Countering heat stress with structural measures

Context

By 2050, the Upper Rhine region will experience significant climatic changes due to global climate change. **Rising temperatures**, **changes in precipitation patterns** and an **increase in extreme weather events** will have a significant impact on the region.
Climate forecasts predict an estimated **1.5 to 3 °C rise in average temperatures** compared to pre-industrial levels. **Heat waves will become more frequent and intense**, with summer temperatures exceeding **40 °C** during **heat peaks**.

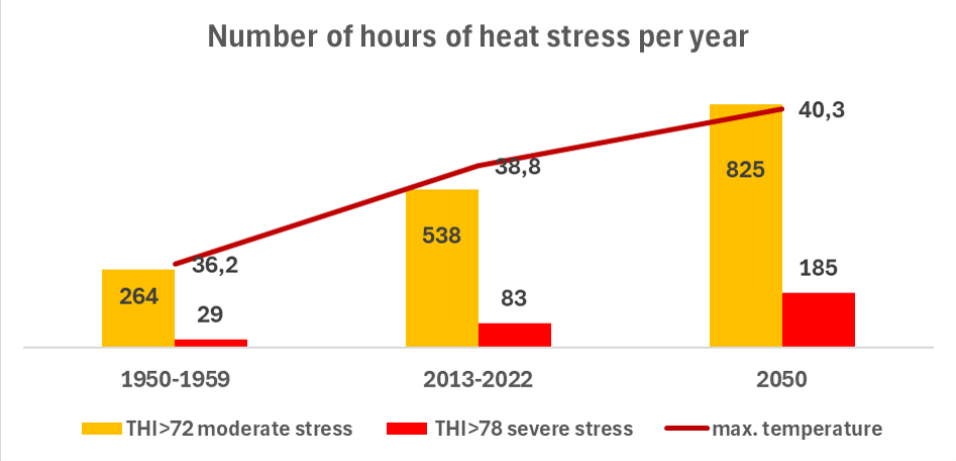


Fig. 1: **Number of hours per year with heat stress**.
The data for Strasbourg shows an increase in the average temperature:

- between 1950 and 1959, it was 9.8 °C, recently rose to 11.9 °C, and
- is expected to reach 13.4 °C in 2050.
- At the same time, the annual maximum temperature is rising to over 40 °C.

As far as heat stress for dairy cows is concerned, the number of hours with **moderate stress** has **quadrupled** in 100 years. The time with **severe stress** has even increased **sixfold**.

Definition and consequences of heat stress

What is heat stress?

The **thermoneutral range** for cows, i.e. the ambient temperature range in which cows can maintain their body temperature with **minimal regulatory measures**, is **between 4 and 16 °C**.

