Relevance of sensing data from Automated Precision Supplementation for breeding and management

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Organe Institute ApS

Cow breath

- Cow breath is not only bad and moist breath.
- There is a lot of valuable knowledge in every breath.
- The gas profile of the breath can be captured in combination with Automated Precision Supplementation (APS).

Interesting gases in cow breath

Methane (CH4) has currently a major interest, as the dairy sector according to FAO[1] globally contribute 4% (±26%) of anthropogenic greenhouse gas emissions.

- Reduced enteric methane production has become one of the highest prioritised goals, for example for the Danish Viking Jersey breeding association, who has the goal to develop the words most climate friendly dairy breed, with 20% less GHG emissions than "large framed breeds", such as Danish Holstein[2].
- In Denmark, policy goals are to reduce GHG emissions with 70% in 2030 compared to 1990, and climate neutrality in 2050. Similar drastic goals for reduced GHG emissions exists internationally (including EU Green Deal). EU agriculture is responsible for 94% of ammonia emissions (2015), and 70% of nitrogen entering EU rivers and lakes.
- ARLA, the large dairy in the Denmark, Sweden and other countries has introduced a regular climate check of their supplier members[3].
- GHG taxation is being introduced, however still not affecting the dairy farmers, but taxes in the level of 200€ per ton CO_{2e} would be expected over time in DK. Emission Reduction Units are currently being traded for a price around 80€ per tonnes CO_{2e}[4].
- Cows produce according Garnsworthy et al. (2012)[5] between 46 and 128 kg enteric CH_4 per year, dependent on productivity levels and feeding regimes.

1: FAO. 2010. Greenhouse Gas Emissions from the Dairy Sector: A Life Cycle Assessment. Food and Agriculture Organization of the United Nations, Rome, Italy.

2: https://www.vikingdanmark.dk/da-dk/videncenter/avl/dansk-jersey/avlsmal-2030.

3: https://www.arla.dk/om-arla/omtanke/artikler/klimatjek-saetter-turbo-pa-co2-reduktionen/

4: https://tradingeconomics.com/commodity/carbon

5: http://dx.doi.org/ 10.3168/jds.2011-4605

Interesting gases in cow breath

Example: SRCU has presented information about other gases in cow breath:

- **Sulphides** (e.g. hydrogen sulphide; dimethyl sulphide) – indicators of excess protein intake/protein degradation
- **Amines** (e.g. putrescine, methylamines) – indicators of rumen acidosis
- **Ketones** (e.g. acetone) – indicator of excessive mobilisation of reserves; ketosis

Cow breath components (ppb)

Ammonia	22.5	Propanols	9.2
Dimethylamine	28.8	Hexanol	0.5
Trimethylamine	15.2	Cis-3 hexen-1-ol	7.7
Acetaldehyde	29.9	Acetic acid	54.1
Hexanal	8.2	Propionic acid	13.2
Trans-2 hexenal	1.8	Butyric acid	28.7
Cis-3 hexenal	3.6	Valeric acid	11.9
Octanal	4.8	Hexanoic acid	4.8
Decanal	1.6	Hexenyl acetate	4.2
Acetone	786.2	Methyl sulphide	2.3
Butanone	140.8	Dimethyl sulphide	226.3
Diacetyl	8.9	Toluene	17.1
Acetophenone	0.8	Heptane	23.2
Methanol	231.0	Octane	21.8
Ethanol	88.5	Nonane	7.6

Role of passive breath analysis

- Both Langford et al. (2022)[6] and Garnsworthy et al. (2012)[5] works with passive breath monitoring, and outlines the perspectives for this in relation to respiratory and metabolic diseases in dairy cows, costing billions to the dairy sector annually due to delayed diagnosis.
- Passive breath monitoring means collection of breath during periods where the animals are positioned so that this is possible, typically during eating and/or milking. The breath collection is followed by analysing specific gases in it using gas sensors.

