WEBINAR

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BIG DATA E INTELLIGENZA ARTIFICIALE

per migliorare **benessere animale, sostenibilità e produttività** negli allevamenti di bovine da latte

5 DIC. 2022
dalle ore 11.00
alle ore 13.00

Alma Mater Studiorum Università di Bologna
Dipartimento di Scienze e Tecnologie Agro-Alimentari
Ingegneria Agraria – Costruzioni Rurali

KU LEUVEN
Department of Biosystems
Division of Animal and Human Health Engineering Livestock Technology lab

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4.

ALGORITMI PER L'AUTOMAZIONE IMPIANTISTICA DELLA STALLA

Stefano Benni *Professore Associato di Ingegneria Agraria, Università di Bologna*

- LA VENTILAZIONE MECCANICA NELLE STALLE
- SOLUZIONI PER L'AUTOMAZIONE DEGLI IMPIANTI
- IL MODULO DI AUTOMAZIOEN DELLA PIATTAFORMA DAIRY SUST

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Mechanical Ventilation

A barn may be ventilated using positive pressure (where fresh air is forced into the barn) or negative pressure (where air is exhausted from the barn and fresh air is drawn in through designed inlets).

All mechanical systems for adult cow barns are specified according to the guidelines laid out in the ASABE Standards, which are principally to:

- Avoid a 1°C to 2°C temperature increase within the barn
- Provide walls with enough insulation to avoid dew-point temperatures at 70 to 80% RH inside the barn
- Maintain noxious gases within acceptable limits (NH_3 <10 ppm, CO <50 ppm, H2S <0.7 ppm, CH_4 <1000 ppm, CO_2 <3000 ppm)

Additional design recommendations for mechanical ventilation systems for adult dairy cattle

Sufficient air changes per hour (ACH)

- 4 to 8 ACH in the winter
- 40 to 60 ACH in the summer (Usually ~40 ACH for tunnels, ~50 ACH for cross-ventilated barns)

Sufficient air exchange per unit body weight under peak heat stress (summer)

- 2550 m^3/h per adult cow
- To consider productivity: 100 m^3/h per liter of milk daily produced

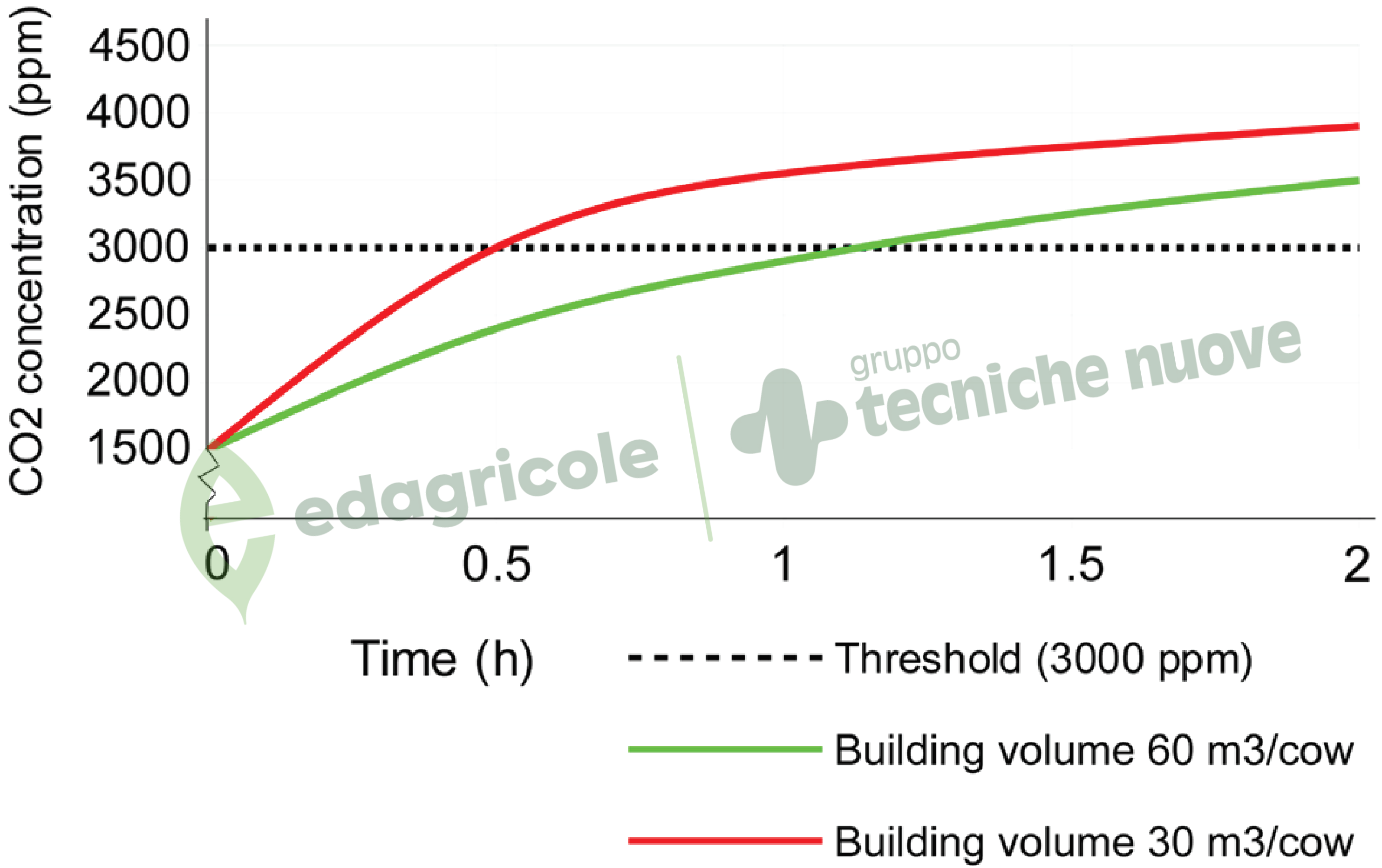
Maintain an inlet speed of 2.5 to 4 m/s to ensure good mixing of air without limiting air flow to the exhaust fans.