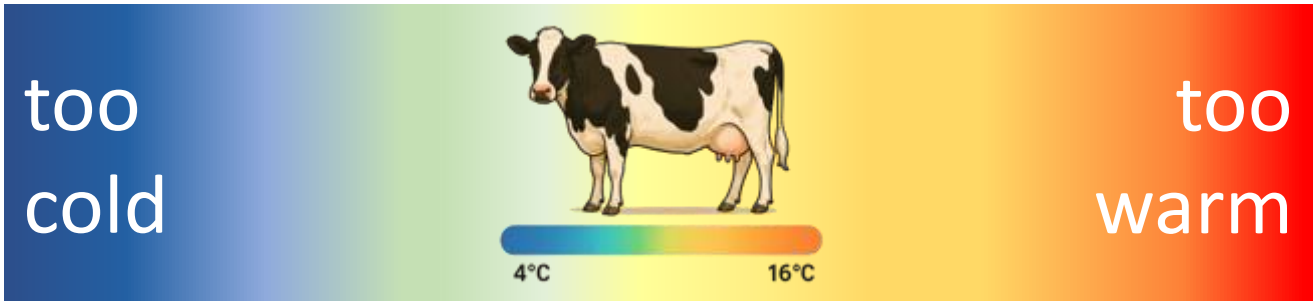


Fig. 2 : Thermoneutral zone of a cow

Heat transfer between cows and their environment

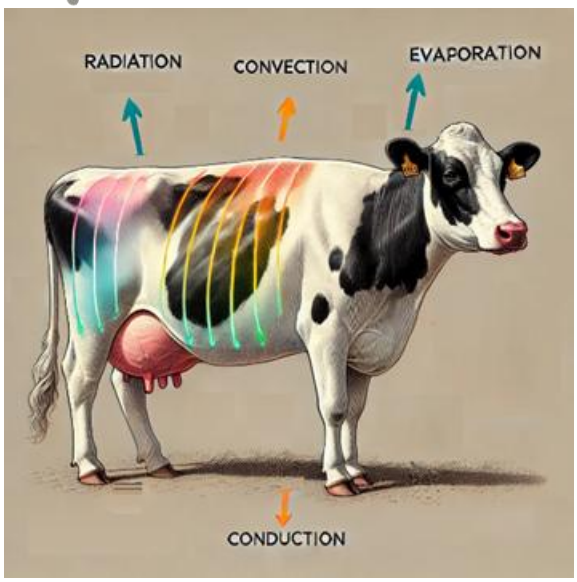


Fig. 3: Outside its thermoneutral range, the dairy cow begins to release excess body heat into the environment via sensitive or evaporative pathways with the aid of physiological regulatory mechanisms.

This leads to a **stressful situation** for the animal, known as **heat stress.** The onset of heat stress depends on:

- **air temperature**
- animal-related factors: **milk yield, age** and **stage of pregnancy**
- other climatic factors such as **relative humidity, wind speed, direct or indirect sunlight**

This phenomenon has led to the calculation of indices that take these effects into account: the **THI** (**Temperature Humidity Index)** and the **HLI (Heat Load Index)**. Threshold values were determined by measurements on animals.

Stress level	THI	HLI
No stress	< 68	< 70
Light stress	68 - 72	70 - 77
Moderate stress	72 - 78	77 -86
Severe stress	78 - 84	86 – 96
Extreme stress	> 84	> 96

Table 1: Threshold values for heat stress
As soon as the THI exceeds 68, the cow suffers from heat stress. These limits, which were set more than 10 years ago, are currently being reassessed as performance potential has increased and cows have become more sensitive.

Consequences of heat stress

When cows suffer from heat stress, they try to **reduce** their own **heat production**. To do this, they **reduce their feed intake** in order to relieve their metabolism. This leads to a **decline in overall performance**, which occurs with a delay of 2 to 3 days after the **reduction in feed intake**. This can then lead to an estimated **reduction in milk yield of 0.3 kg per increased THI point**, i.e. with **10 to 15** additional THI points, milk yield decreases by about **3 to 5 kg or 10 to 23%.**

In addition to a decline in performance in cows, heat stress periods are also associated with **reproductive disorders** and **reduced growth** in young animals.

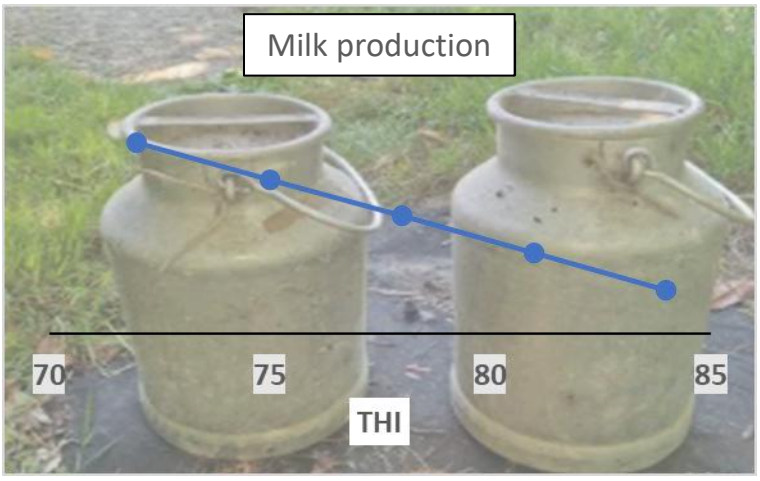


Fig. 4: Decline in milk depending on the THI

10 THI points reduce milk production by 3 kg

Measures against heat stress

As soon as the temperature exceeds 15 °C, it must be assumed that the animals' **heat dissipation needs to be supported**, meaning that cooling is required when the **THI index reaches 65**.

The first measures to alleviate heat stress begin with the **construction** or **redesign** of buildings, taking into account best practices and technical solutions. All structural measures that **increase natural air exchange** and **reduce heat input** into the barn are therefore to be **preferred**. In addition, access to **high-quality and sufficient quantities of drinking water and feed** is crucial for supporting the animals.

Structural measures

- For good natural ventilation, the **area surrounding the building must be unobstructed** (no adjacent buildings or embankments, as shown in picture A).
- Ventilation is most effective in narrow, free-standing buildings exposed to the wind, as this **facilitates cross ventilation** (picture B).
- Long side walls **must not be blocked by adjacent structures** (silos, milking parlours, calf pens, storage rooms, etc.) (picture C).