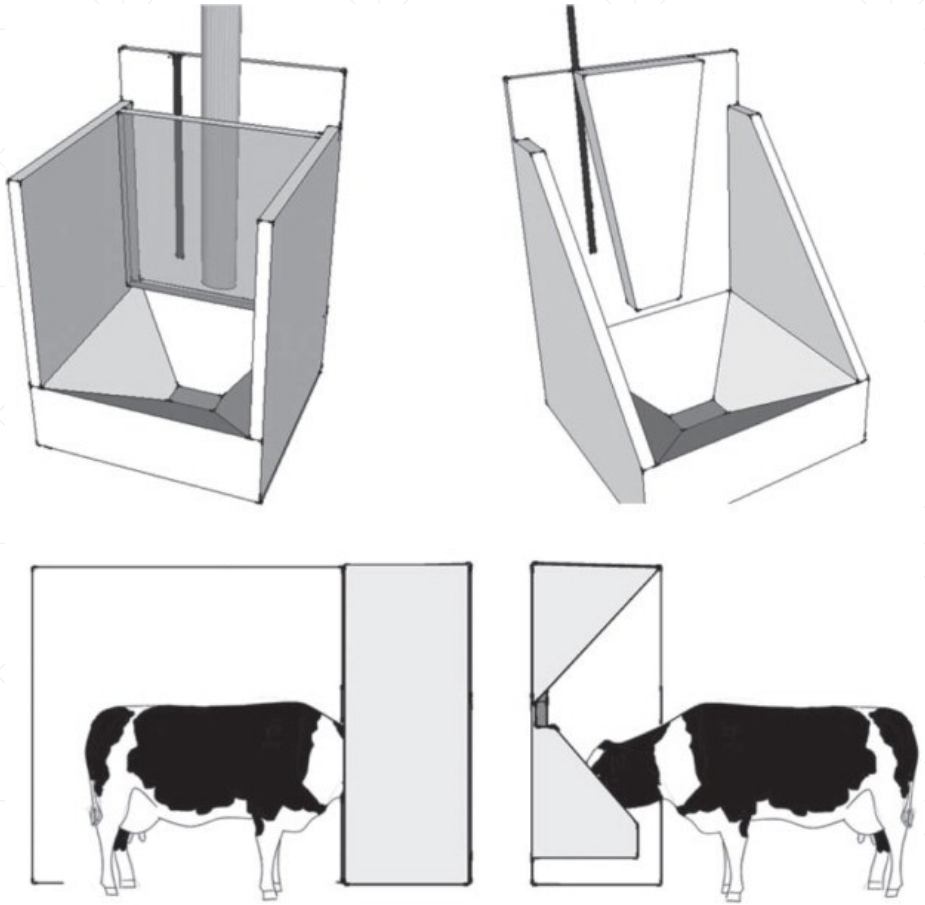


Figure from Langford et al. (2022)[6]

Automated Precision Supplementation (APS)

Pitstop^{PLUS} feeders and Pitstop^{PLUS} Manager are important system components

What Automated Precision Supplementation (APS) is

A schematic presentation

DATA

(D, F) Big data, The Cloud, Azure, MS SQL - iinteroperability, replicability and reuse

SOFTWARE

(B, C, D E) Front end - Pitstop^{PLUS} Manager, backend in master units and slave units

