Smart Farming for Europe
Value creation through Precision Livestock Farming

EU-PLF

Deliverable 3.3

Concept for integrated solutions

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PP	**Restricted to other programme participants (including the Commission Services)**	
RE	**Restricted to a group specified by the consortium (including the Commission Services)**	
CO	**Confidential, only for members of the consortium (including the Commission Services)**	

Table of contents

1 Introduction

Work package 3 aimed at processing the data collected from the operative systems on farm and developing algorithms to automatically and in real-time translate measured animal responses to key indicators defined for the four domains (animal welfare, animal health, environmental load, productivity). Those algorithms were then integrated in the whole system which considers other aspects of farm management. However, it is important to integrate the system according to the needs of individual farmers. The report first describes the outcomes of the interviews with farmers about their requirements for Precision Livestock Farming (PLF) solutions. Then, it reports the advances made during EU-PLF in developing integrated solutions that translate the signals of PLF-sensors to useful alerts and/or control actions in the field of dairy cows (GEA), poultry (Fancom & SoundTalks) and pigs (Fancom & SoundTalks).

An integrated system can be described as a system that combines hardware subsystems such as sensors and actuators, computing systems and software applications to act as a coordinated whole in the support or management of a process. At the heart of such an integrated solution in the world of PLF is the algorithm that links measured bio-signals with key indicators of animal health and welfare or environmental sustainability of the livestock farm. Once validated against Gold standards, these algorithms are implemented in software platforms that can be used by the farmers. These platforms provide information in case of unexpected changes in the measured health or welfare status of the animals (early warning tools). In the aspect of integrated solutions development of software and advice tools links PLF technologies with the end-users.

1.1 Farmers response to PLF technology

During 2014 and 2016, Prof. Dr. Jörg Hartung has visited and interviewed farmers / farm managers from farms where PLF technology was installed in this project. Prof. Jörg Hartung is a professor of veterinary hygiene and animal welfare, and the former head of the Institute for Animal Health, Animal Welfare and ethology at the University of Veterinary Medicine Hannover. He has trained students of veterinary medicine for over 35 years and accompanied many for promotion. His main research interests are the effects of the housing environment on health and welfare of farm animals and the negative environmental impact of animal production. He worked as an expert for nine years at EFSA (European Food Safety Authority) and he is chairman of the welfare committee of the Federal Ministry of Food, Agriculture and Consumer Protection. During the EU-PLf project he interviewed 8 pig farmers/farm managers and 5 poultry farmers / farm managers twice and 7 dairy farmers once. In total, six EU member states were represented in these interviews. Each interview was conducted by personal, face to face, free format interviews. The aim of these interviews was to gain insight on the achievements and problems associated with PLF in practice. This insight can be used to develop a strategy for the market entry of PLF technology and it gives indications on how to design the integrated solutions. Only results from first round interviews for pig and broiler farmers are available at this point in time, therefore, the results are only preliminary and should be considered as a first step in the right direction. The conclusions from these interviews are listed below:

- The farmers identified feed price, labour costs, veterinary and medicine costs, and energy costs as the most important production factors.
- These farmers decided to join the EU PLF project because they saw it as a unique opportunity. They are all interested in the PLF technology.
- The farmers are cautious to buy PLF technology, unless benefits are proven and convincing. In the project, installation was free. In the future, they want to see if the investment in the technology pays off.
- Farmers are open to change and innovation, but they need training, preferably on site, and qualified services to work with the new systems.
- Not all farmers are familiar with the term 'PLF'. The farmers with PLF experience had a more positive attitude.
- Most of the interviewed farmers saw PLF as a useful EVOLUTION rather than a REVOLUTION, because they are already familiar with automated systems.
- Three items were negatively associated with PLF: high investment costs, too complicated operation, and slow maintenance service.

- The farmers stress on the fact that they did not want to lose contact with their animals through the technology. Direct contact with the animals remains important.
- Farmers asked for help in disease prevention, and consequently to reduce the use of antibiotics. They stated that they did not have a clear grip on prevention.
- The farmers see welfare and health as important factors in production and their income. They made however clear that welfare measures without a regard on economy are unrealistic.
- The farmers had varying opinions on the future of animal farming in Europe. They expect increasingly difficult conditions caused by welfare movements and environmental concerns.
- PLF was seen as a positive technology on the farm. One disadvantage was that not all instruments were properly working. Therefore there is a need for flagship farms for demonstrations.
- Farmers must be enabled to identify themselves with the technology and the data. They must be able to interpret their own data.
- It is important that the industry delivers fully functional and durable systems. Otherwise they damage the trust in PLF.
- Farmers want that the market helps them pay back the investments they made for improved welfare and health for the animals.

Summarising the interviews, farmers are open to change and innovation and they see PLF as a positive technology on the farm. They need an affordable, reliable and intuitive tool that can be used to keep contact with their animals. They need training, preferably on site, and qualified services to work with the new systems. It is clear that the integrated solutions should be designed with the farmer’s perspective and objectives in mind.

2 Companies involved in the project

2.1 GEA Farm Technologies

GEA Farm Technologies, member of the GEA group, is as a globally leading producer for technical innovation, integrated product solutions and effective animal hygiene. GEA Farm Technologies (FT) enables dairy farmers to cost-efficiently produce milk according to high standards. Today, manure systems and barn equipment for livestock complete their profile as a total system provider for all sizes of business. With in-depth system competence, with professional products and all-encompassing services GEA FT is working hard for a better milk quality and animal-friendly livestock breeding. GEA FT has a strong relationship with different Universities and industrial partners to improve Health Management know how.

(http://www.gea.com)

2.2 Fancom BV

Fancom BV is the world leader in the development and production of total solutions for climate and feed control and process data management (biometrics) for the pig and poultry production sectors. With a network of specialised network dealers, professional advice, installation and service is provided in more than 40 countries worldwide. Fancom is a subsidiary of CTB Inc., a leading global designer, manufacturer and marketer of systems for the poultry, pig, egg production and grain industries. Fancom collaborates closely with important global research institutes and no less than 20% of the employees are involved in a dedicated process of developing new solutions and improvements.

(http://www.fancom.com)

2.3 SoundTalks

SoundTalks is a young and ambitious spin-off company of the University of Leuven (KU Leuven) in Belgium and the University of Milan (UNIMI) in Italy.

SoundTalks delivers smart measurement and control systems to monitor, diagnose and improve system processes and/or quality of life. SoundTalks' team can assist researchers with its robust, high-performance, user-friendly & reliable measurement equipment and provides engineering consultancy on acoustic measurements and systems, sound quality, noise source identification and localization, noise radiation and automation using smart control systems. SoundTalks offers easy to use, automated monitoring tools to assist the farmer and the veterinarian in their daily decisions in the management process (https://soundtalks.com)

3 Dairy Cows

3.1 CowView System

3.1.1 Objective

Detect health and welfare problems using data on real-time location of Dairy Cows

3.1.2 Company

GEA Farm Technologies

3.1.3 Product Description

GEA is developing more features for the CowView system during the EU-PLF project. This is a real time positioning system for the analysis of animal behaviour.

CowView is an implementable PLF system that consists of hardware and a web based portal and mobile application. The hardware consists of tags that are based on a collar on the top of the neck of cows and antennas including receivers. The tags send the position signal with a frequency of 1 Hz which is received by the antennas. The information is forwarded to the central hub and pre-processed there. The main data analysis takes place on a server in the cloud. The portal and mobile applications both provides the farmer with access to the data visualisation and analysed results. Both applications can be accessed by a desktop computer or by mobile devices via the internet (see Figure 1)

CowView has implemented algorithms for high and low activity indicating heat or health related events. These are presented to the farmer as attention lists and the real-time positions of the cows in the barn are displayed. Furthermore CowView is integrated into the GEA herd management software including bi-directional data exchange.

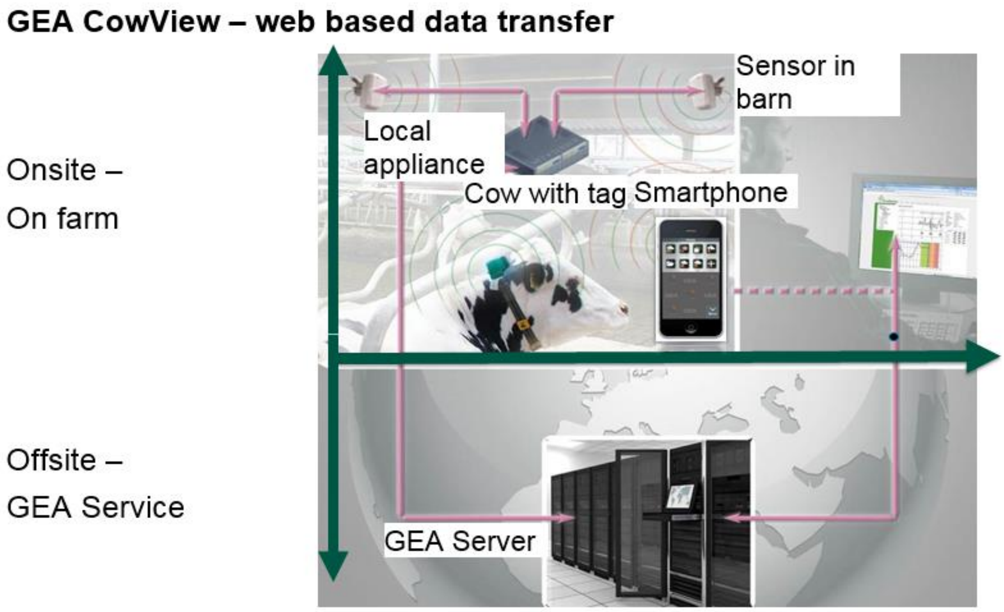

Figure 1. Setup of GEA CowView equipment and data transfer

3.1.4 Background/history

The purpose of CowView was to:

a) Track the cow´s position
b) Analyse her behaviour
c) Create warnings and alerts
d) Includes workflow management
e) Online application
f) Interface to DairyPlan (GEA´s herd management program, allows data exchange and interaction with the GEA system like milk meters and sorting gates)

Features:

- ✓ Based on RTLS technology: Real Time Locating System
- ✓ Positioning of objects in real time allows tracking and identification of location of these objects
- ✓ Usually consists of tags and wireless receiving antennas
- ✓ Common technology in logistic systems

Monitoring cow behaviour with CowView

CowView observes and analyses the overall behaviour of the cows. Feeding, stall, standing and walking are continuously observed and compared (Figure 2). Duration and frequency of the individual parameters are calculated and additionally walking distance is analysed.

Figure 2. The behaviours that are captured with the CowView system

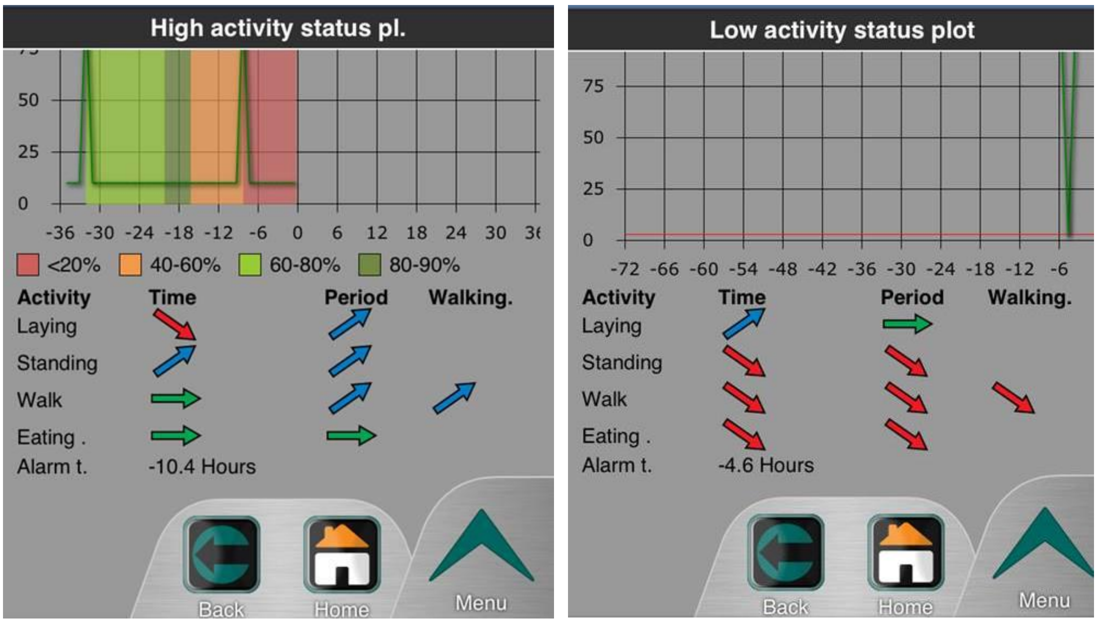

Figure 3. Display of High and Low Activity in the CowView software

In Figure 3 the green arrows indicate that the behaviour has not changed. The blue arrows indicate an increase in duration, higher frequency or longer distance. The red arrows show the other way round a decrease in duration, a reduction in frequency or walking distance.

The graph below shows an example of an individual cow behaviour in comparison to the group she belongs to (Figure 4).

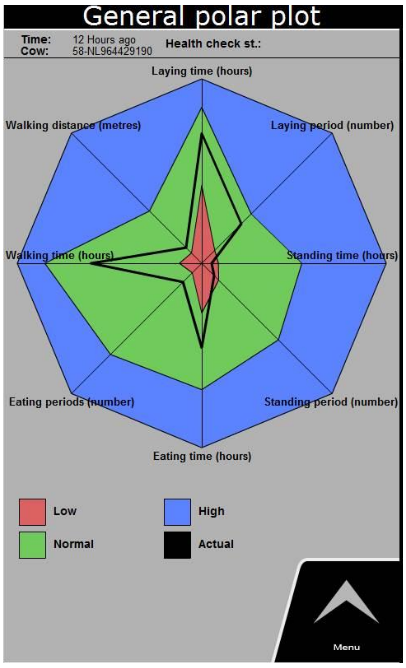

Figure 4. Individual cow behaviour in comparison with group activity

The green area is the normal behaviour of the respective group. The red area displays the 10% of the group who show the specific behaviour less long or less often, the blue are the 10% who show the behaviour longer or more often.

The black line is the actual behaviour of the respective cow.

This cow stands less long and less often compared to the other animals of the group. The other behaviour types are in common with the group mates.

Main menu features CowView software system

The main features of CowView syste before the start of the project are reported in Figure 5 and listed below:

- <u>*Search and find*</u>:

  The user can search for individual cows based on their numbers. The system indicates with a precision of 30 cm where the cow is located in the barn.

- *Inspections:*

  This point lists the cows that need special attention. It includes cows that are on the high and low activity list as well as cows that need to be checked for pregnancy or dried off.

- *Actions:*

  If the user or manager decides to do an action on cows like insemination or hoof trimming this menu will indicate the cows that are on these action list. This is part of the workflow management where in bigger installations managers decide on the action and others perform the action. Therefore they can use this list, find the cows and enter that the action has been performed.