Minimum air volume

The air volume per animal inside a building (static air volume) can play a important role on air quality whilst the minimum ventilation rate fluctuates up or down.
Reducing the ventilation rate and starting or increasing production of air contaminants increase the concentration of air contaminants. In large volume buildings the increase is slower compared to small volume buildings.
Additionally, the variation in gas concentration during the day is reduced. It means that concentration of gas, dust and micro-organisms and its variability during the day can be reduced by dilution (buffer effect). Furthermore, the inertial action of the air mass can help to maintain the climatic parameters in a steady state. The gas concentration in non-steady state conditions can be calculated by:

$$c = [\frac{X}{V} + c_a 10^{-6} - \frac{X - V(c_0 - c_a)10^{-6}}{V} e^{\frac{-V \cdot 3600}{vol} t}] 10^6$$

where: c = Gas concentration after time t; t = time (h); X = amount of gas produced (m^3/s);
V = ventilation rate (m^3/s); c_a = gas concentration in the outside air (ppm); c_0 = gas concentration in the building at the beginning (t=0) (ppm); vol = air volume of the building (m^3)



CO2 concentration (ppm)
4500
4000
3500
3000
2500
2000
1500
0
0.5
1
1.5
2
Time (h)
Threshold (3000 ppm)
Building volume 60 m3/cow
Building volume 30 m3/cow
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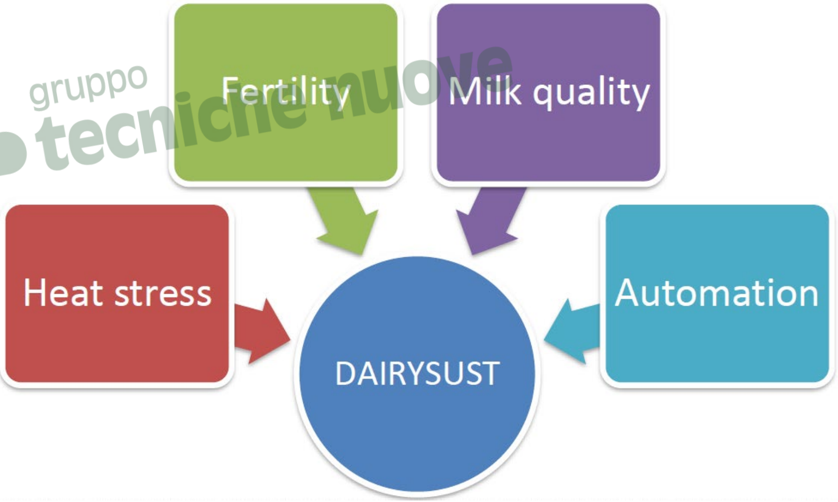
LA PIATTAFORMA INFORMATICA DAIRYSUST