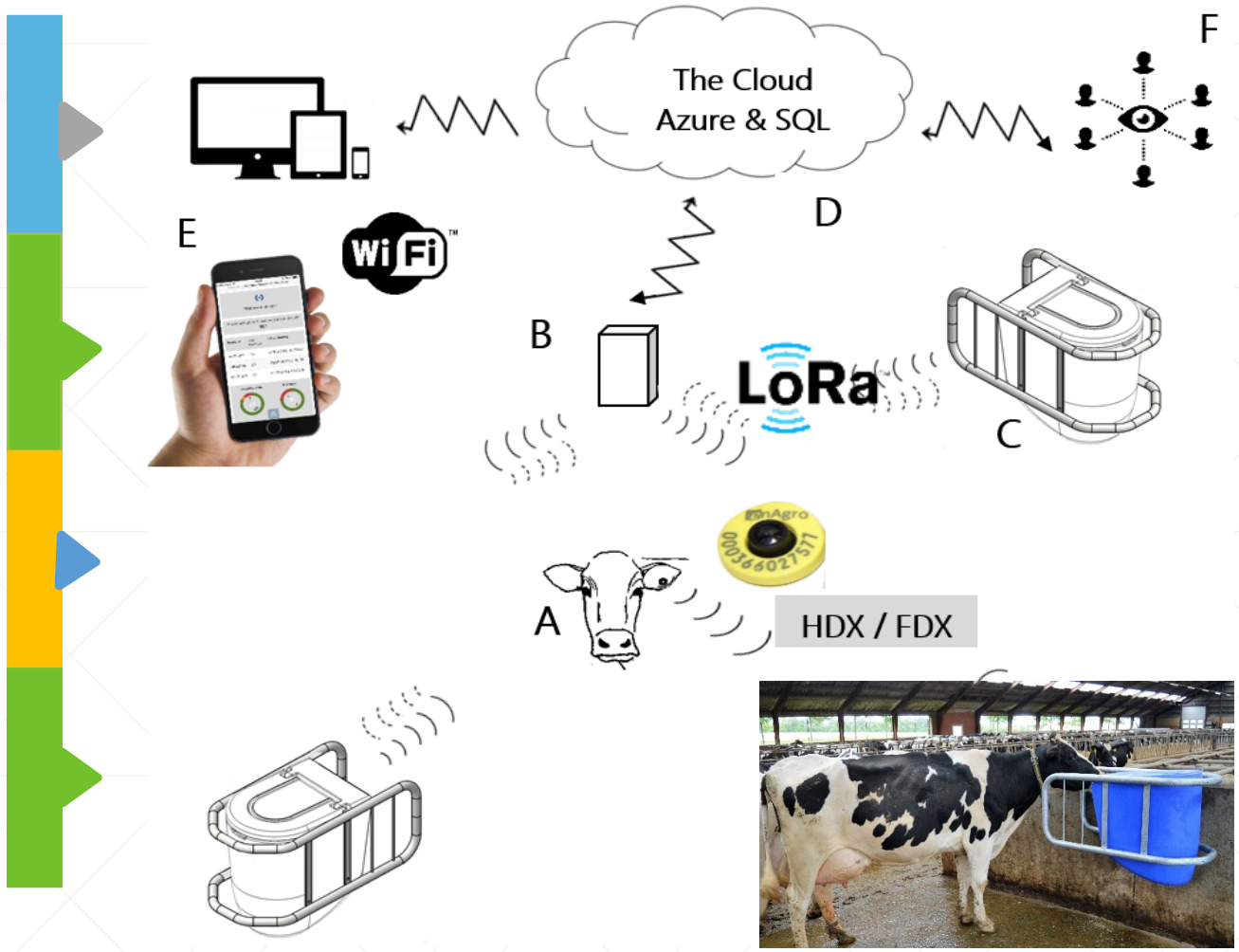
COMMUNICATION

(A, B, E) LoRa, WiFi and cabled

HARDWARE

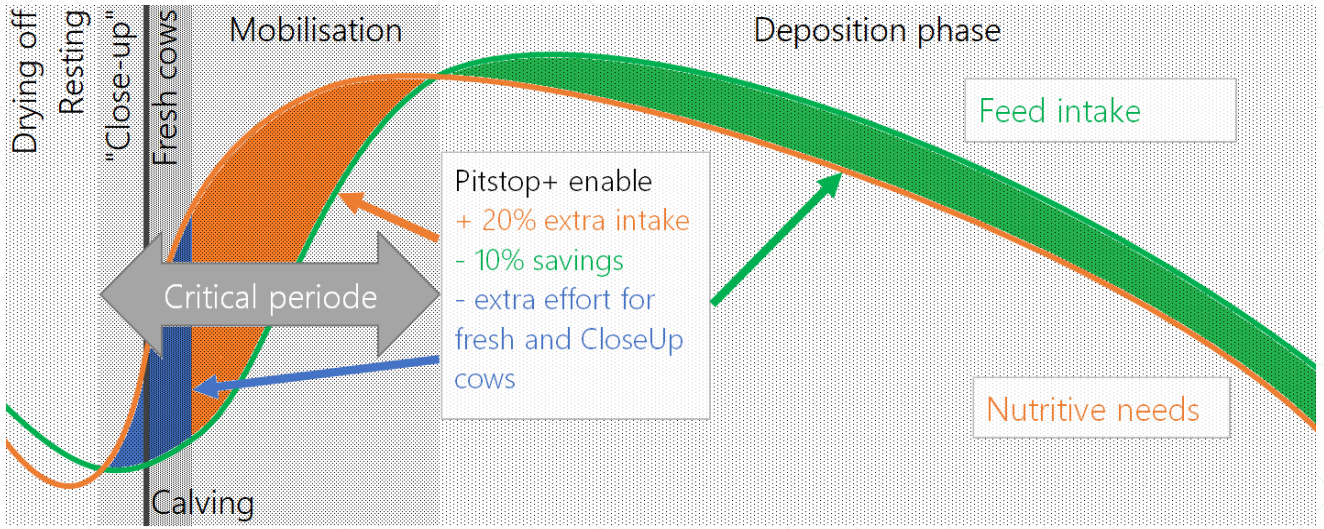
(A, B, C) Feeders, sensors – antennas and accelerlometers, PCB boards, electronic ear tags, dosing aggregates,

