UPV, BC3	Modelling climate smart adaptations	Modelling GHG mitigation co-benefits and trade-offs after implementing adaptation measures to adapt from heat stress in dairy farms	Proceeding ECCA, 3rd European Climate Change Adaptation Conference, June 2017, Glasgow, UK/Scotland
21	Proceeding EAAP, 67th Annual Meeting of the European Federation of Animal Science, August / September 2016, Belfast, UK	Elena Galán	UPV, BC3	Farm modelling heat stress. Economics	Modelling the management of heat stress in permanently housed dairy farms	Presented in August 29, 2016. Abstract is in the proceedings
22	Proceeding EAAP, 68th Annual Meeting of the European Federation of Animal Science, August / September 2017, Tallinn, Estonia	Elena Galán	UPV, BC3	Farm modelling heat stress. Emissions. Welfare.	Modelling the effects of heat stress of dairy cattle at farm scale	Presented in August 30, 2017. Abstract is in the proceedings