- *Risk:*

  The risk list is a personalized list that each herd manager can create himself using his/her criteria for cows at risk. This may be fresh cows in the first week after calving or cows that have a history of a known condition like ketosis or hypocalcemia.

- *Crisis:*

  The crisis list is as personalized as the risk list. The crisis animals may be animals that are being treated because of a disease or have had a surgery.

- *Selection:*

  This menu shows the cows that are being selected according to the system settings the next time they come across a sorting gate.

Figure 5. CowView features included before the start of the project

3.1.5 Current status

The aim of the project was to provide more specific information about the low activity cows, indicate reasons for the change in behaviour and advise on actions to perform

Development requirements

Before the EU-PLF project the CowView system raised alarms if the individual cow behaviour deviated from her own history and deviates from the group behaviour. Farmers are interested in a more detailed description of the following information:

1) Group information: They want to know more about specific group of cows or the whole herd, e.g. cows in a certain pen or with a certain reproductive stage. This allows conclusion about changes in behaviour in regards to management changes.
2) Individual cow information: They want to know more about the specific amount of hours and frequencies of the different behaviour we can monitor. So far this information is displayed in a not so user friendly way. Furthermore individual values cannot be derived from the system (e.g. how many hours did this cow walk 3 days ago).
3) Integrated: they want to compare their herd behaviour to a “standard”. The standard can be a literature standard (= recommended hours lying down) or the standard of the herd.

Those information should be shown in an user friendly way with and easy and readable menu.

For enabling this the cow group worked on the validation of feeding and lying behaviour, frequencies and meal definition. So far the validation had been performed by GEA so independent validation provided value to the quality of the data. This was performed together with University of Milan and resulted in a publication in the Journal of Dairy Science (Tullo et al., 2016a).

Additionally, feeding trials were conducted at two farms to investigate different approaches to quantify feeding behaviour (Tullo et al., 2016b; Sloth et al., 2016). One approach was to identify herd-level cut-off points for defining meals. Different models were tested and analysed, but finally it was decided to present feeding events in three categories (short, medium and long) instead of defining meals.

The next step was to identify the most suitable way to implement the results in the software application. The visualization so far when it comes to detailed information about cow behaviour is already in the system but the user friendliness had to be improved. Therefore, GEA created some drafts and conducted a market survey to get customer feedback on a new design (Figure 6).

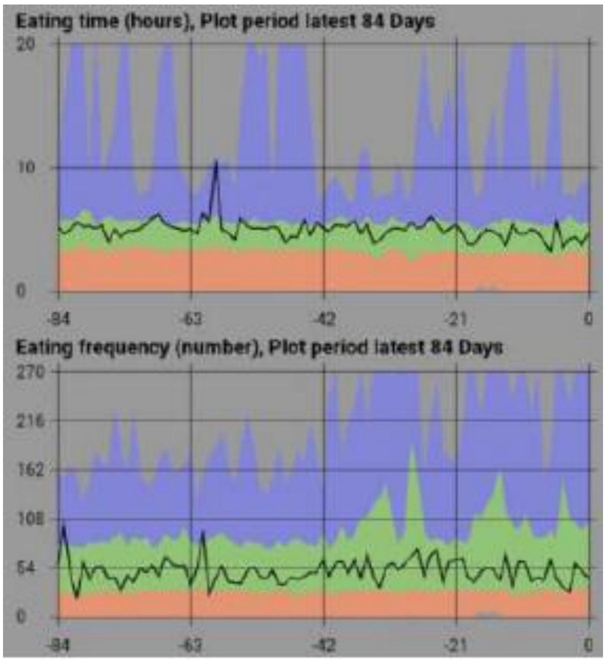

Figure 6. Current design of individual eating time and frequency

The black line displays the cow´s individual behaviour. The green area represents the group`s behaviour in this case eating frequency. The red area represents the cows of the group that perform this 10% lowest and blue highest respectively.

The disadvantage of the current display is that individual values from specific dates cannot be identified and the group relation is not easy to understand for end users. In Figure 7 draft of the future design of variable display.

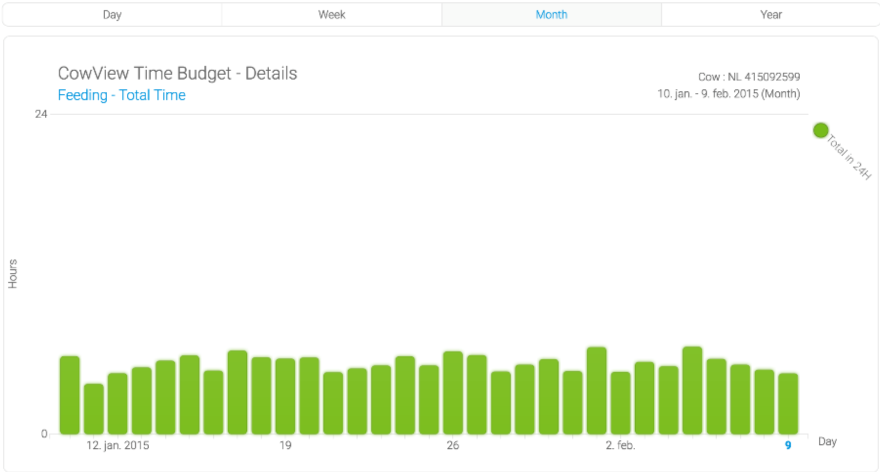

Figure 7. Draft of future design of display of eating time

3.1.6 Next steps

A customer survey was conducted using individual interviews either personal or via Skype. The customers were all already using the CowView system and familiar with the functionalities. The main objective of this interview was to identify the most user friendly way to display the information. Three concepts of graph design were presented to the customers consisting of a grouped graph, individual graphs or a stacked graph (Figure 8).

Figure 8. Draft of graph display for eating events display

The questions were:

- How relevant is the information for you? (1=very relevant , 6 not relevant)
- 1st impression, which graph is most appealing? (distribute 10 points)
- Which graph is most intuitive? (choose one)
- Which gives you the best overview information? (choose one)

- Which gives you the best detailed information? (choose one)

Figure 9 displays the result of the answers of 8 customer interviews. Overall the graphical display of grouped columns was accepted best.

Eating events details	A	B	C
How relevant is the information for you? (1=very relevant , 6 not relevant)	1,75		
1st impression, which is most appealing? (distribute 10 points)	5,38	2,63	2,00
Which graphic is most intuitive?	6	1	1
Which gives you the best overview information?	5	1	2
Which gives you the best detailed information?	5	1	2

Figure 9. Results of customer interviews comparing 3 different graphical display

As a next step the result of the questionnaire was transformed into a specification for the software engineers.

The decision on presenting feeding events in short, medium and long visits will be included for other behaviour as well.

The market survey provided first insight on which data to implement, how to display it, where to store the data and for how long. The answer of our customers to this was very straightforward: the behaviour of a cow that is on an alarm list has to be displayed to app. one month back on a smart phone display. This is the device every farmer is working with when being in the farm. The longer historical data like year history can be displayed on the PC interface. These kind of analyses will not be performed by the users on a daily bases and thus can be available on the PC only.

4 Poultry farms

4.1 Data Visualisation Tool

4.1.1 Objective

Development of a platform to integrate production data, climate data and PLF technology data from poultry farms.

4.1.2 Company

Fancom and SoundTalks

4.1.3 Product Description

For every farm participating in this project, a website was created to visualize the data coming out of the PLF-sensors. Data registered from the existing sensors on the farm were, -where possible -, also visualised. The collected data are divided into 3 main domains: production, climate, and biometrics. All data are visualised with a time step of 1 day.

4.1.4 Background/history

PLF technologies are potentially interesting for the farmers and other stakeholders to improve animal welfare, increase technical results and minimize the environmental footprint. PLF measurement data have the potential to put a number on sustainability in an automated way. However, most farmers and other stakeholders (e.g. vets) do not have the skills to utilise the data from the PLF technologies effectively. It is time consuming to combine and analyse the data coming from different sensors in different formats and frequencies. Fancom goal was to develop a tool that brought together the scattered data, analyses the data and presents them in an easy way to the end user. The farmers participated actively in evaluating the usefulness, resulting in a web-based visualization tool that is practical and useful for the farmer and other stakeholders (e.g. vets, advisors, researchers). The development and the use of this tool were presented at a scientific conference (Koenders et al., 2015).

In a further step early warnings were being added to the tool based on (a prediction of) the data collected at the farms. By comparing the predictions with the measured data in an on-line way, users don’t have to check the data themselves but are notified when something unexpected happens.

4.1.5 Current Status/ Work done so far/Results.

In order to present the PLF-data in a usable format to the different EU-PLF Pig&Poultry farmers, it was opted to build a visualisation tool on web2py (www.web2py.com). Web2py is a free, open-source web framework for agile development of secure database-driven web applications, implemented in Python (www.python.org). Web2py is a full-stack framework, meaning that it contains all the components you need to build fully functional web applications. Web2py encourages the developer to separate data representation (the model), data presentation (the view) and the application workflow (the controller).

For the graphics, Highcharts (www.highcharts.com) was used. Highcharts is a charting library written in pure JavaScript, offering an easy way of adding interactive charts to your web site or web application.

The visualisation tool is hosted at pythonanywhere (www.pythonanywhere.com). Pythonanywhere makes it easy to create and run python programs in the cloud. There is storage space and one can configure one's own webserver. By making use of these tools it is possible to make a visualisation with a minimum amount of code, applicable on different platforms (windows, mac, desktop, mobile, tablet).

4.1.6 Raw Data Visualisation- Poultry

For the poultry houses, the raw data include (Figure 10- 13):

Production data	*Climate data*	*Biometrics data*
Feed per day (kg/d)	Minimum Temperature Inside (°C)	Average Activity Index (%)
Water per day (L/d)	Maximum Temperature Inside (°C)	Variance of the Activity Index (%)
Daily mortality & culling (number of animals lost)	Average Temperature Outside (°C)	Average Distribution Index (%)
Growth data	Minimum Relative Humidity (%)	Variance of the Distribution Index (%)
Weight (gr)	Maximum Relative Humidity (%)	
Growth (gr/d)		
Uniformity (%)		
Number of weightings		

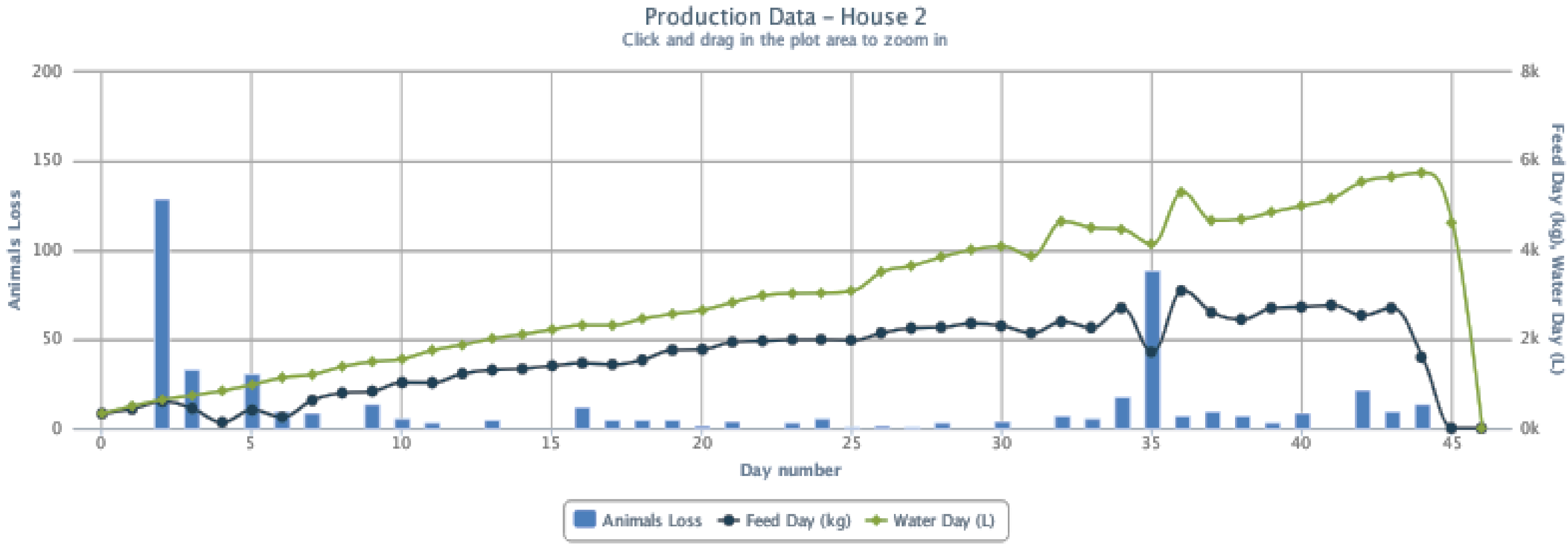

Figure 10. Example of the production data visualisation. The graph shows the feed and water supply in the house together with the daily animal losses.

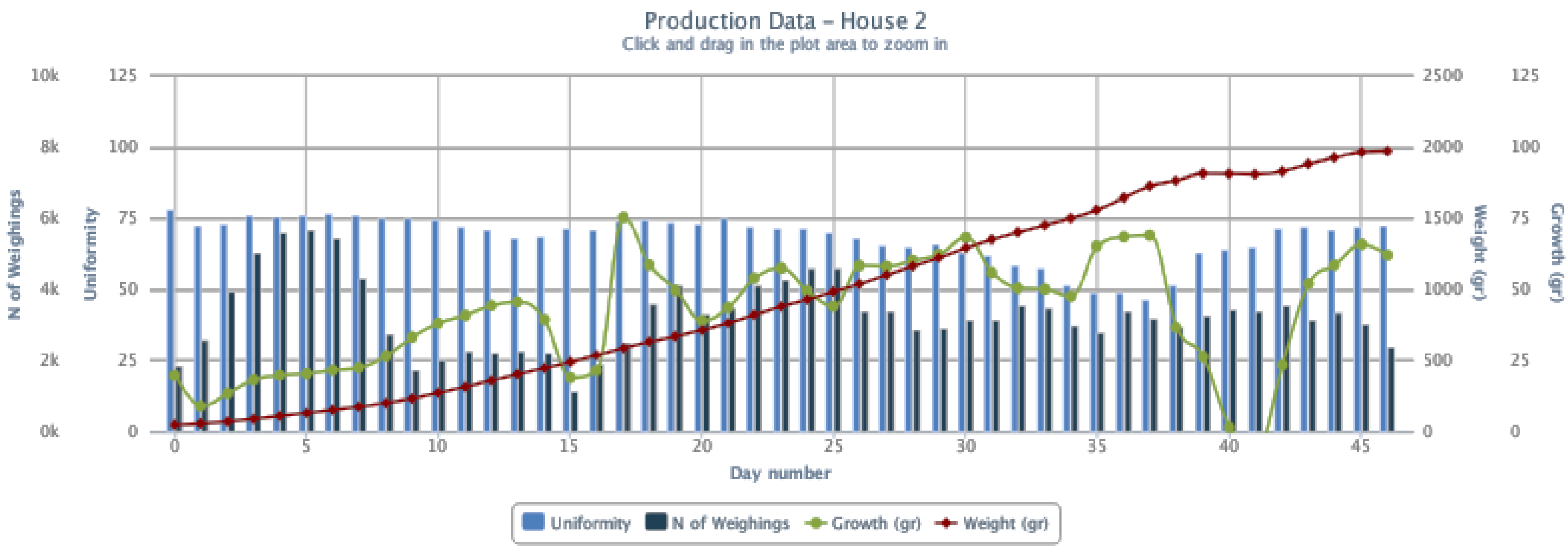

Figure 11. Example of the production data visualisation. The graph shows the growth data of the broilers in the house.

