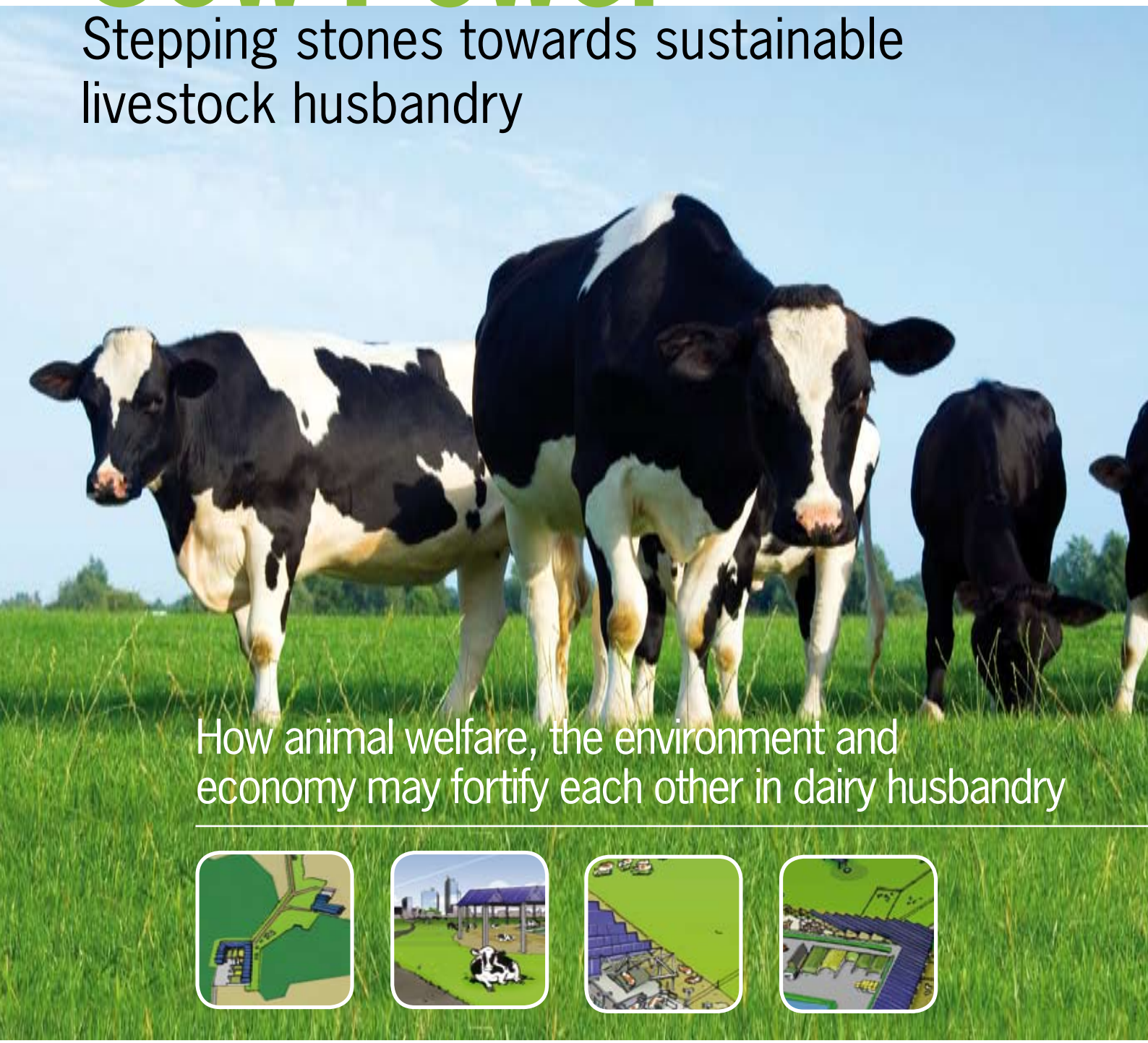
Designs for
System Innovation

Cow Power

Stepping stones towards sustainable livestock husbandry



How animal welfare, the environment and economy may fortify each other in dairy husbandry

WAGENINGEN UR
For quality of life

This brochure is one of the results of the Cow Power (Kracht van Koeien) project, realised by the Animal Sciences Group of Wageningen University and Research Centre (Wageningen UR) and commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality within the framework of the research programme titled 'Towards Sustainability in Production and Transition' (*Verduurzaming Productie en Transitie*) (BO-07-009-005).

Learn more about the project and subsequent activities at
www.krachtvankoeien.wur.nl

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Slightly edited version 1.1 23 March 2009

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Cow Power – Designs for system innovation. Wageningen – Lelystad, Wageningen UR,
ISBN 978-90-8585-486-9

Preface

Stepping stones towards sustainable livestock husbandry

Livestock farmers and others are increasingly moving towards sustainable livestock husbandry. A husbandry system uniting the needs of animal, environment, consumer and entrepreneur. If it was up to the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), sustainability is the future. The Minister of Agriculture has defined unambiguous ambitions: in 2023, livestock husbandry in the Netherlands will be 100% sustainable.

Realising sustainable livestock husbandry is a practical quest in the end. Many parties and initiatives are already aiming at sustainability in dairy husbandry. In interaction with livestock farmers, trade and industry, and policy makers, the Animal Sciences Group of Wageningen UR has produced designs for four completely new husbandry systems that will contribute to making Dutch dairy husbandry more sustainable by leaps and bounds.

We are convinced that a sustainable future requires a turnaround in thinking and acting: a system innovation. That is why the designs of Cow Power (in Dutch: Kracht van Koeien) leave the well-trodden path: they bring new promises and in some cases they are unorthodox. But they also clearly represent the wishes of the stakeholders: the farmer, the environment and the citizen as well as the cows.

The design concepts break with a number of generally accepted ideas, but that also means they hold great promise. A promise that can be fulfilled in the not too distant future. In this respect the designs must be seen as sources of inspiration, certainly not as blueprints.

And we shouldn't rely on just the farmers to realise that promise. It requires an effort from many different parties. After all, the social benefits are not only for the farmer or the animal either. Therefore, we hope you will consider them with an open mind and that you will use them to contribute to a sustainable development of Dutch dairy husbandry. At the end of this brochure you will find information on how to respond and how to take initiatives. We look forward to hearing from you.