IoT components



Key challenges / pain points

TMR is worldwide now the most used feeding concept



Increasing frequency of costly diseases and self-dead cows

Technologically advanced feed additives exists, but no practical and economic methods for dispensing

Increasing consumer concern for the ethical quality of food

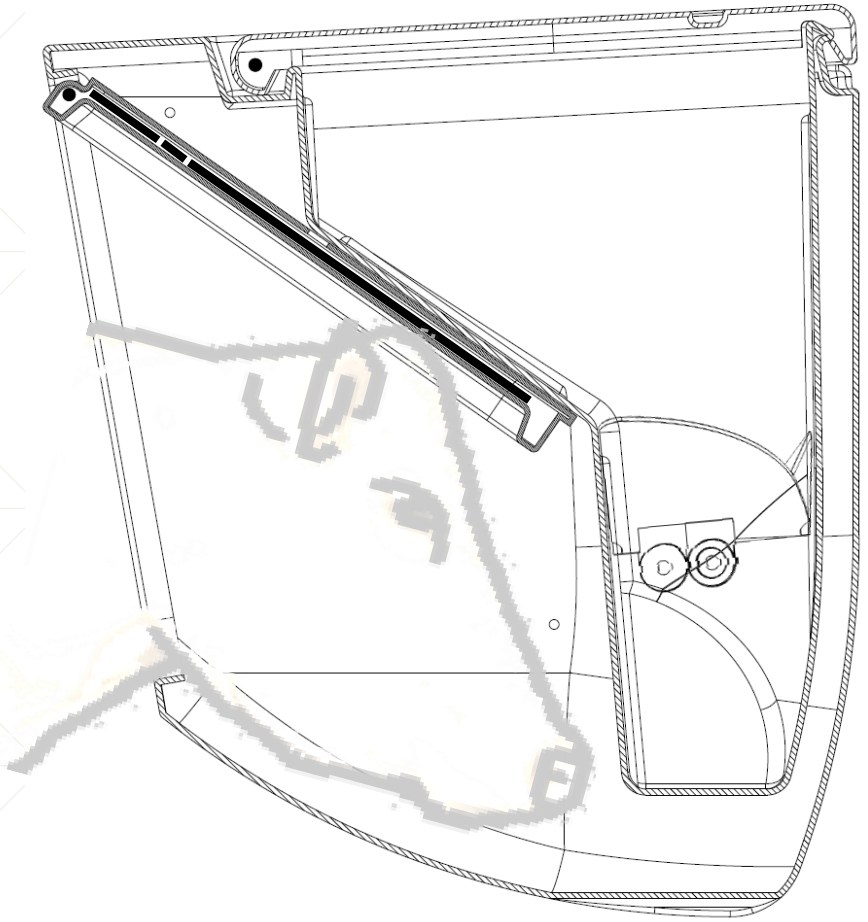
Results from practical trials with APS

The effects of MicroFeeder's Pitstop^{PLUS} concept for APS was tested in practice in the IoF2020.eu mega project in six testbeds in Germany, Latvia, Lithuania and Denmark with a total of about 2,700 dairy cows. Results are shown here for cows having completed 100 lactation days:

Cows with > 100 lactation days	Unit	Test	Control	Improve-ment, units	Improvement, %	€ per unit	€ in total	Comment
Cows	Number	572	795	-	-			
Extra minerals	Kg	3,4	0,1	3,3	-	2,25	-7,35	
Milk yield	Kg ECM/cow/day	39,7	39,8	-0,1	0	0,35	-14,57	305 days
SCC	1,000 per ml	245	299	**-54,0**	**-18**			
Inseminations per pregnancy	Number	1,65	1,75	**-0,11**	**-6**	30	3,19	Depends much on the semen price
Empty days		117	118	**-1**	**-1**	2	1,98	
Not started		22	68	**-46,0**	**-68**			
Diseases incidences per cow per year		466	853	**-0,25**	**-23**	400	99,22	
Culled		53	52	1,0	2	1.611	-2,82	Divided by number of test cows
Price for Pitstop^{PLUS}						1.200	-3,20	One feeder per 75 cows, lasts for a minimum of 5 years
Net profit, € per cow per year							**76**	

Precision supplementation features

- Closed chamber.
- The place taken up by the head of the cow means the feeder is quickly filled with the cow breath.
- Communication and electronics already exists to identify the cow, register the time of the visit and communicate data with “the cloud”.



Visit behaviour

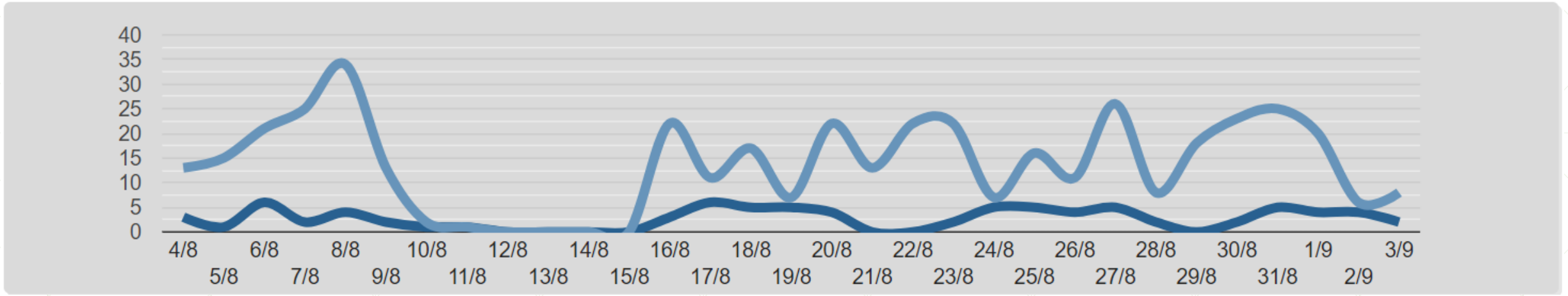
- Cows with access to get supplements from the feeders are typically visiting the feeders 3-5 times per day and they typically stay around the feeders for 1-2 minutes and stick their head in and out several times during the visit.
- Cows without access to minerals are typically checking the feeders 1-3 times per day.
- Because APS is based on cows' natural behavior, we see a variation in their visit pattern of individual cows.
- We have not seen "no-eaters" unless in cases where the cows have lost their electronic ear tag, or similar comparable causes.
- Cows averagely eat about 70-80% of the amount they are offered.