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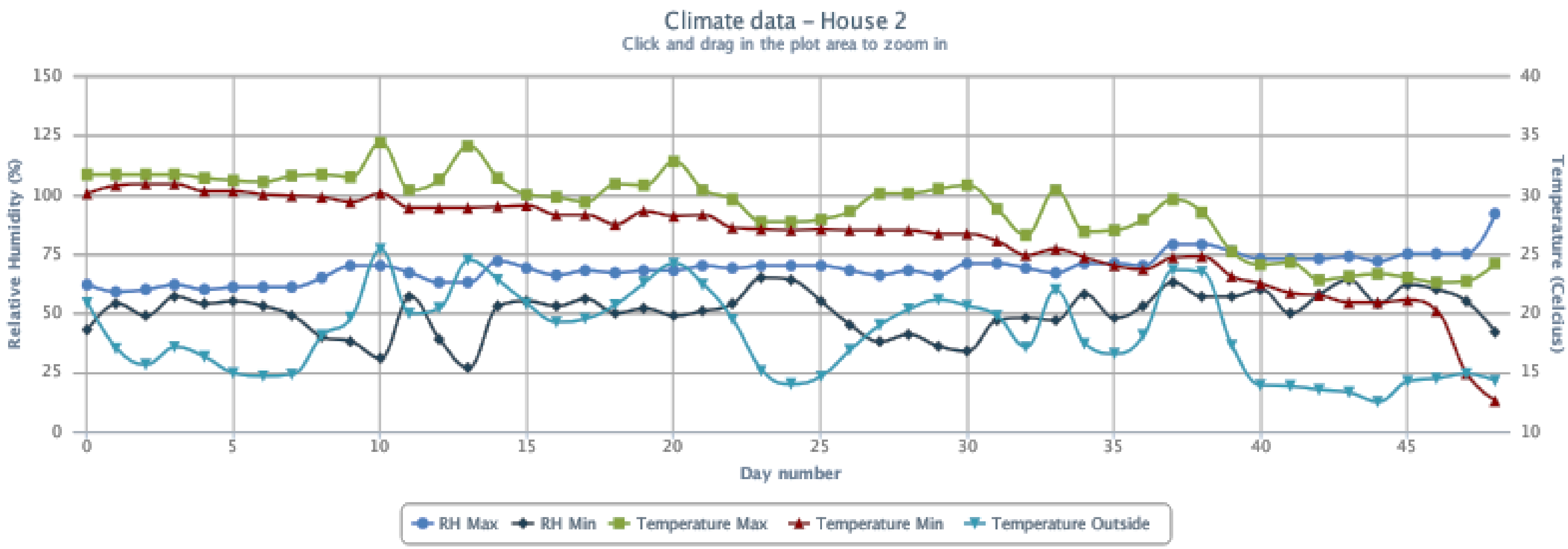


Figure 12. Example of the climate data visualisation for a complete broiler batch

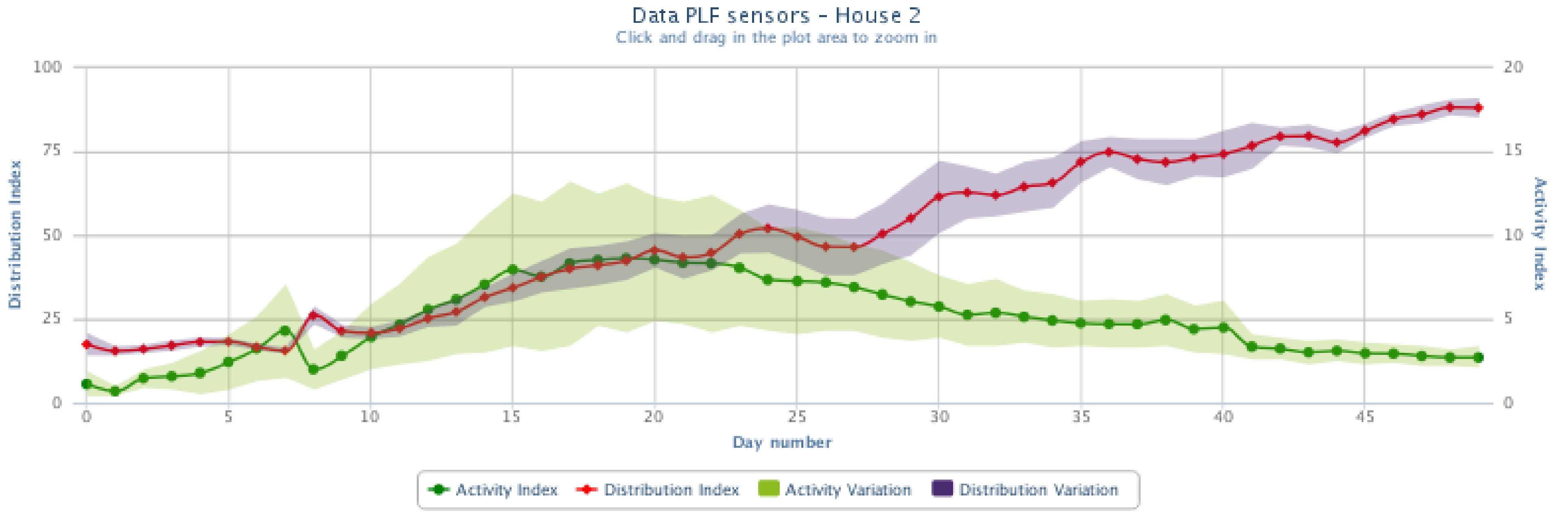


Figure 13. Example of the biometrics data visualisation.

4.1.7 Interpretation of data

Measured data versus reference curves

For each animal breed type, a reference curve exists. The farmer uses these reference values to monitor the performance of his animals. It allows him to identify on daily basis if his flock is performing on target, below target or above target. An example of such a visualisation is presented in Figure 14. The tool plots the daily animal feed supply [kg feed/animal], and compares it with the reference feed supply value of that specific animal. The daily reference values are presented in a green band in the figure, whereas the measured data is presented in blue column bars. The same procedure is applied for animal water supply, animal growth rate and animal weight.

The difference of these reference curves with early warnings is that these are not time-variant, but they represent a general expected reference curve for a specific animal breed.

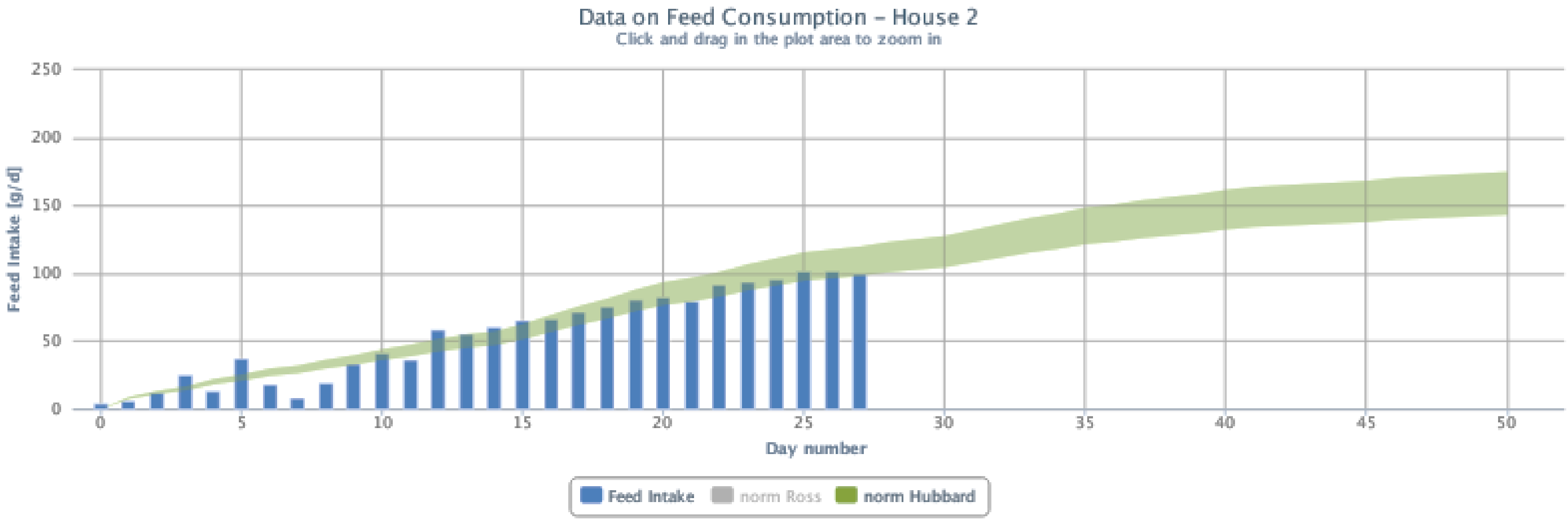
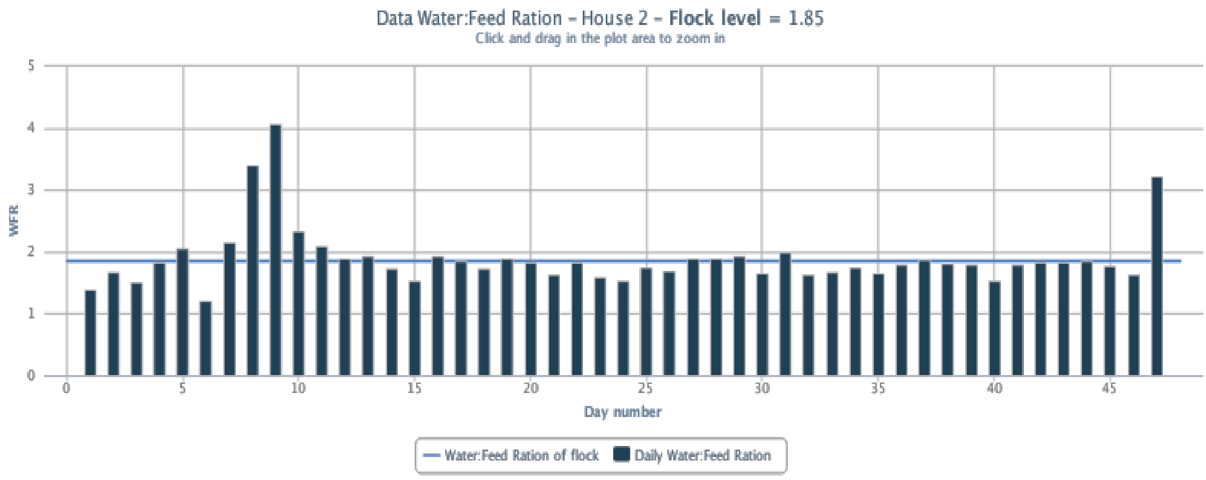


Figure 14. The automatic visualisation of the daily measured process data compared to a breed-specific reference curve.

4.1.7.1 Calculation of Key Performance Indicators (KPI)

In order to evaluate the performance of the flock in his house, the farmer uses some standard KPI's. These KPI's are well-known in the sector, and used by all stakeholders. Calculating these KPI's on a daily basis informs the farmer on the trends in his house, and allows him to compare different flocks with each other. The KPI presented in our visualisation tool (Figure 15)include the water:feed ratio (WFR), the feed conversion rate (FCR), the flock mortality rate, the economic feed margin and the European Production Efficiency Factor (EPEF) for a broiler farm (Figure 16). The economic feed margin estimates the difference between the variable cost of production (feed and young animals) and the sales return of the meat, given the current market prices.