Bram Bos
for the Cow Power (Kracht van Koeien) Project Team
Animal Sciences Group Wageningen UR (*March 2009*)

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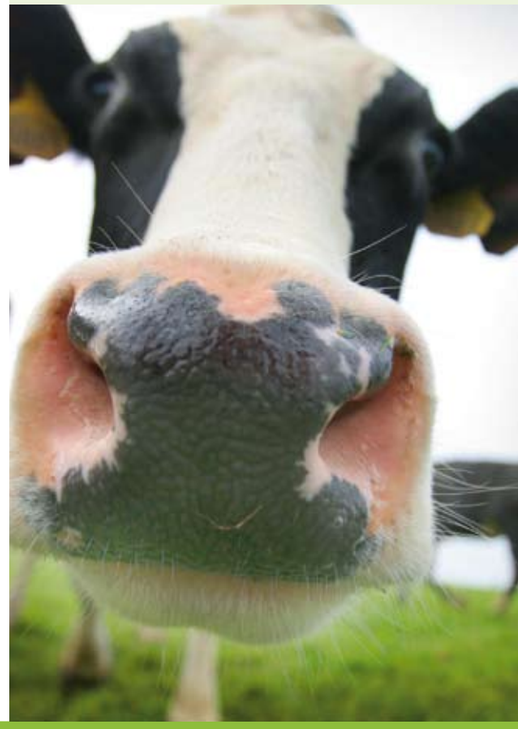


Cow Power in a nutshell

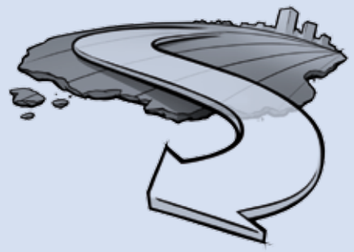
Dairy husbandry in the Netherlands could be much more sustainable than it is now. It seems difficult, but it is certainly feasible: dairy husbandry where cows have a good life, where the farmer makes a good living, a husbandry that cares for the environment and, on top of all that, caters for the wishes of the citizen. This ambition is the starting point in Cow Power as well as the objective of the designs. In this way we can ensure that it is not in the first place the milk, but dairy husbandry itself that can be kept for a long time.

Cow Power shows that a number of paradoxes and conflicts – such as between animal welfare and environment or between environment and economy – are not laws of nature. They are the consequence of the way dairy husbandry in the Netherlands has developed over the past decades. Parting with certain standards and 'accepted' operations will make it possible to overcome such paradoxes. That will not happen overnight. It requires a turnaround in thinking and acting. A system innovation.

"Dairy husbandry is an intricate system where farmer, animal, soil, crop, capital, energy, and nutrients are interconnected in many ways. Pulling one string will have consequences elsewhere - in unexpected places. This is why system innovation is necessary: a turnaround in thinking and acting. We have based Cow Power on the conviction that this way will allow animal welfare, environment and economy to go excellently hand in hand."

Peter Groot Koerkamp, co-projectleader Cow Power

But what is perfect dairy husbandry? First of all, we investigated what the ideal situation is for farmers, cows, citizens and the environment. These ideals seem at odds in many cases. Then we went on to trace the main bottlenecks in the current dairy husbandry system that obstruct reconciliation of these ideals. Removing these bottlenecks requires major turnarounds in thinking and acting. These turnarounds are not really new in themselves. Elements of them have been devised and tested here and there by pioneering dairy farmers, fellow researchers and other stakeholders in the sector. Combined, they are the starting points for the four design concepts for dairy husbandry systems.



Turnaround in thinking, turnaround in acting

A. Satisfy the cow's every need rather than giving her what happens to be left over

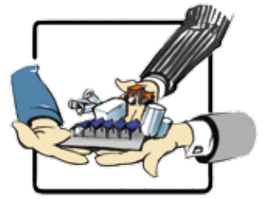
- Give the cow much more space, quietness, and exercise. Throughout the year.
- Take cow power as starting point, rather than the power of feed concentrates.
- Consider housing, outdoor range and pasture as one entity.

B. Consider minerals as a resource rather than waste

- Keep faeces (dry manure) and urine separate.
- Substitute artificial fertiliser and apply new fertilisers differently.
- Process faeces and urine sub flows and apply them with precision.
- Do not use feed concentrate from faraway countries.

C. Share capital and labour with others instead of dividing them over more cows

- Save labour and cost by sharing capital assets.
- Cooperate between farms.
- Combine energy production with cheap shelter for cows.
- Use land for multiple functions and share land ownership.



D. Consider the soil a productive ecosystem instead of a dead substrate

- Treat soil as a live organism.
- Minimise soil tillage, prevent compaction.
- Apply intensive and extensive (low-input) farming practices at the same time.
- Increase the soil production by precision fertilisation and irrigation.

Improvements

We have combined these turnarounds in thinking and acting in four design concepts for dairy husbandry, resulting in the following main improvements:

- For the animal: much better animal welfare, better health, more physical exercise, need-based feeding and, consequently, a longer life expectancy of up to an average of nine years.
- For the environment: a reduction of ammonia emissions by 75%, a reduction of greenhouse gas emissions by 50-75%, a reduction of eutrophication by 75%, the possibility of climate neutrality through green energy production, a smaller ecological footprint of fodder and feed concentrate production, and an increased biodiversity on the farm and in the surrounding area.
- For the farmer: labour savings through automation and a system that is easier to manage and requires less intervention. More flexible labour by sharing capital assets and an equal or better profit, also when producing regular milk.
- For the surroundings and society: socially desirable dairy husbandry that is visible and incorporated in other spatial and social functions, such as nature and urban development. Suitable in Natura 2000 areas. Verifiable good animal welfare which is visible and recognisable.

In this brochure we present four design concepts of sustainable dairy husbandry. Our main objective is to show that a much higher degree of sustainability in dairy husbandry is feasible. The designs are not technological panaceas nor are they blueprints. Some innovations require more development and testing and that takes time. Other innovations are not concerned with technology, but with different methods of operation and collaboration. The designs show how it could be done, not how it has to be done; different roads lead to sustainability.

We are aware of the fact that farmers come in all types and sizes. That is why we have made different designs that may be attractive to different entrepreneurs. Every dairy farmer can benefit from them, pick out elements and modify them to suit his own farm. But they are just as much a challenge to system designers and governments to examine their own role with different eyes. And last but not least, the designs will require room for entrepreneurs to make riskful investments in sustainable systems. Consequently, it is the duty of local, regional and national authorities to provide that room.