AUTOMATION MODULE



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Automation module



- Identification of the optimal parameters to activate devices, e.g.:
- Fans, soakers, shading curtains, artificial lighting.
- Application depends on the equipment installed in the barn (number of devices, definition of independently controlled areas…)



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Automation module

The algorithm of the automation module was tuned in order to be compatible with the structure of the database and was adapted in order to work with newly available data sources.

The automation module has been defined in order to be able to work in synergy with the algorithm for the assessment of the impact of heat stress previously described.

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Automation module

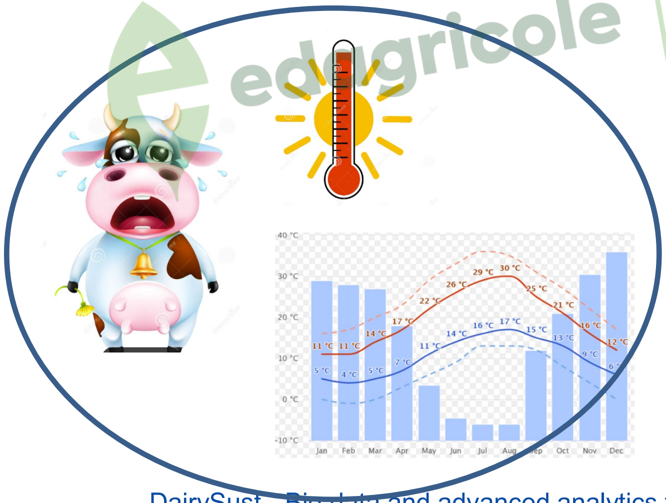
INPUT (the day 0 is the current day; i indicates the hours of a day)

- Percentage of animal suffering heat stress at day-1: NA-1
- Percentage of animal suffering heat stress at day-2: NA-2
- Percentage of animal suffering heat stress at day-3: NA-3
- Percentage of animal suffering heat stress at day-4: NA-4
- Percentage of animal suffering heat stress at day-5: NA-5
- Average THI at day-1: THI-1
- Average THI at day-2: THI-2
- Average THI at day-3: THI-3
- Average THI at day-4: THI-4
- Average THI at day-5: THI-5
- Current (hourly) Temperature at day 0: T0(i)
- Current (hourly) relative Humidity at day 0: rH0(i)
- Forecast of the (hourly) Temperature at day +1: T+1(i)
- Forecast of the (hourly) Temperature at day +2: T+2(i)

OUTPUTS (the day 0 is the current day; i indicates the hours of a day)

- Suggested (hourly) functioning level of the cooling systems (ventilation, water soaker line, etc.) for the day 0: Level0
- Suggested (hourly) functioning level of the cooling systems (ventilation, water soaker line, etc.) for the day +1 : Level+1
- Suggested (hourly) functioning level of the cooling systems (ventilation, water soaker line, etc.) for the day +2: Level+2

The algorithm allows to activate automation in the usual systems in the barns (e.g. opening windows, starting fans, activating misting and cooling systems).



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Automation module

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- Percentage of animal suffering heat stress at day-5: NA-5
- Average THI at day-1: THI-1
- Average THI at day-2: THI-2
- Average THI at day-3: THI-3
- Average THI at day-4: THI-4
- Average THI at day-5: THI-5
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- Suggested (hourly) functioning level of the cooling systems (ventilation, water soaker line, etc.) for the day +2: Level+2

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Automation module

The capability of the automation module also allows to integrate the previously obtained heat stress module and to provide automation of the electronic devices of the barn in order to optimize the indoor microclimate, enhance milk quality and improve cow management and feeding.

The algorithm can provide additional support in system automation if powered also by weather forecast, to provide early activation of environmental control.

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