Examples of profiles of cow visits to Pitstop^{PLUS} feeders

NB: Supplements were missing / feeders empty from 9 -16 August

Activity of the cow with eartag ID No.: 208_002903503014

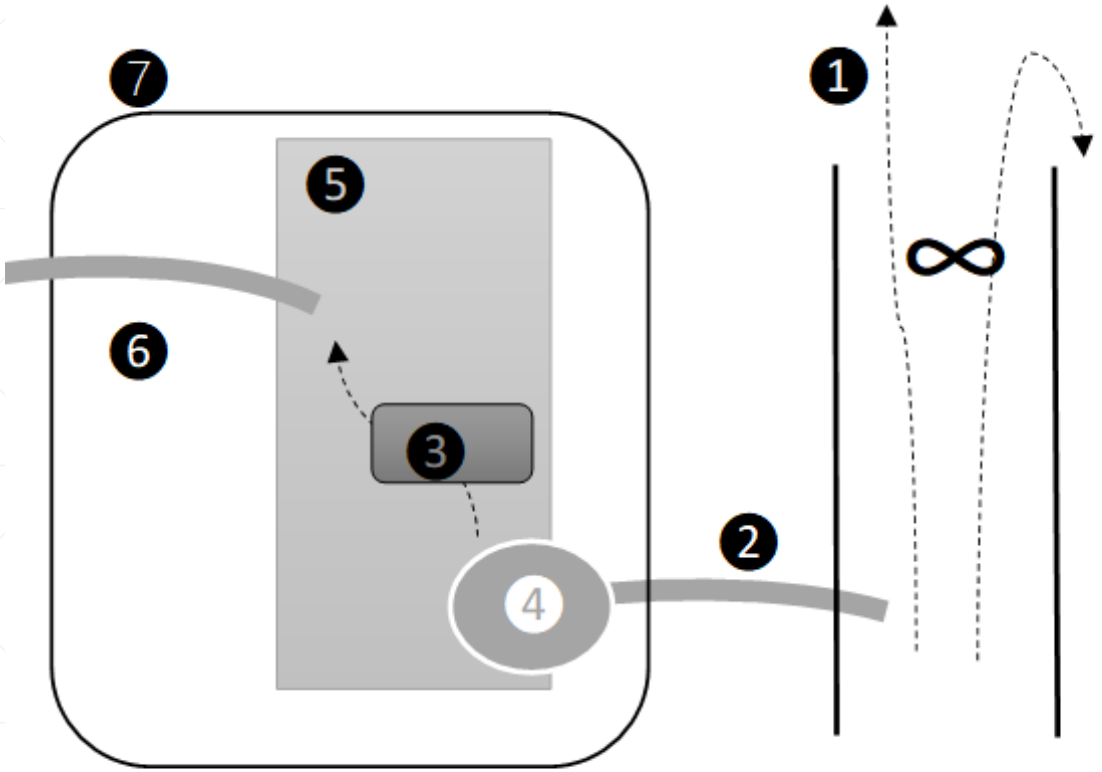
Daily feedings (dark blue) and activity (light blue)



The Breather^{AIR} project

- Objective: Development of versatile device for measuring gas concentrations in air of production units for management purposes.
- Production units can be industry buildings, stables, animals, etc.
- Management purposes comprise business management, including optimization of resource economy, animal health monitoring, emissions monitoring, animal breeding, etc.
- The project is funded by the Danish Innovation Fund and coordinated by MicroFeeder, having Danish Technology Institute among main subcontractors.

Components



1 An air collection / sampling chamber unit for the control of the sampled air volume and quality.

2 A passive air sampler, consisting of an air pump that via a tube drags air from the air collection unit to the analysis chamber.

3 A replaceable gas sensor, typically integrated with a print card with electronic components for supplying the gas sensor with electricity and for capturing sensor data and either store this or communicate it to the cloud.