"What people will think of the design concepts? I guess that many will show scepticism, while others will be surprised by the possibilities. We hope the designs will the topic of conversation. I expect that ambitious and progressive farmers, consultants and parties of the agri- and food business will steal a glance at the designs and make a practical conversion to their own farm or work."

Bram Bos, co-project leader Cow Power

The Cow Power designs are not blueprints, but they do show that animal welfare, environment, and the economy can be congruent in dairy husbandry.

Substantial gains possible

Cow Power presents great promises. Within five years it can be possible to considerably increase animal welfare, reduce environmental load, and still maintain profitable operations at a dairy farm. However, it is vital that we do not stubbornly stick to our old ways and that we are prepared to consider things we once thought impossible. Our designs demand flexible thinking on the part of farmers, consultants, policy makers, researchers and citizens, and the willingness to develop and enrich them on the basis of their own needs.

Sustainability is the future

A Dutch landscape without cows is inconceivable. For tourists, and certainly for the Dutch themselves. We have been keeping cows in the Netherlands for thousands of years. We have grown together. Over the past decades, improved breeds, new technology and strong dairy cooperatives have made it possible for the Dutch dairy branch to develop into a leading global exporter of milk, milk powder, cheese and butter. But will it stay that way? Cow Power shows that integrated, sustainable dairy husbandry has a future in the Netherlands.

Dutch dairy farmers are facing exciting times. Land and labour are relatively expensive, while prices are increasingly being liberalised and EU product subsidies are being phased out. Substantial increases of scale seem unavoidable, though many wonder whether such strong growth is actually cost-effective. At the same time, the environment and animal welfare are a growing focus of attention. All these issues will not solve themselves. The dairy branch fears that autonomous developments will increasingly force dairy husbandry towards factory (intensive) farming. Preventing this will require system innovation, a turnaround in thinking and acting.

To many people, a Dutch landscape without cows is inconceivable.

Dutch dairy husbandry

Let us start with the figures. In 2007 there were 21,313 farms in the Netherlands with a total of about 1.4 million dairy cows. The total milk production amounted to 10,800 million kilos of milk; the average milk yield per cow was 7,879 kilos per year. Forty percent of the farms had 70 dairy cows or more. Out of the total farmland area in the Netherlands (1.9 million hectares), some 1.0 million hectares were in use as grassland (53%). In addition, 221,000 hectares were used for green maize (12% of the total).

Only a relatively limited share, that is some 10%, of the milk produced is consumed as fresh milk and dairy products. The rest is processed into cheese, butter, condensed milk, and milk powder. It takes 10 litres of milk to make one kilo of cheese and as much as 25 litres to make one kilo of butter. More than 80% of these processed products are exported. In addition, all specific types of proteins, sugars and fats from the milk are used for special applications. For that purpose the milk is 'cracked'.

	Production (*million kg)	Export total (* million kg)
For fresh consumption		
Cream	**11.9**	
Milk and milk products	**1445.1**	
Whole milk and cream		**406.7**
Milk processing products		
Cheese	**714.0**	**562.6**
Butter	**125.2**	**112.5**
Butter oil		**41.5**
Condensed milk	**308.9**	**274.1**
Non-skimmed milk powder	**105.6**	**138.2**
Skimmed milk powder	**48.9**	**42.9**
Whey powder	**264.0**	

Source: PZ/CBS. The total number of kilos in this table is lower than the 10,800 million kilos of milk that are produced, because 1 kilo of cheese or butter requires many more kilos of milk.

Economic pressure increases

To many dairy farmers, 2015 will be a magic year. That is the year the EU milk quota regulation will be repealed. This means there will no longer be a fixed maximum of milk production per farm. Since the EU agricultural product subsidies will be phased out at the same time, many dairy farmers feel forced to increase their farm size substantially. It seems the only way to keep the family income up to the mark. For a large group of farmers this will mean more credits and even harder work, in a market of fluctuating milk prices. On top of that, the cost price of a litre of milk is already higher than the revenues – apart from exceptions such as in 2007. Dairy farmers compensate the difference with a lot of unpaid labour. After all, to many of them dairy farming is not just for profit - it is their way of life.

Given the current growth of scale in dairy husbandry, this situation can not be maintained forever. Eventually, farmers will have to start hiring people to do the extra work, and they will have to pay those employees. Furthermore, there is a limit to mortgaging the land to finance additional investments. As a result, dairy husbandry will increasingly be cost-price driven, at least as long as this milk will have to compete on the world market as high-grade, but anonymous raw material.

To many dairy farmers, 2015 will be a magic year. That is the year the EU milk quota regulation will be repealed. Since the EU agricultural product subsidies will be phased out at the same time, many dairy farmers feel forced to increase their farm size substantially.

Environment and animal welfare

There is a lot of economic pressure on dairy farming these days and therefore attention for other sustainability aspects such as animal welfare and the environment will not come naturally. 'Let's first scrape a living, then we can start worrying about the frills', is what many think. Fortunately, many other dairy farmers realise that this is not the way forward. The milk quotas may be repealed, but in their place environment and animal welfare will increasingly be preconditions for growth and development. So you better make sure you are prepared.

And that is what happens throughout the Netherlands. There are numerous networks of farmers and consultants who are experimenting with pasturing (for instance PureGraze, Koe & Wij), animal health (Vetvice), minerals (Koeien & Kansen, Vel & Vanla), space for cows (foil arch dairy housing (serrestal), loose housing (vrijloopstal)), cooperation (Ecolana), agrobiodiversity (numerous agricultural nature conservation associations), labour efficiency (EDF), and mutual learning (Melkvee Academie). So a lot is already happening in specific areas.

We think it takes more to achieve integrated sustainable dairy husbandry. Why? First of all, because a specific solution to one problem in dairy husbandry will often and easily have unwanted consequences for a different aspect. Secondly, because the responsibility for sustainable dairy husbandry will usually end up on the dairy farmers' plates. At the same time parties such as consultants, dairy cooperatives, banks and governments have a major influence, both directly and indirectly, on the opportunities and scope for dairy farmers to improve their operations. And thirdly, because the effects of improvements on specific aspects may easily evaporate under the pressure of 'autonomous' developments such as continuing increases of scale and increased production per cow.