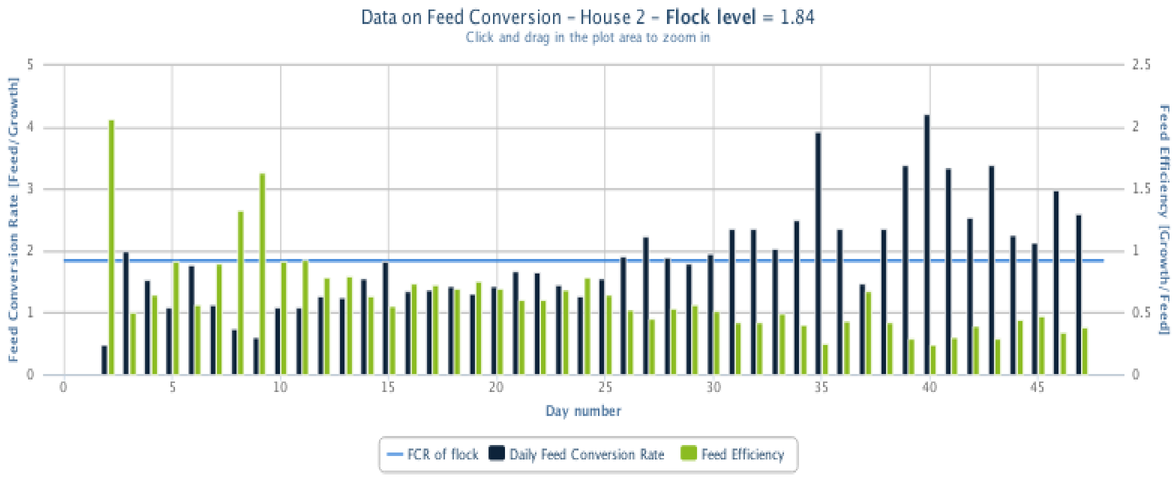


Figure 15. Visualisation of the KPI for broilers. From top to bottom: water:feed

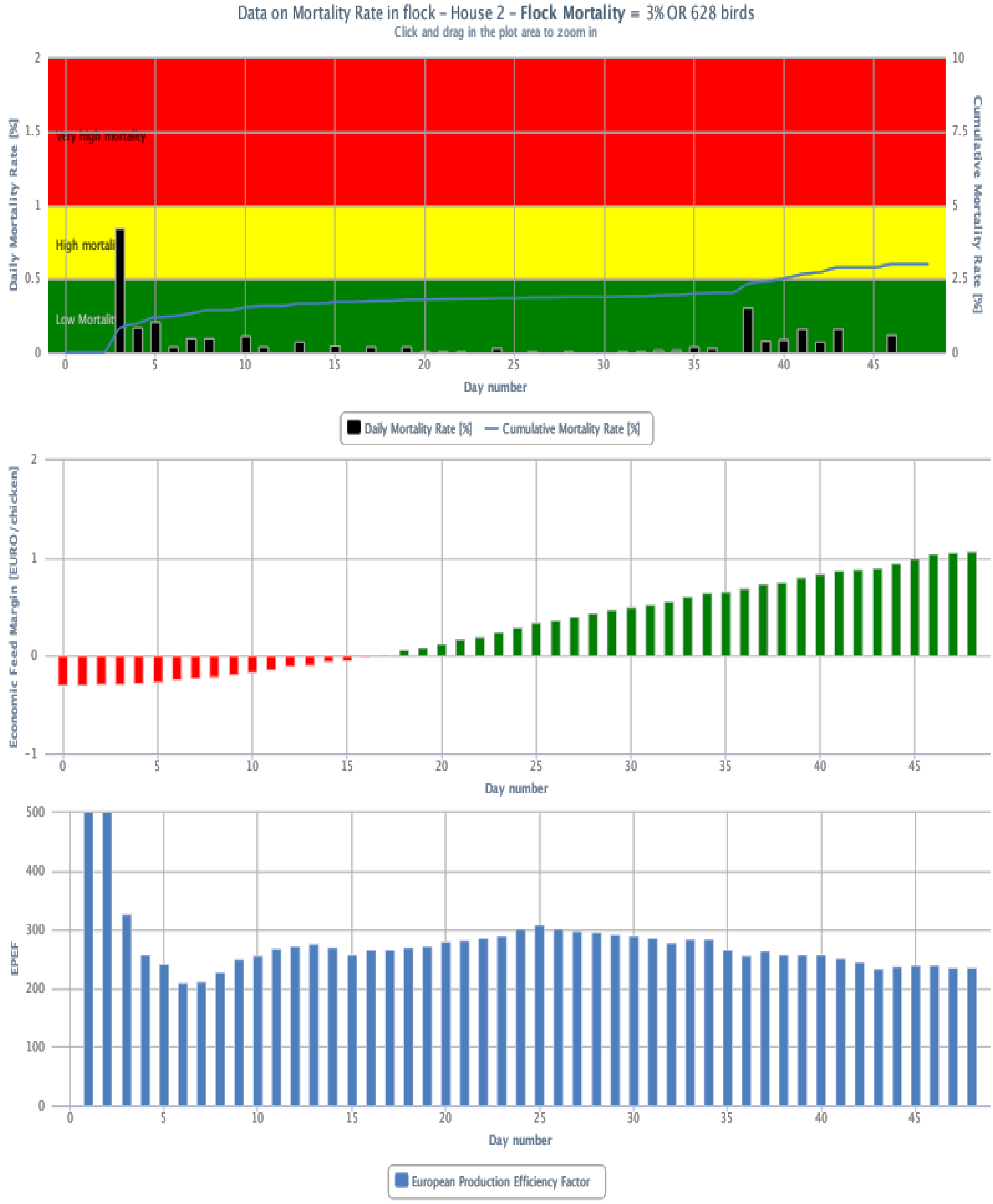


Figure 16. Visualisation of the KPI for broilers. From top to bottom:, feed conversion rate, mortality rate, Economic feed margin and EPEF.

4.1.7.2 *Monitoring legal requirements*

In broiler houses, the stocking density is legally determined. Based on a list of criteria, the farmer is allowed to raise a certain amount of birds per square meter of floor area. Stocking density is usually expressed in kg per square meter. Continuous monitoring of bird weight allows the farmer to monitor the stocking density of his flock during the rearing period. The visualisation of the stocking density is presented in Figure 17.

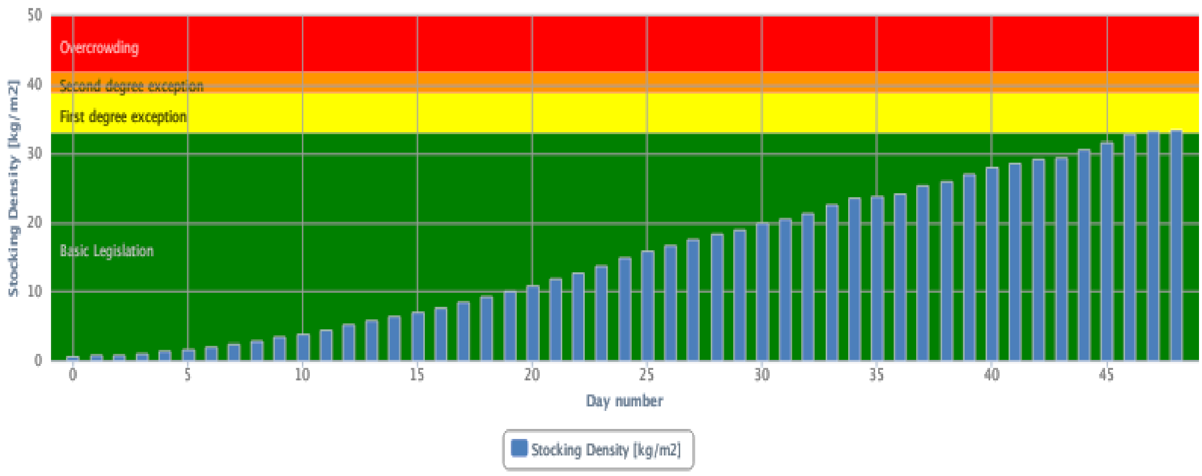


Figure 17. Visualisation of the stocking density (blue column bars) in relation to legal levels (green: 0-33 kg/m^2, yellow: 33-39 kg/m^2, orange: 39-42 kg/m^2, red: 42+ kg/m^2)

4.1.8 Early warnings

With the help of the visualisation of raw data, the farmer can look into his data, and evaluate himself when the data deviate from the expected values. One step further is the implementation of an algorithm that does this detection automatically, i.e. an early warning tool. Smart software compares actual measured behaviour with the expected behaviour of the group and generates an early warning when abnormal behaviour is detected. This will allow a management by exception protocol for the farmer. This procedure has been scientifically described and published (Kashiha et al., 2013).

An example of the early warning protocol is presented in Figure 18 for the variables distribution and water intake of broilers. The early warning protocol predicts the expected behaviour of the data based on historical data. When the measured data point lies outside the range of the expected behaviour, a warning is raised.

This warning can be hard, meaning that a text message or email is sent to the farmer to take immediate action. The type of action will depend on the type of warning, and on the variable that is causing the alarm. The warning can also be soft, meaning that a notification will made of this alarm in a notification list. The farmer can access this list when he wants, preferably once a day to address all alarm situations in his farm.

4.1.9 Future Developments

In the near future, additional biometric measures, such as sound measures and measures related animal health and welfare will be added to the tool.

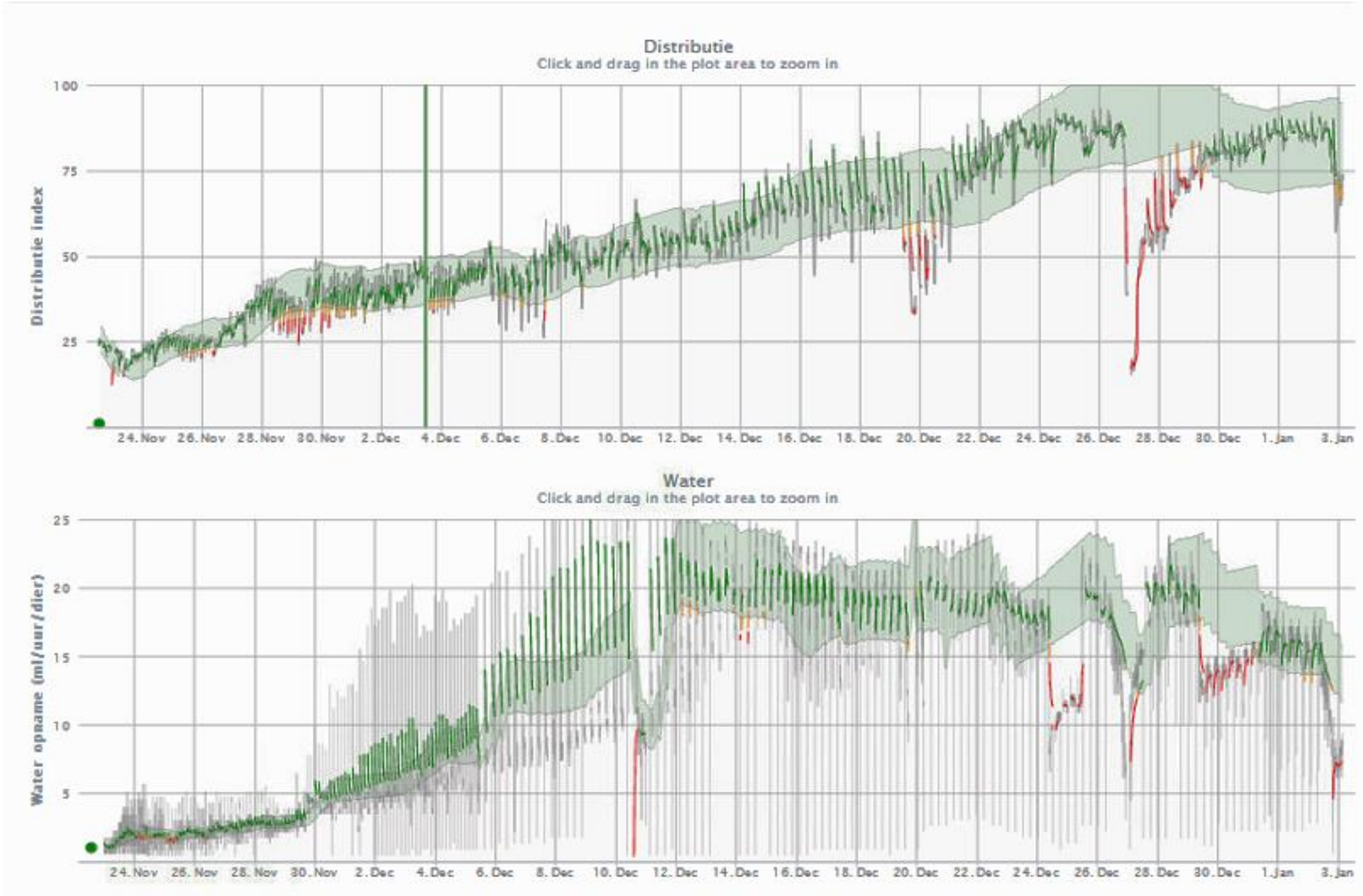


Figure 18. Early warning protocol applied to the distribution index data (top) and water supply data (bottom) during the rearing of broilers. The early warning protocol predicts the expected behaviour of the data based on historical data. Measured data that lies within the range of the expected behaviour is coloured green, whereas data out of the expected range is coloured red

4.2 Eyenamic

4.2.1 Objective

For the Eyenamic camera solution, a PLF-sensor that monitors the activity and distribution of broilers by camera analysis, an integrated solution is developed towards the end of the EU-PLF project.

4.2.2 Company

Fancom BV (core product) and SoundTalks NV (cloud solution)

4.2.3 Product Description

EyeNamic™ uses camera technology in the house. Cameras mounted in the ridge of the house continuously monitor part of the floor below. Analysis software translates these images into an index for animal distribution and activity, both of which are extremely valuable indicators of animal welfare. EyeNamic™ enables the behaviour of a flock of broilers to be followed from minute to minute so that any abnormal behaviour is signalled quickly. Farmers can intervene at an early stage and limit any negative consequences. A more detailed product description can be found in Deliverable 2.1.

4.2.4 Background/history

The technology behind Eyenamic is developed during the long term cooperation agreement between KU Leuven and Fancom BV. The first publication in this cooperation was on using camera technology to measure animal activity levels (Bloemen et al., 1997). After fine-tuning the technology to measure the activity index of animals, the focus of the research shifted to the control of animal behaviour by light intensity changes (Kristensen et al., 2006). In recent years, the focus was on the one hand on relation of the automatic bird behaviour monitor to animal health and welfare problems (Aydin et al., 2013), and on the other hand on the automatic detection of negative events during the production cycle (Kashiha et al., 2013). In this last research topic, it became clear that there was commercial value in an automatic bird behaviour monitoring tool.

4.2.5 User Interface v01

The EyeNamic™ Monitoring System (ESM) is integrated in Fancom's FarmManager software package. The ESM module consists of multiple cameras that are installed in top-down perspective in the broiler house. The numbers of cameras in the house depend on the width and height of the house. The ESM-module is marketed specifically for broiler farmers. The EyeNamic™ devices are connected via an Ethernet switch with a FarmManager PC. The

EyeNamic™ information that is visible in the Farm Manager system is actual data (present day), round to date data (historical days) and previous rounds (historical rounds). The following operational values are available for each device:

- Distribution index
- Activity index
- Matrix occupation density (row + col)
- Matrix activity density (row + col)
- Number of rows
- Number of columns
- Picture where original calculation is based upon

The automatic minute-to-minute monitoring of bird behaviour in a broiler flock is possible with the ESM system. Clear overviews provide the farmer information on the activity level and the distribution level of his flock (Figure 19 and Figure 20). A good animal distribution in the house avoids local zones with overcrowding, will result in less mortality and a more uniform growth. A vivid activity in the flock will prevent leg problems, enhances water- and feed intake of the birds and will result in a better performing flock.

Figure 19. Graphical presentation of the present distribution index in User Interface v01

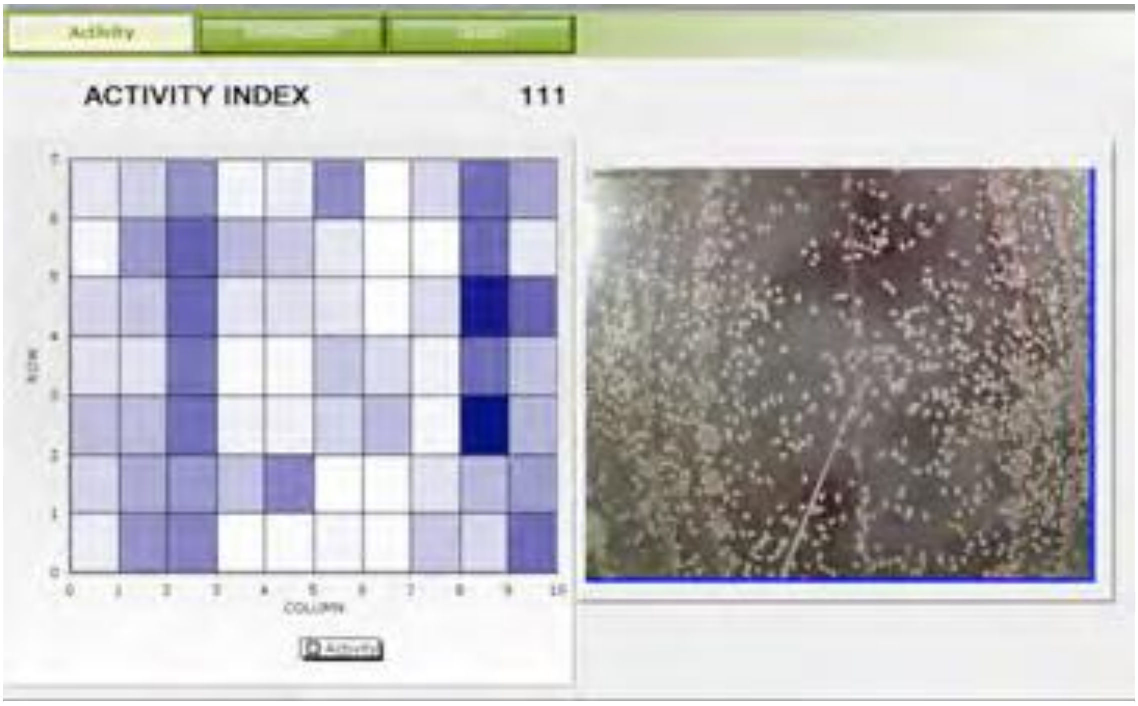


Figure 20. Graphical presentation of the present activity index in User Interface v01

The EyeNamic data are fully integrated in the Farm Manager software. Deviations from normal behaviour are directly visible, and can be compared with other house parameters such as house temperature, water intake, and animal growth (Figure 21). This allows an early intervention when deviations occur, even before the event negatively affects animal health or well-being. ESM however does not support early warning alarms, so active monitoring by the farmer is required.