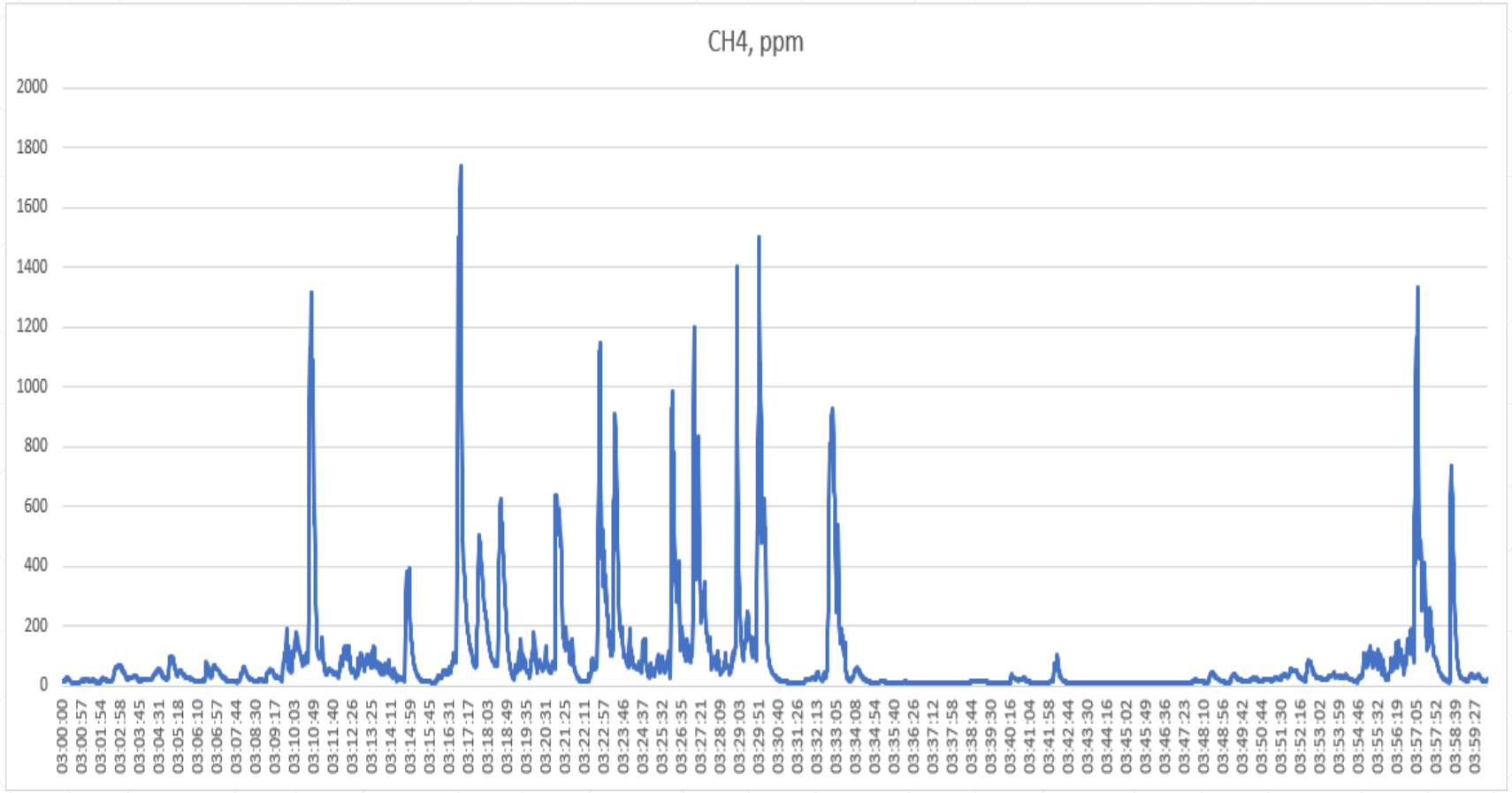
4 Air pump for a controlled sampling from the air collection unit.

5 Analysis chamber.

6 Outlet for analysed air.

7 A control box designed for allowing plug-and-play exchange or replacement of gas sensors of various types, shapes and sizes to the envisaged use.

Methane measurements during 1 hour for 1 feeder



- The eructation peaks represents different cows.
- There is a clear difference in the height of the eructation peaks.
- Measurements are done with a relatively expensive sensor (3,000 €).
- Shortly, we will test the preciseness of the measurements using cheaper sensors (in the level of 5-20 € per sensor).

Key messages

- Cow breath contains a complex composition of gases, including greenhouse gases, gases that are indicators for respiratory and metabolic diseases, and gases indicating excess protein in the ration.
- Passive monitoring of gases in dairy cows breath has in international science dissertations been recognised as a cost effective method for optimising dairy health and business management. We also see a perspective for breeding purposes.
- Automated Precision Supplementation appears as an optimal system for passive monitoring of gases in cow breath, considering the closed design of the feeders and the frequent visit of the cows to the feeders.
- Innovative activities are ongoing to develop a simple gas monitoring apparatus, which can be attached to various feeding and/or milking stations, including feeders for APS, for the purpose of bringing passive monitoring of gases in cow breath into commercial use.

- The Breather^{AIR} project is funded by the Danish Innovation Fund and coordinated by MicroFeeder.
- Read more about Precision Supplementation (and in the future also about the Breather^{AIR} apparatus) https://www.organe.dk, https://www.pitstopplus.eu, or https://www.microfeeder.com

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