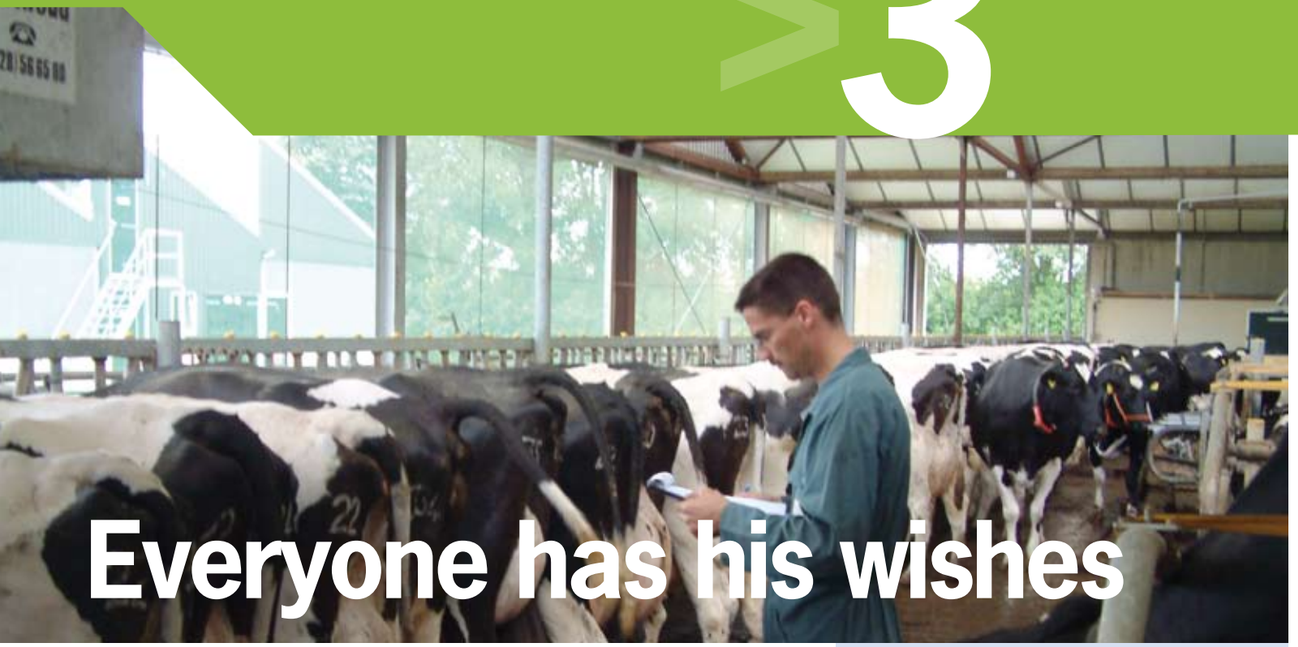
In our opinion dairy husbandry in the Netherlands has a legitimate and sustainable future as global food supplier.

Sustainable base: The power of cows

Definitions of sustainability are innumerable. Usually it is no problem to agree on the general idea: that eventually our welfare should not harm others – people elsewhere on the planet, animals, the environment and nature, at the present or in the long term. However, as soon as we talk about sustainability in more concrete terms, it is harder to give an agreed and practical definition of sustainability. People may fundamentally dissent on livestock husbandry regarding the question whether using and killing animals can be sustainable in the first place. In this brochure we assume animal production can basically be sustainable, even if we keep animals locked up and eventually even kill them. This is a value-based starting point, not a scientific argument. A starting point however, that links up with the vision of our client, the Minister of Agriculture of The Netherlands. In 2008, in her 'Toekomstvisie Duurzame Veehouderij' (her future vision on sustainable animal husbandry) she portrayed the ideal of an 'in all aspects sustainable husbandry, with broad public support'.

In addition, it is our opinion that dairy husbandry in the Netherlands can have a legitimate and sustainable future as food supplier. The power and capacity of cows lies in their skill to convert low-grade vegetable products such as grass and residual flows into high-grade foodstuffs. Those low-grade products and residual flows are amply available in the Netherlands and much farmland is not even suitable for anything but grass production. Moreover, we have a favourable climate for animals and sufficient freshwater. In addition, the development towards a bio-based economy means that new classes of residual flows become available. Dairy farming and livestock husbandry in general can play an important role in a cascaded conversion of these residual flows into valuable resources.

In short: dairy husbandry which is primarily based on what is locally available has a perfect place in this region. It does mean a shift in the purpose of dairy husbandry: from just milk production to putting to value regionally available low-grade vegetable products and residual flows. This also sets a maximum on the volume of dairy husbandry in the Netherlands. With the entire package of changes that we propose here, we think that the volume will mainly be limited by the regional availability of residual flows. If – as expected – this availability increases, further growth of dairy husbandry in the Netherlands can be compatible with integrated sustainability of that branch. Yet it will be a completely different type of dairy husbandry.



Everyone has his wishes

Sustainability means preventing that the costs and side effects of our prosperity are passed to others, Herman Wijffels, a reknown Dutch banker and visionary, stated. In order to make a design that shifts as little 'expense' onto others, we must first find out what those involved want. In this case at least: the farmers, the citizens, the environment and of course: the cows.

If it were up to the cow

If it were up to the cow, she would have space. Cows are happy when they are healthy, when they can choose between being indoors or outdoors, when they have a place to rest and can display social behaviour within their own familiar herd. This is what the brief of requirements of the dairy cow, the BoR Dairy Cow, shows. But what does this mean in practice? The Cowel model that we developed shows the relative importance of different environment characteristics for a good life of the cow.

Animal welfare and health are important. Not only for the animals themselves, but also for the dairy farmers. If the cow's needs are not fulfilled, this may lead to abnormal behaviour, weakness, pain, stress, illness or even death. In addition to the ethical objections this raises, it also costs money. Cows in the Netherlands do not live as long as we would like and this has economic consequences. They are replaced at a relatively young age because of claw disorders, mastitis and, due to the focus on production and lack of space, problems with conception. And the latter is still what starts lactation. Of course we can try to adapt cows to their environment through breeding. But why not look at it from another angle: what adaptations does the cow ask from her surroundings for maximum welfare and good health?