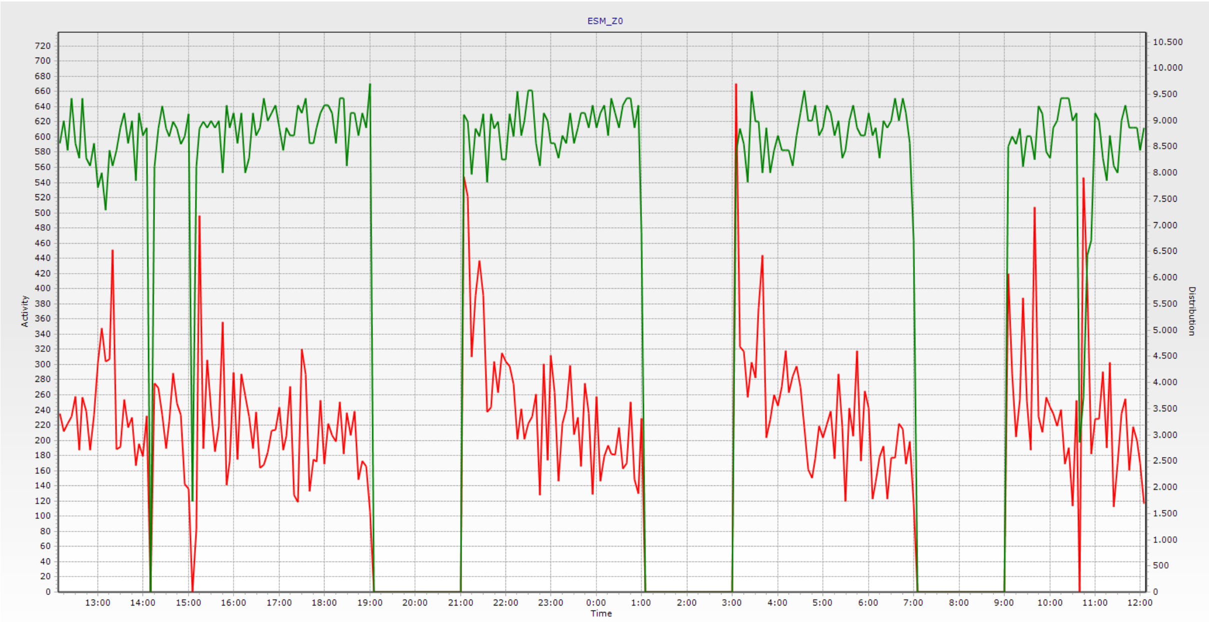


Figure 21. EyeNamic data visualisation of the present day (last 24 hours): red line – activity index; green line – distribution index.

4.2.6 User Interface V02 (Cloud Solution)

Near the end of the EU-PLF project, the development of an advanced user interface was started based on the comments from the previous integrated Eyenamic solution (Figure 22-23).

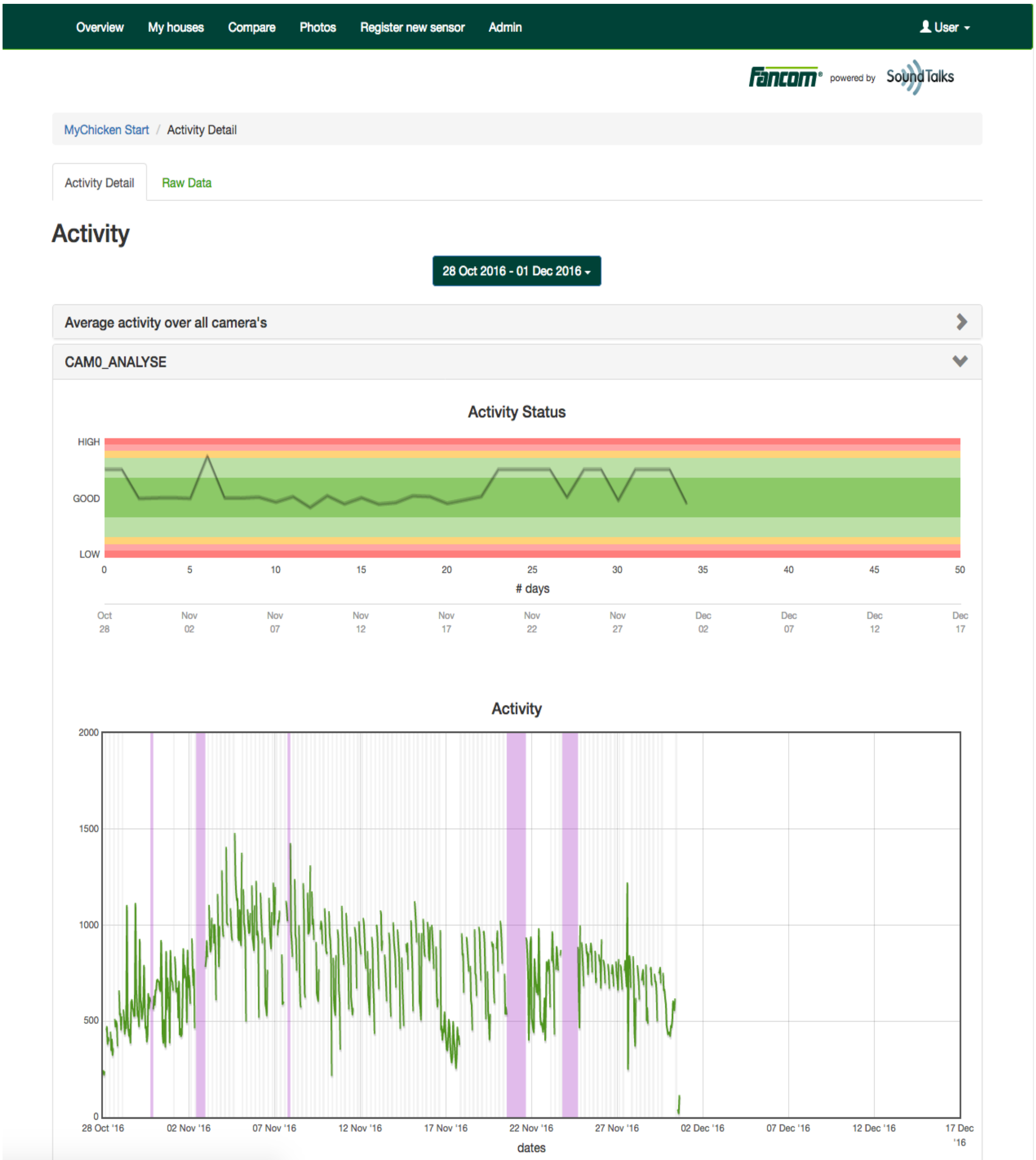


Figure 22. Screenshot of the User Interface V02. In this picture the activity level of the flock is reported.

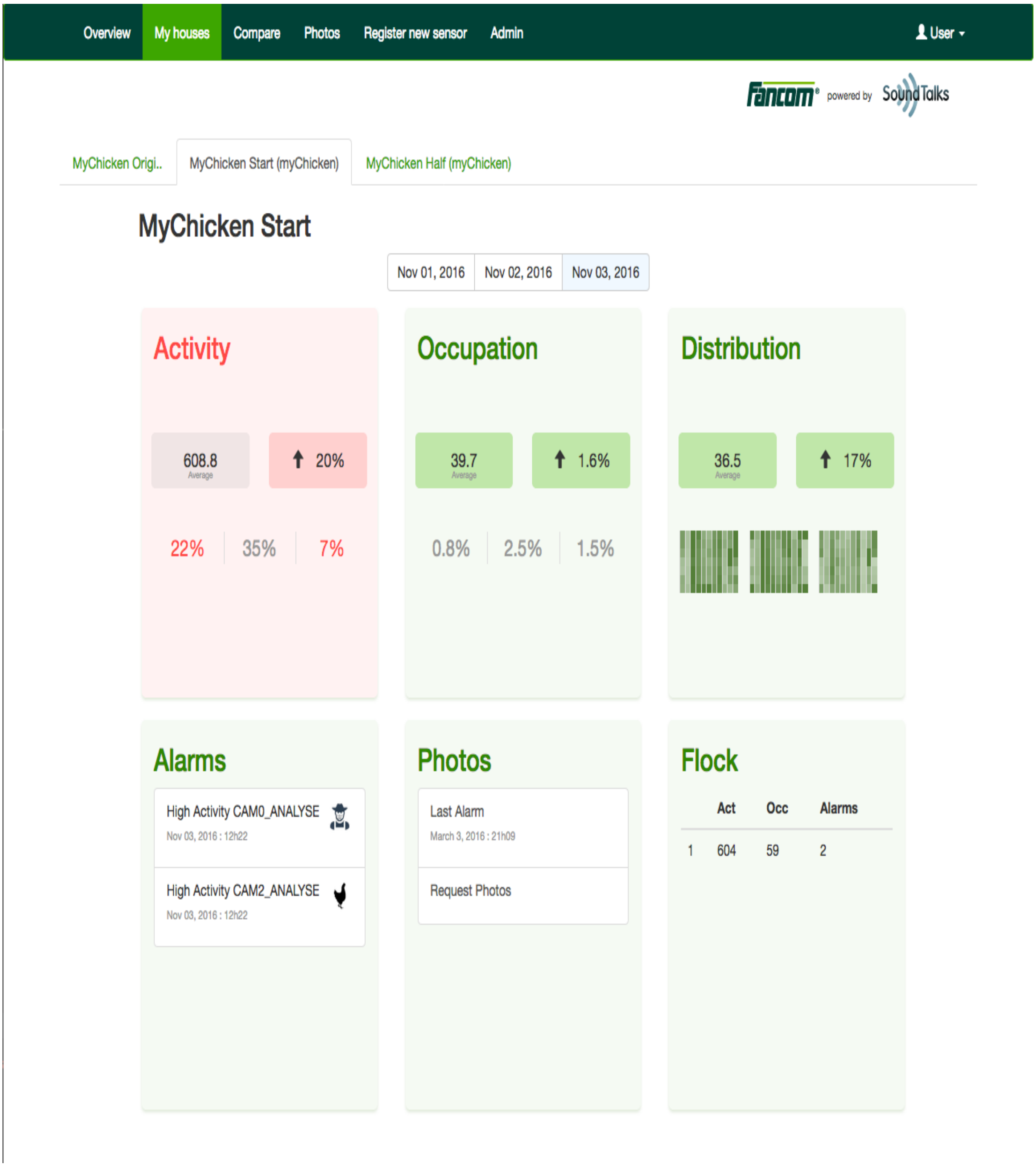


Figure 23. Screenshot of the User Interface V02. In this picture the overview of the interface is reported

4.3 Future development

The analysis of sounds in a broiler farm is at an earlier stage compared to that of pigs and calves. At the moment, it is investigated whether there is a link between vocalisations and Key Indicators. It is the objective of this analysis that once such a link is found, the algorithm is implemented in the current system and the information is combined with the rest of the PLF outcomes for a better understanding of the animal status in the farm.

5 Pig farms

5.1 Data Visualisation Tool

5.1.1 Objective

Development of a platform to integrate production data, climate data and PLF technology data from pig farms.

5.1.2 Company

Fancom and SoundTalks

5.1.3 Product Description

See paragraph 4.1.3

5.1.4 Background/history

See paragraph 4.1.4

5.1.5 Current Status/ Work done so far/Results.

See paragraph 4.1.5

5.1.6 Raw Data Visualisation- Pigs

For the pig houses the raw data consist of:

Production data	***Climate data***	***Biometrics data***
Feed per day (kg/d)	Minimum Temperature Inside (°C)	Average Activity Index (%)
Water per day (l/d)	Maximum Temperature Inside (°C)	Percentage Resting (% of total (measured) time)
Weight (kg)	Average Temperature Outside (°C)	Percentage High Activity (% of total (measured) time)
Number of Animals		Cough level over the last 24 hours

Based on the farmer's feedback, the visualisation of the production data was transformed to animal level. Water and feed supply were not only presented on pen and compartment level, but also on individual animal level, i.e. kg feed/animal and l/animal for water. These data are presented in Figure 24-26. Climate data like minimum and maximum temperature inside (°C) and average temperature outside (°C) are reported in Figure 27.

In the pig compartment, biometrics data were acquired from both video and sound data. Activity levels in the pen were obtained by eYeNamic, an image-processing algorithm. The visualisation of the activity levels is shown in Figure 28.

The recorded sounds in the pig compartments were translated to a level of coughing in that compartment by the Soundtalks respiratory distress algorithm (Hemeryck et al., 2015). The visualisation of pig cough data is shown in Figure 29.