As cows are not very sensitive to cold, in many situations it is possible to construct buildings that are **more open than usual**. In order to achieve natural air movement at the animals' height, **low-lying open openings should be provided on the long side** if possible.

Measures on buildings

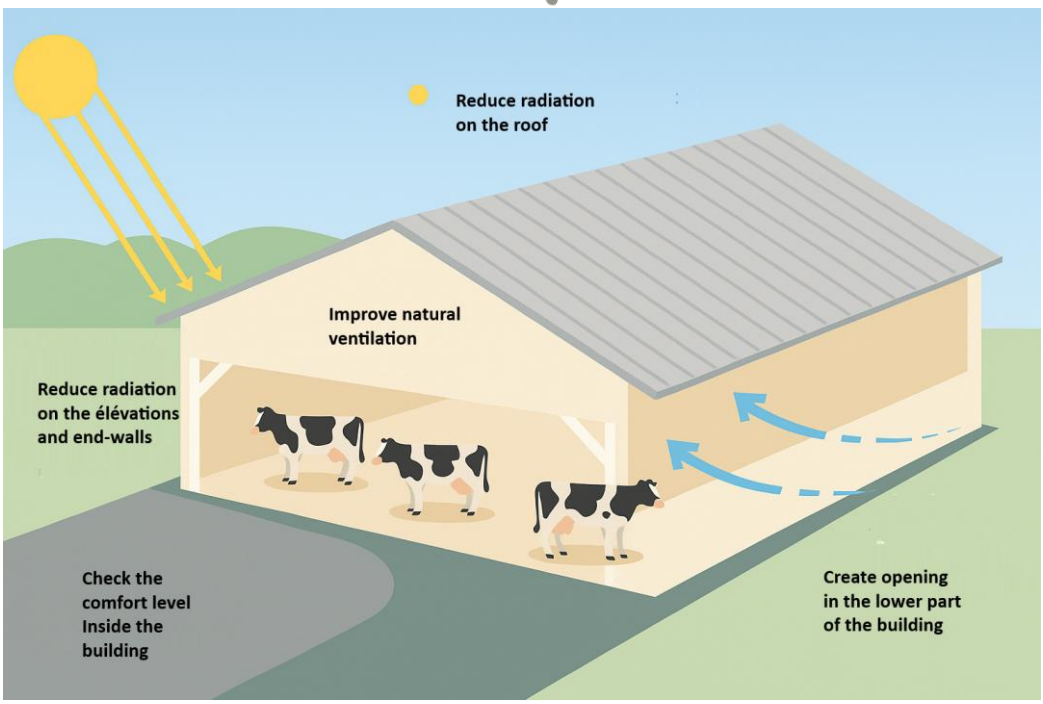
Radiation from walls and roofs should be limited, and **direct sunlight on resting areas** should be avoided. The following recommendations should be taken into account when considering changes to or the design of buildings:

- **Limit** the **height of masonry** on walls exposed to the sun (south, south-west and west sides) **as much as possible**.
- **Avoid installing translucent panels** on the sunny sides of the roof (pictures D and E). In existing buildings, translucent coverings can be **painted over with a shading paint** from the inside.
- Prefer a **classic open ridge** (ridge with **wind protection**, etc.) to a skylight, which increases the greenhouse effect.
- **Insulate the roof** if it is close to animals, i.e. in **low buildings with low volume.**
- Choose **light colours** for the roof to promote the **reflection of solar radiation** and thus **reduce the heat stored**.
- On the east, south and south-west sides, the openings must be protected from sunlight in summer by **roof overhangs** (picture F).

Avoid direct sunlight by not using translucent materials on the south or west side, especially above the feeding area (picture D) and resting area (picture E).

Avoid direct sunlight by installing a roof overhang (picture F).

Fig. 5: Factors to be considered for improving the indoor climate in the barn before resorting to mechanical ventilation or spray mist.



Further measures – mechanical ventilation

If these solutions are not sufficient, **mechanical ventilation** can provide **additional assistance**. It enables rapid air movement (in the range of **1 to 3 m/sec**) near the animal to support heat dissipation.

- Installation of **fans** depending on **fan type and building design**.
- **Shower or spray mist** primarily at the **resting area** or even at the **feeding table**.
- Use of **water for cooling** as a last resort and ***only in combination with mechanical ventilation***
  - ➢ so that humidity and thus the THI are not increased.

These techniques are energy- and water-intensive. Their **economic benefits must be assessed according to the circumstances of the farm** (see outputs ResKuh Energy and Water).

Sources

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