Focus on the cow's requirements

We assume a maximum welfare and good health for the cow is guaranteed if all her needs are met. Therefore, she should be able to perform all activities and behaviour necessary to fulfil those needs, without limitations. We have laid this down in a list of requirements the cow imposes upon her surroundings: the brief of requirements (BoR) of the dairy cow. These requirements have been classified per need and they have been worded 'solution-free'. This means the way a requirement is met in practice is open for various solutions.

BoR Dairy Cow: depicts the cow's requirements to satisfy all her needs. It is based on some five hundred, mainly scientific, articles and on experiences of experts in welfare and behaviour.

Cowel: indicates what impact an environment characteristic has on the dairy cow's welfare if this characteristic does not comply with the ideal.

You can find more information on both studies at **www.krachtvankoeien.wur.nl**

The relative importance of requirements: Cowel

The Cowel model was developed by the Animal Sciences Group in order to gain insight into the extent to which the various characteristics of a husbandry system are important to the cow. It indicates the impact an environment characteristic has on the dairy cow's welfare if this characteristic does not comply with the ideal. At the same time the model provides an insight into which characteristics of a husbandry system are most important to animal welfare and which ones are less important.

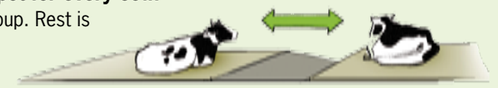
The BoR Dairy Cow shows that the cow prefers to have at least 360 m^2 of space to move around. Then cows are not in each other's way, they can move away if they want to and they do not show aggressive behaviour among themselves. Of course that space is considerably more than the area of 6 to 8 m^2 the average cow now has in current housing systems.

Cowel makes it easier for us to estimate the relative importance of this aspect: the gains in welfare from doubling the cow's space to at least 13.5 m^2 is considerably greater than the gains in welfare we make with the step from 13.5 to 360 m^2. Despite this fact, we have based three out of the four design concepts on the ideal. Yet dairy farmers who double the space to 13.5 m^2 are already realising a considerable welfare improvement.

What does the cow want?

Not all environment characteristics are equally important to the cow. Some have a much greater impact on the cow's welfare than others. Below we will discuss in more detail the nine characteristics of a husbandry system with the greatest effect on the dairy cow's welfare, according to Cowel. Cutting back on these characteristics has a major impact on the cow's welfare.

At least one spacious resting spot for every cow.
Cows like to rest together as a group. Rest is a necessity of life for the cow.



Good feed.
The feed must enable the cow to maintain homeostasis and to produce milk. It must contain sufficient energy, dry matter, crude fibre, protein and trace elements. Cows are selective when it comes to food: it must be tasty, varied and fresh, and not contaminated with manure or saliva.

No negative stimuli such as leakage of current and cow trainers.
Negative stimuli will cause (chronic) stress. This has an adverse influence on welfare and health.

Complete freedom of choice to move within the area and within the herd.
A cow wants to make up her own mind. Cows want to be able to get out of the way of higher ranked animals and in large herds they like to split up into smaller groups. Sometimes a cow wants to get away from the group. Yet, she still wants to be able to see and hear the rest of the herd.

Calm and predictable handling by the people, so she can move at her own pace.
A cow likes an orderly life and she prefers to know what to expect. Driving and other unfriendly treatments will cause stress.

No impact of obstacles during rising up, lying down and during lying and resting. Possibility to lie down at a distance of at least two metres from another cow. A cow must be able to lie down in the way she would in the pasture. She wants to be able to opt for her own personal space, but cows may still like to lie close together.

A comfortable climate (Temperature Humidity Index below 71).
To avoid stress from heat or cold.

Passage ways and feeding areas with a nonslip, dry and clean floor without sudden changes in the level or texture.
If the floor is too smooth, the cow may slip, if too rough, she may damage her claws. Uneven, wet or dirty floors are detrimental to the cow's locomotor system.

Sufficient light during the day (more than 200 Lux). A cow must be able to see her surroundings properly, so she can recognise her herd fellows, explore her surroundings or play with her companions. In addition, light is important for fertility, which in turn is in the farmer's interest.

Cows in pasture

Pasturing can easily be incorporated in the Cow Power design concepts. People very much like to see cows out in the pastures, and pasturing is an excellent solution for many requirements a cow makes upon her environment with regard to health and welfare. Yet we have not included pasturing as a firm requirement in the BoR of the cow.

Why not? Pasturing in fact combines several functions, such as being outdoors, exercising and grazing.

Being outdoors and exercising can be solved in various ways. But for grazing – pulling off and taking up grass in the mouth – pasture land is a prerequisite. Although there is discussion and uncertainty among scientists whether this is one of the cow's needs, we nevertheless decided to include pasturing in our designs as a precautionary measure. With current pasturing methods, this has consequences for the environment (nitrate), economy (reduced grass yield) and labour (collecting cows every day).

The green outdoor range of 360 m² per animal available to the cows throughout the year in three of the four designs is necessary for maximum welfare. The green outdoor range is a major increase in living space, but it is not intended as an alternative to grazing in summer and certainly not sufficient for the production of feed.

If it were up to the farmer

There is no such thing as the dairy farmer. Farmers come in all types and sizes. Cow Power wants to call upon entrepreneurs who look beyond just economy. Entrepreneurs who also want to do justice to the values of the animal, the environment, the landscape and the citizen in their operations. 'Kreas buorkje' is what they call it in Frisian, in other words 'farming neatly'. The designs provide for five needs that we recognise among 'our' farmers.

In Cow Power we specifically address two groups of dairy farmers: social farmers and new growers. Those are farmers who want to develop in their own way and want to seize the opportunities presented by social desires and trends, including the attention for animal welfare and for the environment.

Two target groups

Social farmers are interested in developing their farm by adding new activities and creating economic and social links with their surroundings, such as nature and landscape management, organic agriculture etc. Growth in farm size is not their first priority, but growth in quality is. They have a positive view of the future and as entrepreneurs they have every confidence that their branch will be able to maintain a solid position in the Netherlands.

New growers keep striving after the largest possible top farm in an unorthodox business structure and have interest in innovations. They are creative, persevering people who like to take initiative and who show leadership. In many cases they are young people with relatively large farms. They have confidence in the future.

What do these progressive farmers want?