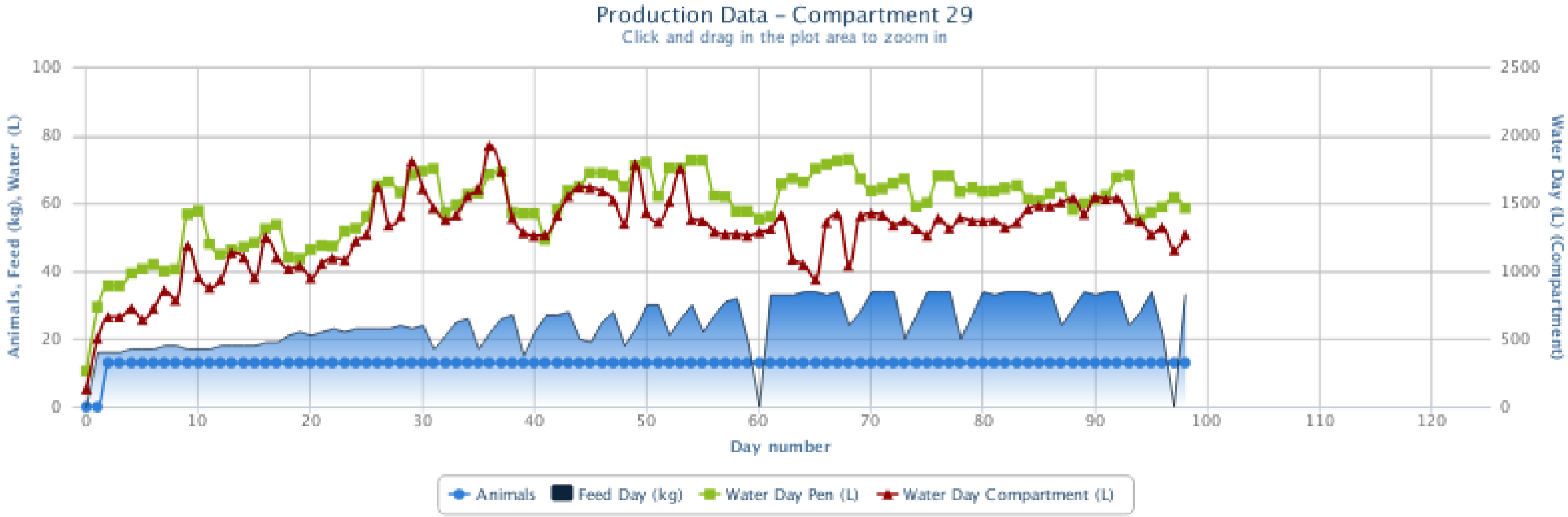


Figure 24. The visualisation of the Pigs Production data .The graph shows an example of the production data over a complete fattening period, i.e. daily feed supply, the daily water consumption and the number of animals in the pen.

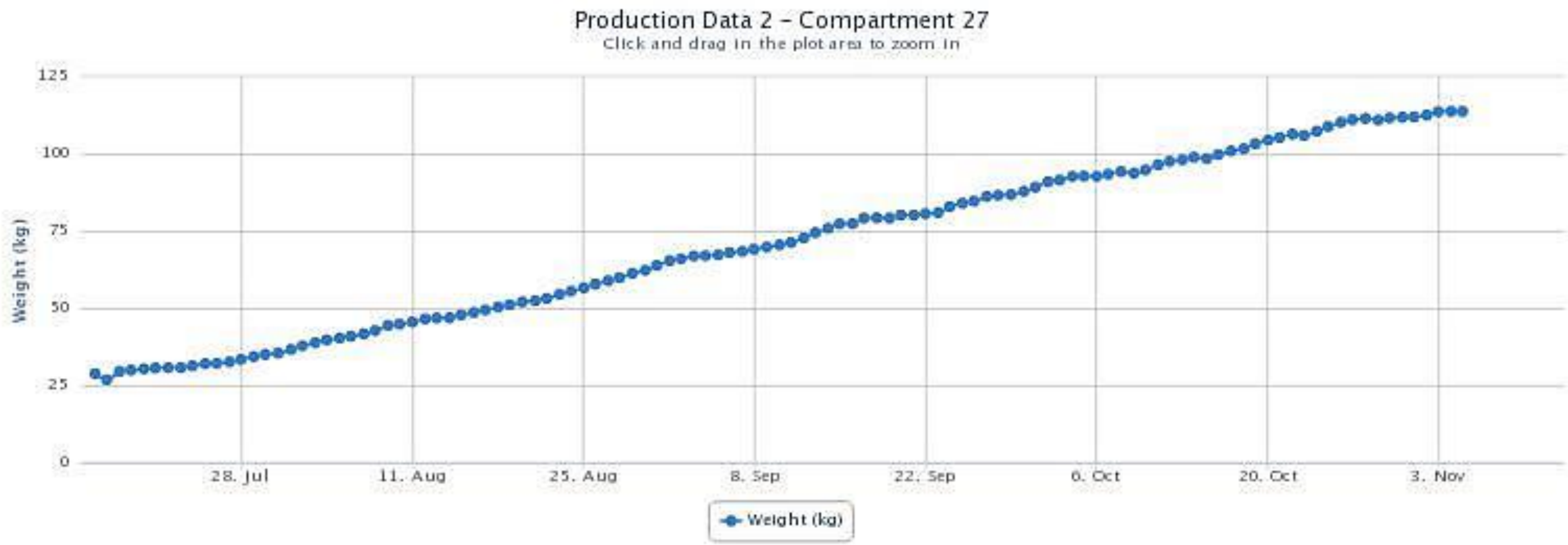


Figure 25. The visualisation of the Pigs Production data . The graph shows the weight curve of the pigs in the pen, measured with a camera based weighing device (eYeScan).

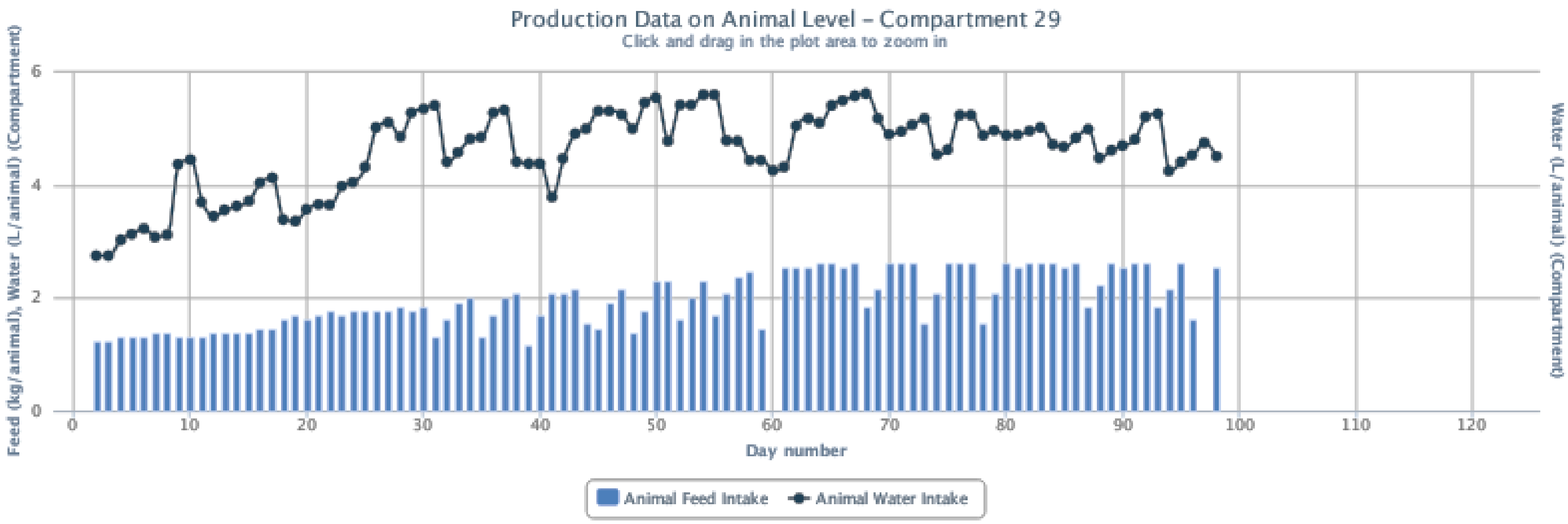


Figure 26. Visualisation of the pig production data (water [black dots] and feed [blue columns]) on animal level.

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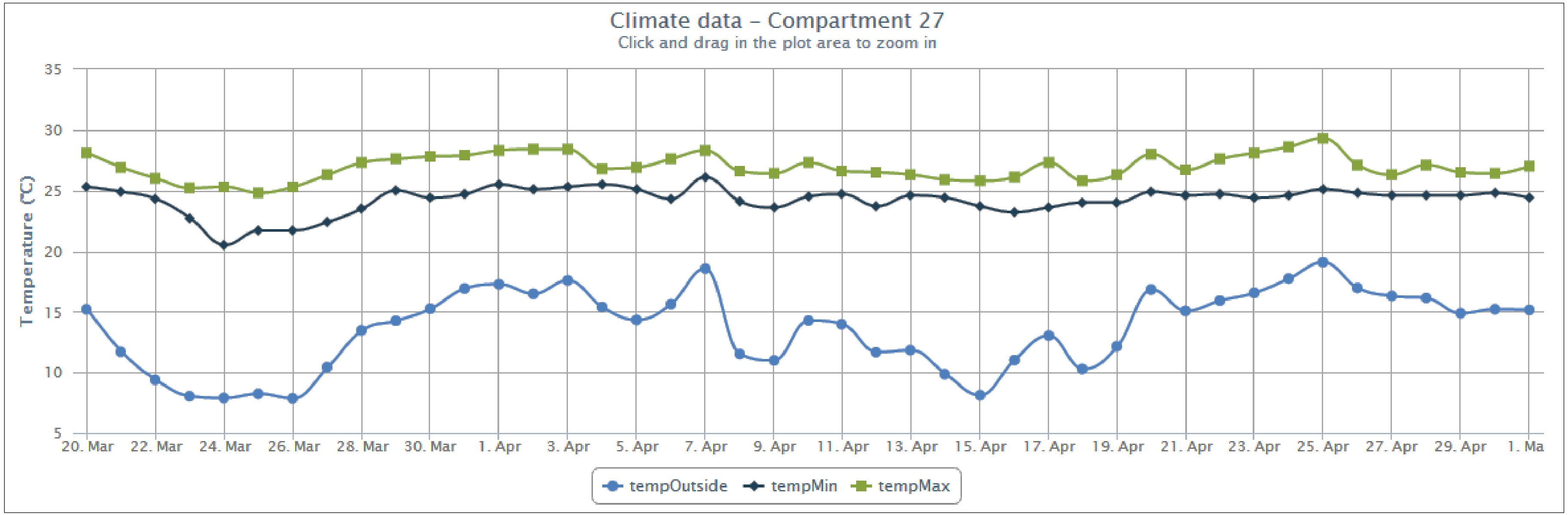


Figure 27. Visualisation of the Pigs Climate data.

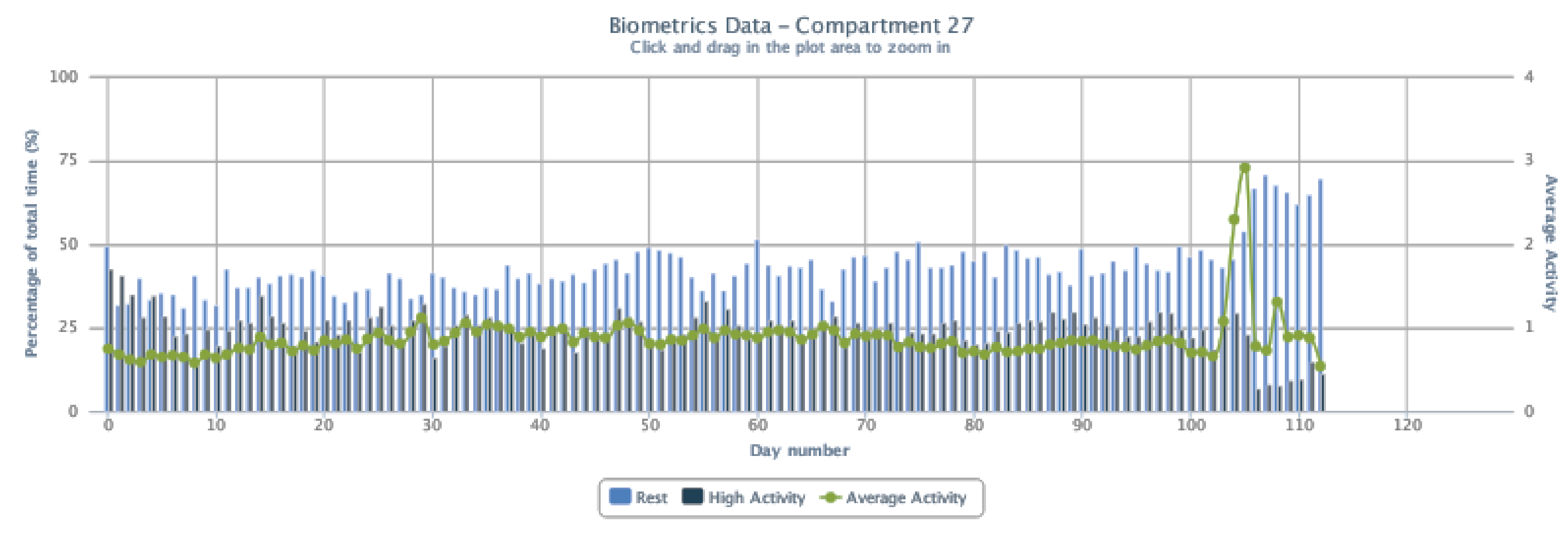


Figure 28. Visualisation of the camera-based biometrics data for pigs: activity levels.

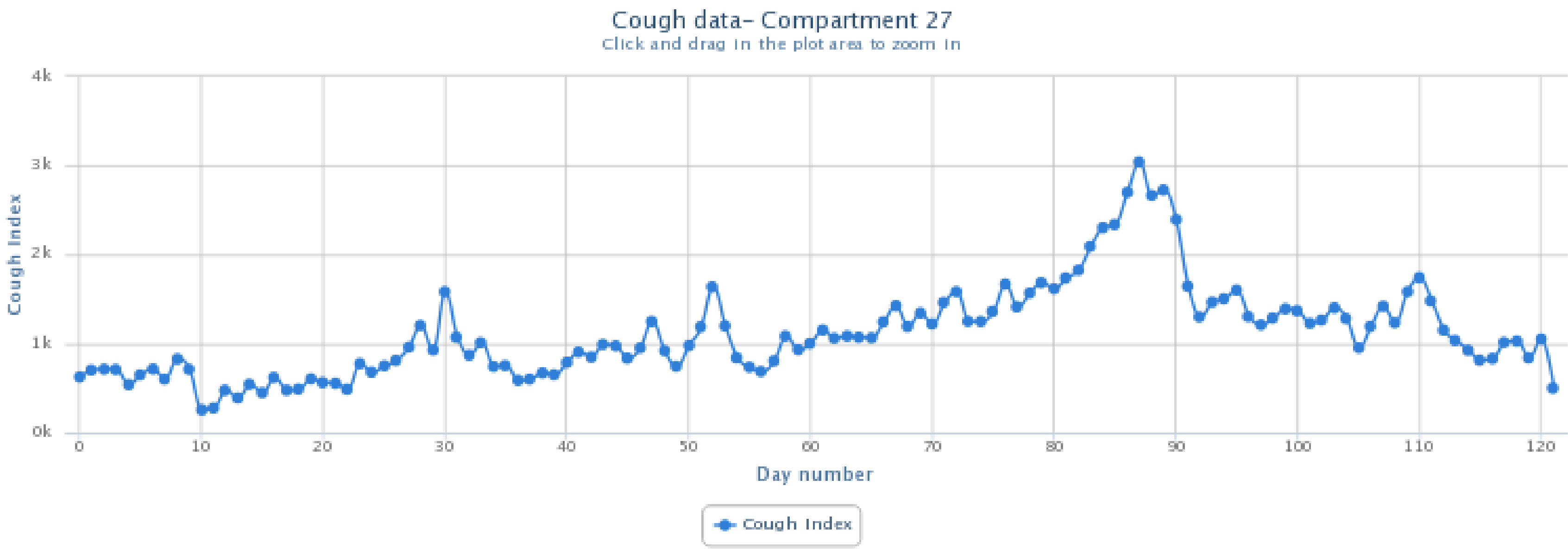


Figure 29. Visualisation of the sound-based biometrics data: Pig Coughs.

