Embedded energy in dairy stables

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Implications

The calculation of the embedded energy[1] (EE) of twenty barns shows that there is a considerable variation of EE per cow, where the lowest values were one fourth of the highest. Use of timber instead of concrete in walls had most effect to reduce the amount of EE. Cold barns can contribute to reduce the amount of EE, while the amount of EE is higher in free-stall than in tie-stall barns.

While for an existing building the amount of EE is nearly fixed, calculating the anticipated amount for a new building can help to reduce energy use in agriculture and thus contribute to a more sustainable production. Incorporating EE in planning new buildings should be of special importance for organic farming, since regulations demand more area per animal than in conventional farming. In addition to building new, renovation, extension as well as recycling of building materials should be considered. Planning new buildings should also include operational energy, as well as working conditions, animal welfare and economic considerations.

Background and objectives

In countries with cold winters, dairy cows are usually kept in stables in the period without plant growth, sometimes all-year long. There is a goal in organic farming to reduce inputs and to use energy efficiently (IFOAM 2006), and buildings should be included when the energy use of a farm is analysed. Energy for buildings in relation to the overall energy use on a dairy farm has been reported to be between 17 % (Dux et al. 2009) and 32% (Rossier and Gaillard 2004). Despite of both importance and uncertainty, farm buildings are seldom included (f. e. Yan et al. 2011) in articles found about energy use in dairy farming.

We describe how we estimated the EE of twenty dairy stables in Norway near the coast around 63° north. Ten farms are managed conventional and ten organic. Only two built a new barn after conversion, thus we do not differ between organic and conventional barns. The objective of this article was to estimate the amount of EE in existing dairy stables using a simple screening method and to compare the effect of a) different building materials, b) insolation, c) stable type (tie-stall or free-stall barn) and d) additional functions (storing place for silage, hey or machinery) per dairy cow.

Key results and discussion

In buildings older than 30 years, slurry is stored in the cellar. The tie-stall in the ground floor is insulated and in the top floor, hey was stored. Often parts of the building are used to place machines. In 20 to 30 years old buildings the silage tower or horizontal silo is inside the building, the top floor for hey is less usual. Most of the buildings were gradually extended to place more animals, to include silage storage or to adapt to claims for separate rooms for milk, workers and veterinarians. Since 2001, seven free-stall barns for cows were built, without silage-storage and garage-function. Only two out of the twenty stables were cold barns (walls in the barn not insulated).

On average, the amount of EE per cow and year were 2150 MJ. This amount is comparable to the findings of Dux et al. (2009). For our farms it varied from 1320 to 4300 MJ. Using of timber instead of concrete in the walls of the barn reduced the amount

[1] "Embedded energy, also known as embodied energy, is defined as the Energy that was used in the work of making a product." http://www.appropedia.org/Embedded_energy. Accessed: 14.05.2013

of EE. On average, the amount of EE in free-stall was higher than in tie-stall barns. Additional functions as silo and machinery in the building had on average no effect on the amount of EE. The two cold barns had less EE than the average of the insulated barns.

When the entire energy use in agriculture is analysed, often buildings and machinery are not mentioned at all or it is argued, that buildings on the included farms were similar for the different farm types (Thomassen et al. 2008) or had “a similar design on the farms studied” (Cederberg and Mattsson 2000). For the barns on the 20 farms in the project the results show, that the amount of EE in barns can vary considerable (Dux, Alig, & Herzog 2009). Therefore, to include this source in energy balances is important.

How work was carried out?

The results presented are from dairy farms in Norway near the coast around 63° north. The stables were built or extended between 1960 and 2011, the oldest parts in use were from 1930. During farm visits, building materials and main characteristics of the buildings (for example age, measures, building materials, and number of animal places) were noted. Where construction plans were not available, the ground plan was taken from a digital map. The buildings were photographed to find detailed measures. A simple construction plan was created and different surfaces were calculated. The precise approach of Dux et al (2009) was simplified. Since the stables differed in their appearance but little in the composition of different modules, we defined different types of such modules and the material used for one square meter floor, wall or roof. For example, walls of concrete, timber or timber with aluminum paneling, for some including insolation, were described. For all these modules we used the ecoinvent database to calculate the EE for a lifetime of 50 years, including production and use phase as well as disposal (Althaus et al. 2005). Finally, for each farm the EE for the stable was summed up. Nevertheless, the results are rather a rough estimate, for example no test drilling where conducted to determine the construction of walls in relation to different layers or the amount of reinforcement. Transportation of material from store to farm where not included being neutral to the location of the different farms.

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References

Althaus HJ, Kellenberger D, Doka G and Künniger T 2005. Manufacturing and Disposal of Building Materials and Inventorying Infrastructure in ecoinvent. Int J Life Cycle Ass, 10, (1) 35-42.

Cederberg C and Mattsson B 2000. Life cycle assessment of milk production - a comparison of conventional and organic farming. J Clean Prod, 8, (1) 49-60.

Dux D, Alig M and Herzog D 2009. Environmental impact of agricultural buildings. AgrarForschung 16[8], 284-289. Ettenhausen, ART.

IFOAM 2006, The Principles of Organic Agriculture, Bonn. Available at: http://www.ifoam.org/organic_facts/principles/pdfs/IFOAM_FS_Principles_forWebsite.pdf

Rossier D and Gaillard G 2004, Ökobilanzierung des Landwirtschaftsbetriebs - Methode und Anwendung in 50 Landwirtschaftsbetrieben, Forschungsanstalt für Agrarökologie und Landbau (FAL), Zürich, 53.

Thomassen MA, van Calker KJ, Smits MCJ, Iepema GL and de Boer IJM 2008. Life cycle assessment of conventional and organic milk production in the Netherlands. Agr Sys, 96, 95-107.

Yan MJ, Humphreys J and Holden NM 2011. An evaluation of life cycle assessment of European milk production. J Environ Manage, 92, (3) 372-379.