Growth and development

The design concept offers possibilities for developing the farm, while growth is accompanied by and based on reinforcement of the relations with the social setting.

Social orientation

The design considers that social desires and developments are an opportunity to create economic and social values. Functional relations and all types of cooperation with the surroundings are utilised to the full.

Labour

The design must guarantee work satisfaction and some variation. Interaction with cows contributes considerably to work satisfaction. Automation must not stand in the way of interaction with cows and the work must be sufficiently flexible to allow a flourishing social life.

Operational continuity

The business must be sufficiently profitable to let at least one family make a living. The business must, possibly temporarily, be able to provide for more than one family in the event of a takeover. Hiring labour is another option, just like diversifying and entering into steady relations with the surroundings.

Pasturing

The design allows pasturing without causing conflict with other needs, such as labour, or limiting conditions such as the ratio between home plot area and herd size.

If it were up to the citizen

Dutch citizens increasingly care about animal husbandry. Positive interest is growing, and so is criticism - in particular with regard to the position of animals in livestock husbandry. The fact that this does not always lead directly to a change in buying behaviour in the supermarket, is connected with things such as the lack of choice and trust, and the relative scarcity of products that combine personal and social advantages. On the basis of nearly a hundred interviews we investigated the image of Dutch citizens towards livestock husbandry, in order to find out what the brief of requirements of the citizens is. Then, when we know what the ideal of citizens is, we want to approach this ideal as much as possible in our design concepts.

Just like the farmer, the citizen does not exist either. Yet a meaningful classification of citizens can be made. A division in three classes emerged from our study: the romantics (50%), the pragmatists (35%) and the ethicists (15%). The pragmatists do not worry too much: after all, we keep animals for our own ends. The ethicists, on the other hand, do not take that for granted: using animals is an important ethical choice. The largest group, the romantics, are convinced that their interest is fully in line with that of the animal. 'A good life for the animal is good food for me.'

Compromise or ideal production method

Economic pressure is the main explanation for below-standard animal welfare according to those interviewed. Pursuit of short-term profit, particularly in the food industry, victimises the animals, nature and the environment, and in many cases also the farmers themselves. Things will get better, they think. Livestock husbandry is gradually developing in the desired direction, and will eventually arrive at a compromise between economic production and respect for nature and animals. Not quite the ideal, but an estimate of what people consider practically feasible.

It is striking that dairy husbandry scores a only little higher than intensive farming. Without prior knowledge, citizens have the impression that cows are hardly better off than chickens or pigs. On the other hand, cows in the pastures represent exactly what is considered ideal. Citizens do not want animals to be locked up, but to roam freely and live their lives outdoors in natural circumstances.

In the design concepts we want to link up with the image of the romantics as far as possible. If those designs can do that without major economic repercussions, the pragmatists will be content too. The ethicists will at least consider it a desirable development.

What does the citizen want?

The eleven most important positive characteristics of ideal husbandry in the citizen's eyes are listed below. However, the three different groups of citizens (romantics, pragmatists and ethicists) have different emphasis.

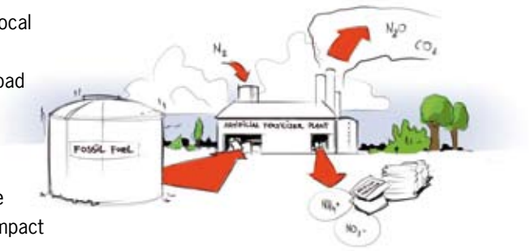
1. Let animals roam freely
2. Treat animals as brothers and sisters
3. Take good care of animals
4. Natural and fresh animal feed
5. A higher price for better animal welfare, if necessary
6. Let animals live in natural surroundings
7. A tasty and fresh product (for people)
8. Fair and sustainable production methods
9. Professional freedom to operate for farmers
10. Reasonable margins for farmers
11. Rules for quality assurance

If it were up to the environment

Dairy husbandry places a considerable burden on the environment: locally by eutrophication and acidification, and globally by greenhouse gas emissions, indirect use of energy for artificial fertiliser and feed concentrate, and use of natural resources from elsewhere. Keeping the sector viable in the future requires drastic steps. Much more drastic than current legislation requires. In our brief of requirements for the environment we deliberately set our aims high because that forces us to consider different solutions. When we do so, much more appears possible than we thought.

Energy and manure

We distinguish nine types of environmental impact: land use, energy use, eutrophication, acidification, greenhouse effect, soil quality, water consumption, local surroundings, and biodiversity. After defining sources and types of environmental impact, a life-cycle analysis (LCA) gives a good impression of the environmental load caused by Dutch dairy husbandry.



The life-cycle analysis of dairy husbandry

The table below shows the results of a life-cycle analysis of dairy husbandry in the Netherlands. The contribution caused by dairy husbandry for five environmental impact categories and four links in the chain is displayed. In this analysis the chain refers to the series of production steps – including production and transport of supplied products – up to the point that the milk is collected at the farm.

	Land use	Energy use	Eutrophication	Acidification	Greenhouse gases
Total → divided over ↓	**1,2 m^2/kg milk**	**5,1 MJ/kg milk**	**0,15 kg NO_3-eq/ kg milk**	**11,2 g SO_2-eq/ kg milk**	**1,3 kg CO_2-eq/ kg milk**
% supplied concentrate	**24**	**58**	**17**	**26**	**26**
% supplied roughage + wet by-products	**12**	**9**	**12**	**4**	**8**
% supplied artificial fertiliser	**0**	**12**	**1**	**3**	**6**
% farm: land, housing, animals	**60**	**18**	**70**	**65**	**59**

Table: LCA of dairy husbandry in the Netherlands, based on 119 regular dairy farms (Source: Thomassen 2008)

It is striking that the supply of products causes a substantial share of the environmental impact. Energy use is particularly important in this respect. The main environmental impact on a dairy farm itself is eutrophication through nitrate leaching, acidification through ammonia emissions, and the contribution to the greenhouse effect through emissions of methane and nitrous oxide. For that reason we have defined specific targets which are higher than the legal minimum with regard to energy use, eutrophication, acidification and greenhouse effect. For the other types of environmental impact, qualitative requirements have been defined or they are in accordance with legal requirements.

What do we want for the environment?