5.2 Pig Cough Monitor

5.2.1 Objective

The objective is to design a web interface that visualises the relevant information that comes out of the pig cough monitor to show to farmers and veterinarians.

5.2.2 Company

Fancom BV and SoundTalks NV

5.2.3 Product Description

PCM assists farmers and veterinarians in their continuous task of monitoring the health status of large groups of pigs, in order to improve the health status and growth performances of the animals in a long term, sustainable way.

5.2.4 Background/history

The M3-BIORES group in KU Leuven started to investigate the possibilities for an automatic tool for the recognition of pig coughs around 2000. They first studied the acoustics of the coughing (Van Hirtum et al., 2002). The group also developed a probabilistic neural network detection algorithm to differentiate pig cough sounds from other pig sounds (Chedad et al., 2001; Moshou et al., 2001). The next step in the research was on the differentiation between induced and non-induced cough sounds (Van Hirtum et al., 2003). Later they brought this research to the field in several validation experiments (Guarino et al., 2004a; Guarino et al., 2004b; Van Hirtum et al., 2004). The research in the group was also focused on the labelling of the pig cough sounds (Aerts et al., 2005). The following step in the research traject towards product development was the identification and differentiation of pig cough sounds associated with different respiratory diseases (Ferrari et al., 2008a; Ferrari et al., 2008b). The localization of the pig cough sounds in the pig compartment was also possible as the studies of Silva et al. (2008) and Exadaktylos et al. (2008a) show. The final work of the group on pig cough detection was on the improvement of the detection accuracy (Silva et al., 2009; Exadaktylos et al., 2008b) and the field test validation of the developed algorithm (Guarino et al., 2008).

Fancom BV showed an interest in transforming this research solution into a commercial product for the end-user, i.e. the farmer. SoundTalks NV, a spin-off company from KU

Leuven, focused on the further development of the cough detection algorithm, whereas Fancom BV focused on the product development and the integration of the Pig Cough Monitor (PCM) into the existing Farm Management package.

5.2.5 User Interface v01

The first version on the user interface for the PCM was developed within Fancom BV and integrated into the FarmManager software package. The PCM consisted of one controller unit to log and analyse all incoming data, and two microphones. Hence, with one PCM system it was possible to monitor two different compartments (one microphone per compartment). The algorithm developed by SoundTalks translated the incoming sound into pig cough counts. Within FarmManager software, these pig cough counts were visualised in the number of pig coughs per hour for the current day (Figure 30), or the number of coughs per day in the past four weeks (Figure 31). The end-user of the PCM was able to identify trend changes in the cough sound recordings by comparing today's data with yesterday's data (Figure 30) or from the pattern in the daily number of coughs visualised in Figure 31 in order to identify respiratory problems in his compartment.

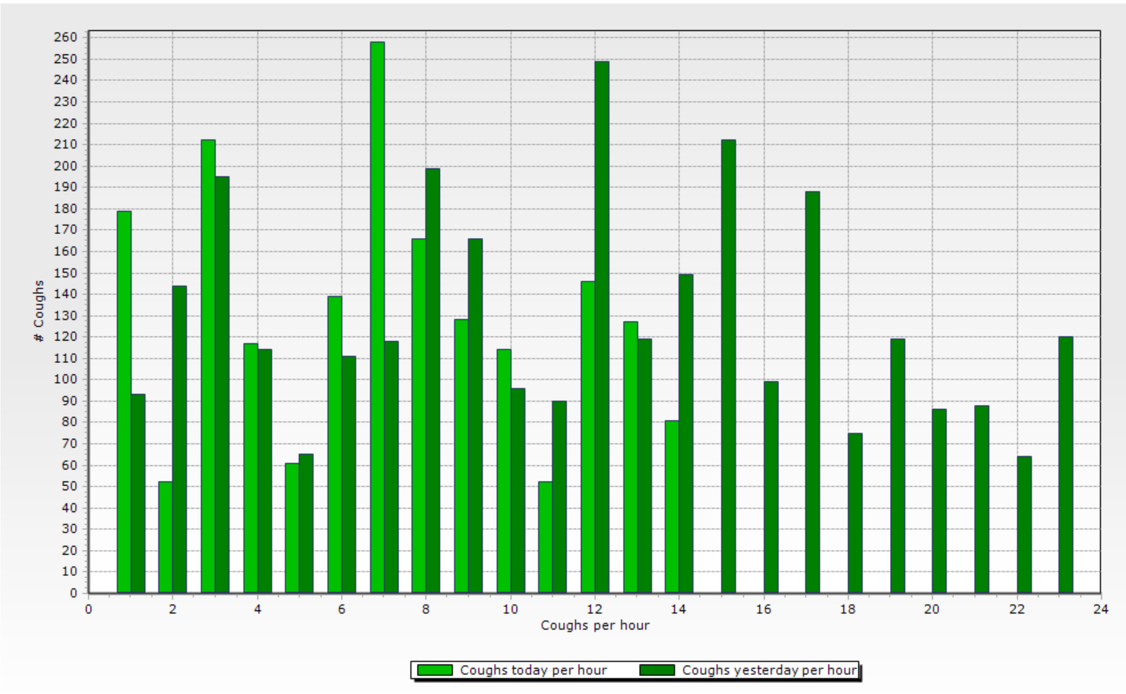


Figure 30. First User Interface of the Pig Cough Monitor. Graphical overview of the number of coughs per hour in the current and previous day.

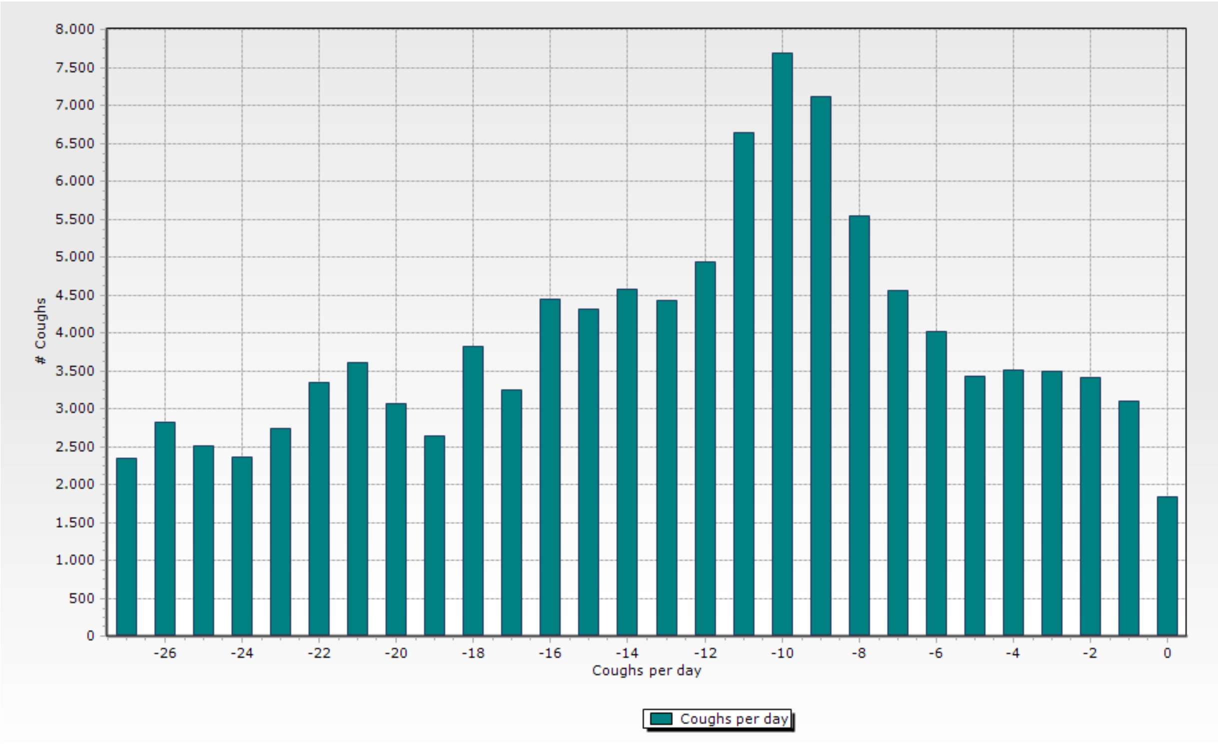


Figure 31. First User Interface of the Pig Cough Monitor. Graphical overview of the daily number of registered cough sounds during the past 28 days.

5.2.6 User Interface v02

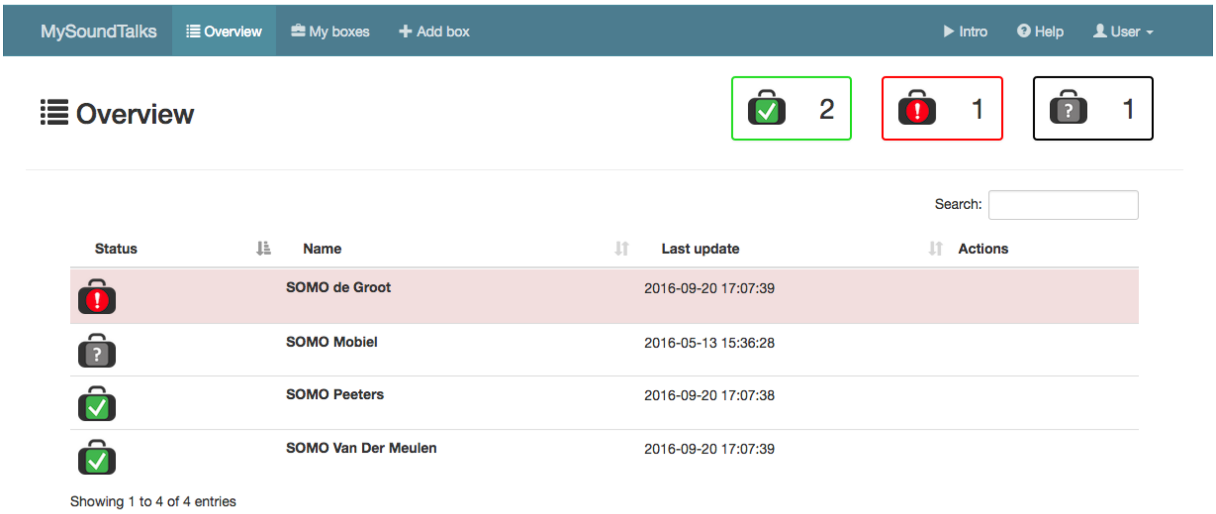


Figure 32. Overview screen for farmer and veterinarian. Box in grey are currently not connected to the server and store the data locally. Boxes in green are online and indicate no respiratory problems at the moment. Boxes in red that a management action is needed for an actual respiratory problem.

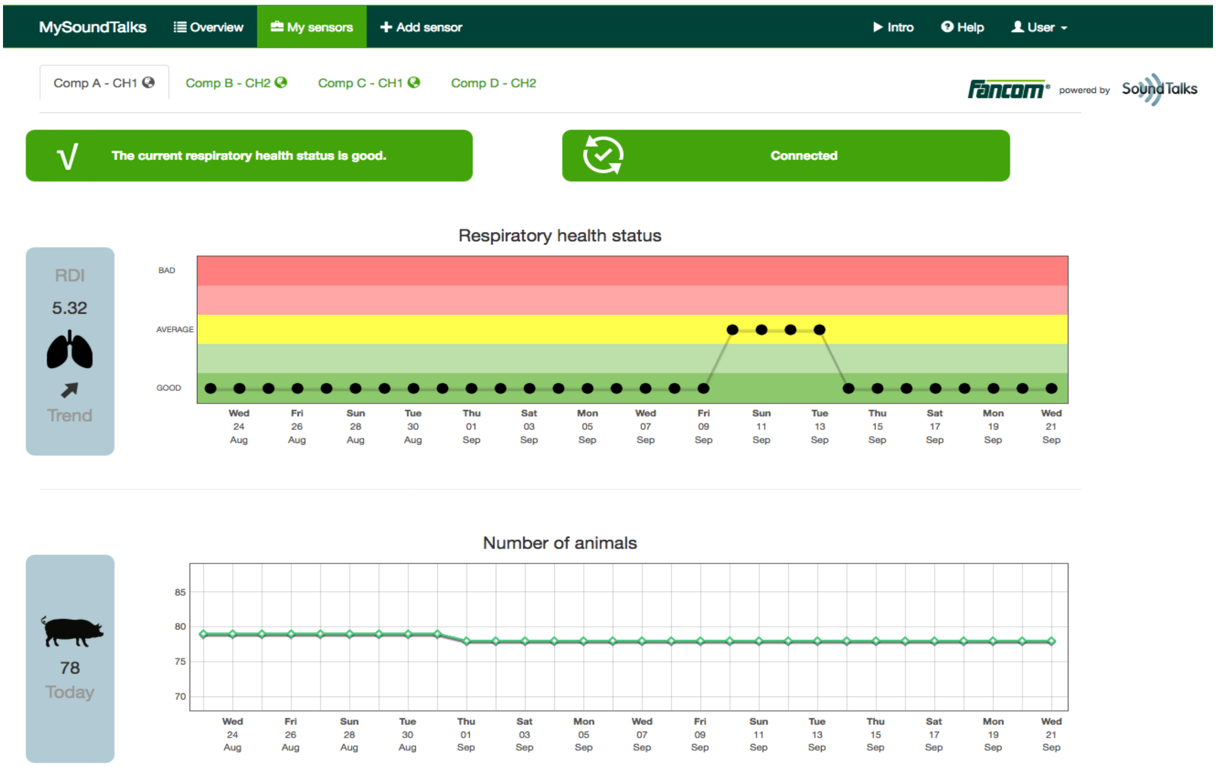


Figure 33. Detailed overview for a farmer. Five colour indication of respiratory health status.