Good land use

We use land to grow grass and food crops. Dairy husbandry uses more than 50% of the farmland in the Netherlands, which makes it the largest land user. Cultivation of cereals, soy and palm kernels for the production of feed concentrate takes up land, not just here, but also in other countries.

Reduced energy use

We mainly generate energy from mineral oil. The European Union wants at least 20% of the energy to come from renewable energy sources by 2020. The national action programme called Schoon en Zuinig (translates to “clean and economical”) responds to this by striving after an increase of the share of sustainable energy from 2% in 2007 to 20% in 2020. In addition, it has been decided that national energy savings must be doubled from 1% to 2% per year. The Cow Power project presents design concepts which give 75% savings on energy use, mainly by reducing the use that is linked to the supplied products such as artificial fertiliser and concentrates. On top of that we want to take maximum advantage of the possibilities of generating sustainable energy (sun, wind and bio-digestion without the use of valuable co-products, i.e. no co-digestion).

Reduced eutrophication

Nitrate and phosphate from livestock husbandry cause a major share of the eutrophication of surface water and groundwater. At European level there are guidelines for the permissible quantity of nitrate in groundwater (50 mg of nitrate per litre) and measures have been defined for the use of fertilisers containing nitrogen and phosphate. In the designs we reduce eutrophication by 75% by minimising losses on the use of fertilisers.

Reduced acidification

Livestock husbandry is responsible for some 90% of the Dutch ammonia emissions. National emission ceilings (NEC) have been defined for 2010 for every EU member; for the Netherlands that is 128 kilotons of ammonia. The Netherlands will be able to meet that target through measures in intensive farming, in particular. A relatively modest requirement of 9.5 kg per housed animal per year has been imposed upon dairy husbandry. In addition, special application techniques to reduce emissions are required: injection, shallow injection on grassland and direct incorporation on arable land. However, the EU ceilings are far from adequate for the problems in the areas that are sensitive to acidification, such as the Natura 2000 areas. For that reason, the designs aim at a 75% reduction of the ammonia emissions by reducing emissions from barns and from the application of manure.

Reduced greenhouse effect

The ambition in the Netherlands is to reduce the emission of greenhouse gases by 30% in 2020 compared to 1990. However, as yet no legal requirements exist for arable farming and livestock production to reduce the emission of carbon dioxide or the other greenhouse gases, methane and nitrous oxide. The design concepts result in a reduction of the methane production by 50% and of the nitrous oxide production by 75%. This is the result of different storage and use of faeces and urine and reduced use of artificial fertiliser and feed concentrate.

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Improved soil quality

Dairy farms have to observe a directive that protects the soil quality when they store and handle agricultural products and feed, animal waste and offal, fertilisers and green municipal waste. The organic matter content and other heavy metal concentrations are primarily important for the soil quality of grassland and arable land. Organic matter improves the structure and workability of the top soil, increases aeration and water drainage, which stimulates soil life. So soil quality is in the farmers’ interest as well. In the designs, a very diverse soil life is part of the system and the organic matter content in the soil will increase.

Improved water use

A dairy farm may use water from different sources such as tap water, ditch water, spring water and rainwater. The main uses include drinking water for cows, water for cleaning and for growing crops. The major share of the total water use comes from rainwater, which evaporates from plants and soil or is carried off through the soil. In the designs we store water from the urine flow, and we make better use of water through irrigation, as a result of which the yield per hectare will increase.

Improved air quality surroundings

Air quality increasingly becomes an important factor in assessing and granting licences. For farms this mainly concerns the emission of fine dust and the limitation or prevention of odour nuisance. Major sources of dust particles on dairy farms include manure, straw and bedding, dry feed, flakes of skin from animals and soil particles blown away on tillage. The European and Dutch standards for permissible fine dust concentrations in living environments will become stricter in the coming years. As far as odour nuisance is concerned, a minimum distance of 50 meters between barns and houses applies outside residential areas and of 100 metres inside residential areas. Rapid discharge of faeces and urine flows will reduce these sources of fine dust and odour.

Richer biodiversity

Biodiversity refers to the diversity of flora and fauna in a certain area. Because dairy husbandry uses an enormous area of land, it has a major impact on the numbers of species in flora and fauna on arable land, ditch banks and water flows. In addition, biodiversity elsewhere in the world is reduced due to land used for feed concentrate production. Through all kinds of direct and indirect effects, biodiversity is reduced as production intensifies. In the designs, the negative effect on biodiversity in the surroundings of dairy farms is lessened considerably as a result of a major reduction of eutrophication and acidification, and through improving the soil quality.

Ammonia emissions from husbandry cause eutrophication of nature areas, causing a reduction in biodiversity. Dairy husbandry is responsible for half of this. Ammonia is a major problem for dairy farmers close to Natura 2000 areas, because they have no more possibilities for growth.

Think differently, act differently

Farmers, citizens, cows and the environment: they may all have their own wishes, but are these compatible? Isn't sustainability just as much a permanent struggle to get the best part of the cake? 'Of course there are limits', according to Peter Groot Koerkamp and Bram Bos, project leaders of Cow Power. 'You can't have the best of both worlds all the time, but often you can have much more than you think. However, that does require the courage to let go of our trusted standard ways of thinking and acting.'

Currently a quest for sustainability is taking place in many different fields. 'Many unsustainable effects of our current ways of producing and consuming can be avoided', Peter Groot Koerkamp says. 'They can be solved without any loss of prosperity or quality of life for ourselves and others.' In some cases that is easy, without changing behaviour: 'A LED lamp, for instance, produces the same quantity of light at a fraction of the energy that a regular incandescent lamp requires.'

Deeply rooted

But more often the non-sustainability is rooted more deeply in our systems. Groot Koerkamp: 'Sure we can make a clean car running on hydrogen, but the entire infrastructure around it is geared to petrol engines. Consequently, we usually just keep trudging along on the familiar road, with gradual modifications to our present cars to make them less polluting. The result is not particularly earth-shattering.'

'In dairy husbandry it is often exactly the same', Bram Bos continues. 'It is easier to install an energy-gobbling air scrubber in an existing livestock house than to design new accommodation in such a manner that we take away the source of the pollution. The same applies to housing animals close together to save costs and to keep track of them rather than giving them the space for their specific animal behaviour, letting go and being uncertain about the effect on your income.'

'In many cases non-sustainability is deeply rooted in our systems. It is easier to install an energy-gobbling air scrubber in existing barns than to design new housing systems in such a manner that we take away the source of the pollution.'