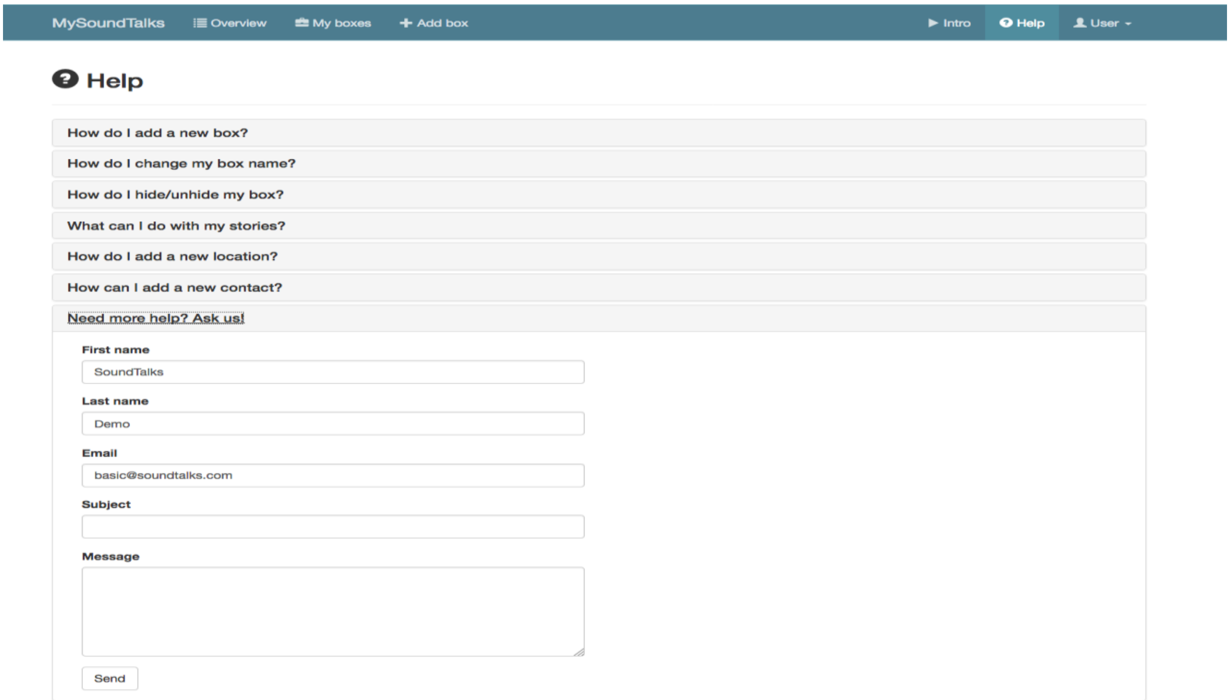


Figure 34. Overview of the help page with possibility to ask a detailed question.

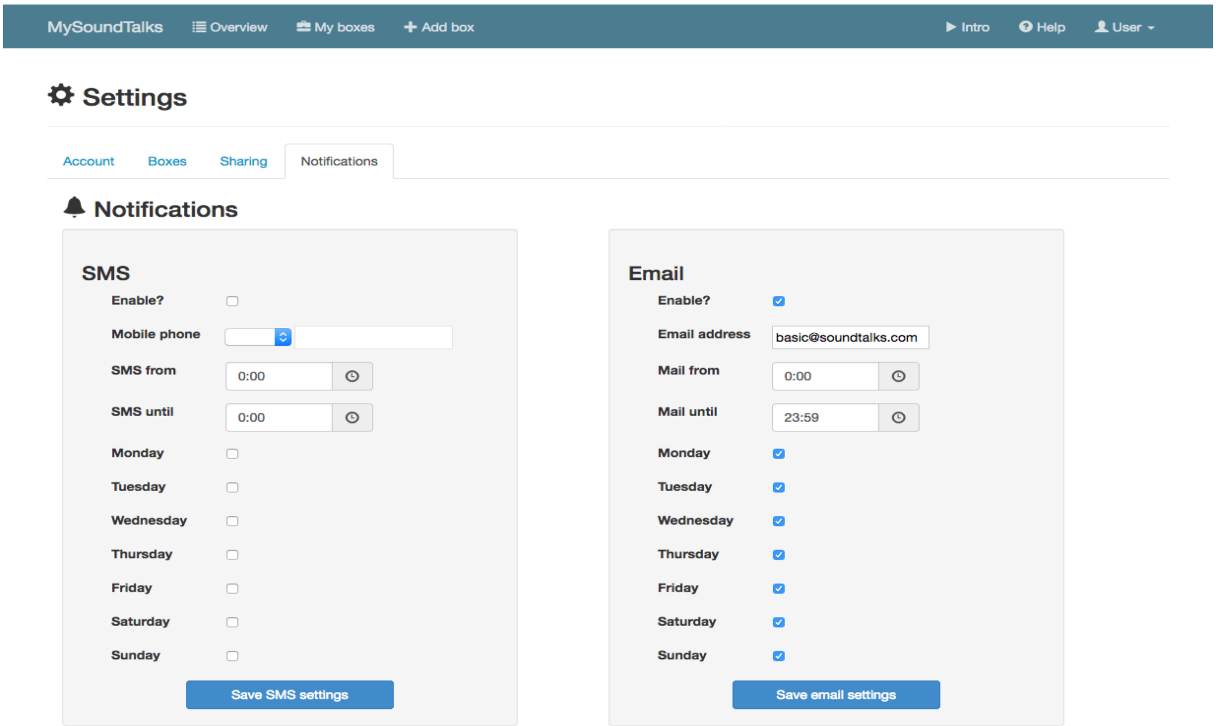


Figure 35. Settings of the notifications, as SMS or email warning.

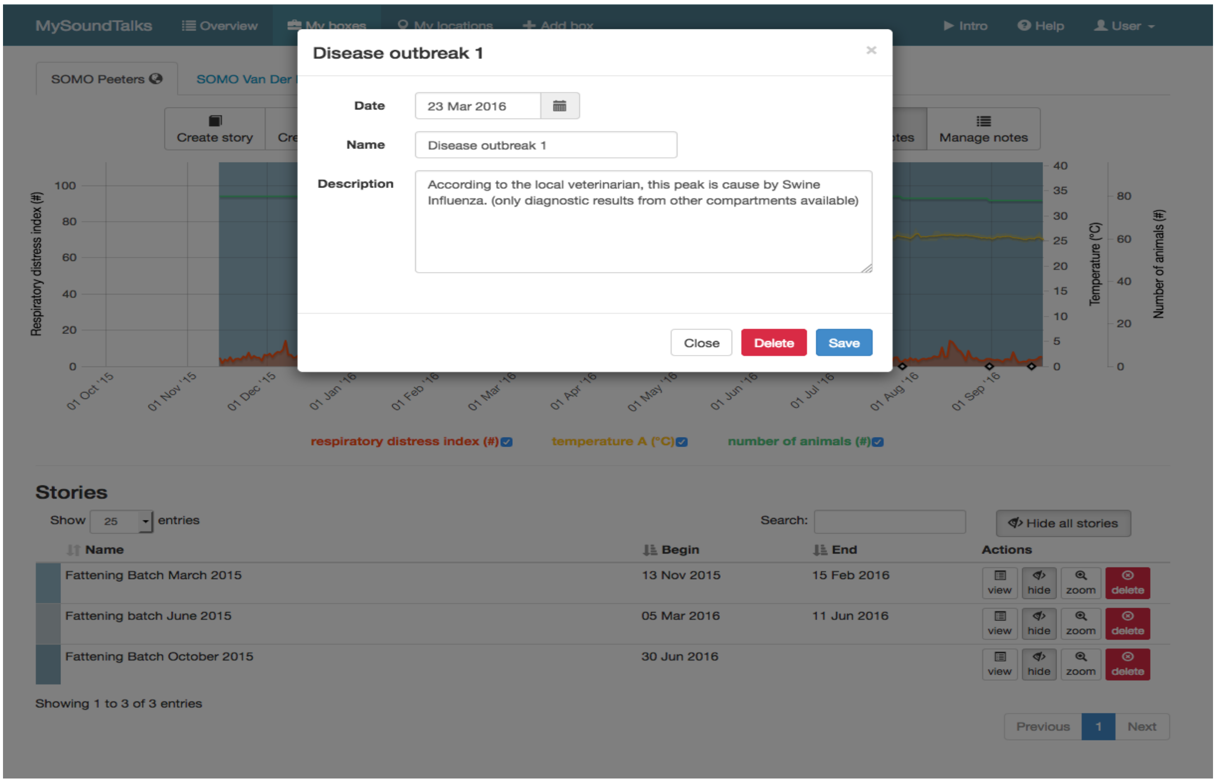
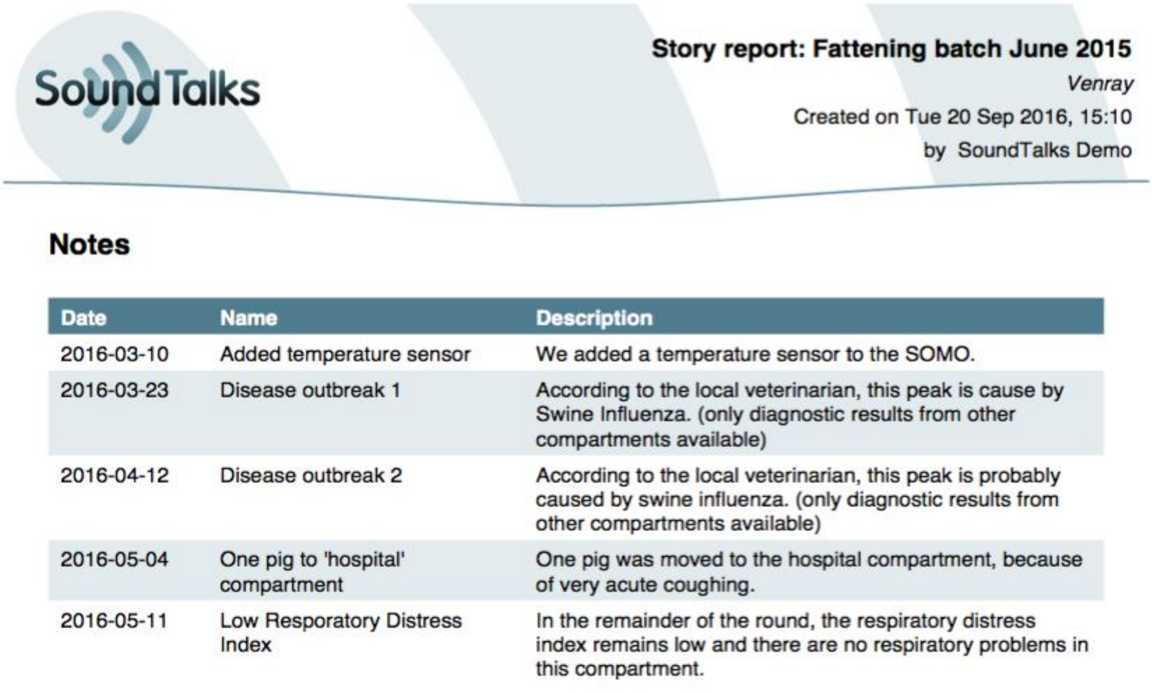


Figure 36. Example of notification. This note will be listed in the pdf report.



Story report: Fattening batch June 2015
Venray
Created on Tue 20 Sep 2016, 15:10
by SoundTalks Demo

Notes

Date	Name	Description
2016-03-10	Added temperature sensor	We added a temperature sensor to the SOMO.
2016-03-23	Disease outbreak 1	According to the local veterinarian, this peak is cause by Swine Influenza. (only diagnostic results from other compartments available)
2016-04-12	Disease outbreak 2	According to the local veterinarian, this peak is probably caused by swine influenza. (only diagnostic results from other compartments available)
2016-05-04	One pig to 'hospital' compartment	One pig was moved to the hospital compartment, because of very acute coughing.
2016-05-11	Low Resporatory Distress Index	In the remainder of the round, the respiratory distress index remains low and there are no respiratory problems in this compartment.

Figure 37. Overview of notes in an automatically generated pdf report.

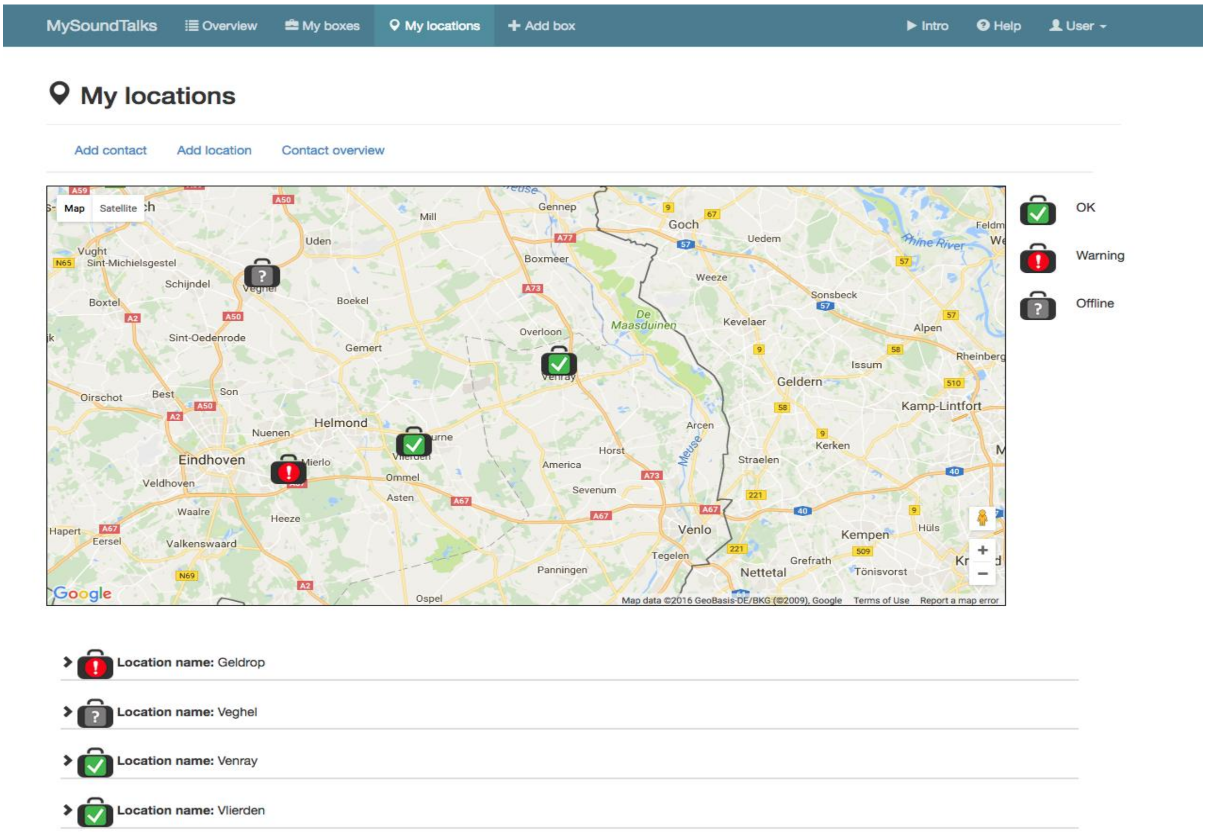


Figure 38. Visualisation of respiratory health status on a map.

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