There is a different way

Bos and Groot Koerkamp are convinced: there really is a different way. Of course they know the objections many people will come up with. Dairy husbandry is a delicate system in which farmer, cow, soil, crop, capital, energy, and nutrients are intricately interconnected. Pulling one string has consequences elsewhere - in unexpected places. Making dairy husbandry more sustainable gets stuck on all kinds of contradictions that seem incongruent.

Bos names a number of these paradoxes. 'More space for cows costs money and increases the cost price. It also causes high emissions of ammonia. Concentrates must be fed efficiently and sparingly in order to reduce the environmental impact, while the use of slurry is inherently connected with uncontrollable losses to the environment. Keeping more cows on a farm often seems the only way to keep the family income up to the mark.'

These contradictions are almost unavoidable with existing methods, the researchers acknowledge. 'It is true that every square metre of slatted floor or slurry pit costs money', says Groot Koerkamp . 'And it is just as true that you can better avoid spreading out slurry over a large area because of the emissions. Concentrates are ecologically sound - as long as you ignore the environmental impact of production, transport and processing. Indeed, increasing the number of cows is the only way to make enough money if you are focussed on doing more of the same all the time.'

Different context

There are many contradictions in the current practice. 'But', Bos and Groot Koerkamp emphasise, 'these contradictions apply within a certain context, in a situation where everything else remains the same. In order to step out of this context and to mitigate or even overcome the contradictions, we must think differently and act differently.'

We will not be able to make substantial improvements if we continue as usual. 'We think it is necessary as well as worthwhile not to take the easy road', Bos says. 'If we want to combine the needs of the cow and the farmer with the requirements of the citizen and the environment, we will only succeed if we have the courage to let go of our ingrained patterns of thinking and acting. Only then will it be conceivable that we do not have to balance the interest of animals against that of the environment or the economy.'

'Cow Power contains proposals for thinking differently and acting differently', Groot Koerkamp says. 'They are the foundations of the designs for sustainable dairy husbandry. Note: none of those proposals is specifically our idea. All kinds of researchers, farmers and other people in the field have been studying various elements for years. We combine their ideas coherently to show that together they can mean a sustainability leap in multiple respects.'

'If we want to combine the needs of the cow and the farmer with the requirements of the citizen and the environment, we will only succeed if we have the courage to let go of our ingrained patterns of thinking and acting.'

THINKING: four turnarounds

The design concepts of Cow Power are based on four turnarounds in thinking:

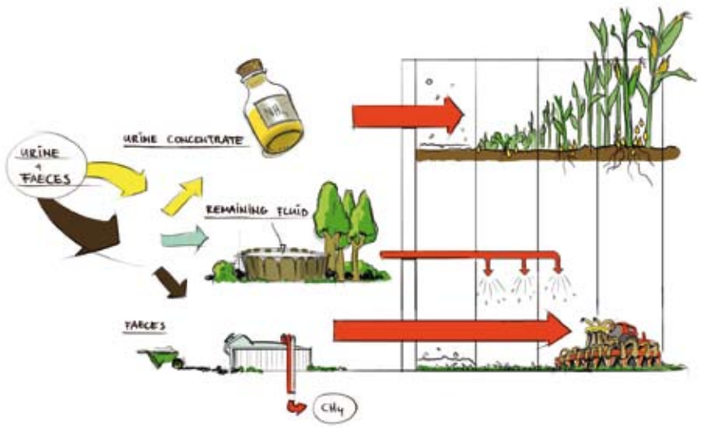
1. Cow Meet all the cow's needs rather than giving her what is economically feasible or conceivable.	**2. Nutrients cycle** Consider minerals in faeces and urine as a resource instead of waste.
3. Capital and labour Share capital and labour with others rather than dividing them over more cows.	**4. Soil** Consider the soil a productive ecosystem instead of a dead substrate.

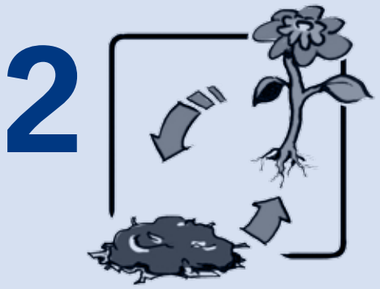
Turnaround in thinking 1: the cow

Really meeting the cow's needs not only improves her welfare. There are positive effects that simultaneously contribute to economic objectives: reduced physical and social stress, natural hierarchy in the herd, improved health through improved adaptation and improved performance of the immune system as well as a lower infection pressure. Healthy cows live longer, require less care and therefore less labour, and even the feed efficiency increases when the animal does not have to use energy to combat disease and stress.

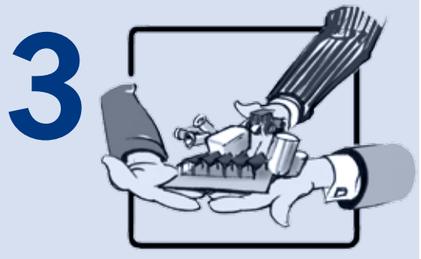
Turnaround in thinking 2: nutrients cycle

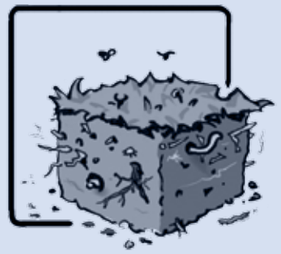
The environmental load of dairy husbandry is caused by losses of nutrients and gases to soil, water and air, mainly involving nitrogen, phosphate and carbon compounds. We are used to reducing these losses by increasing the efficiency of parts of the system, for instance the soil or the cow. This strategy does work, but has its limits. It may also cause unwanted side effects, to the cow's health, for instance. Therefore, it would be better if we looked at the effectiveness of the entire system and ensure that sub flows are preserved in a useful manner. That is what we call Cradle to Cradle. In doing so, we should not focus solely on the nutrients cycle on the dairy farm. Cycles at a higher scale, such as at regional or national level, are just as important. These include, for instance, the useful application of nutrients in vegetable cultivation.





It is better if faeces (dry manure) and urine are kept separate. That is good for the cow, the environment and the farmer.





No more ploughing is a lot like quitting smoking. Problematic, but much better in the end.

Cradle to cradle

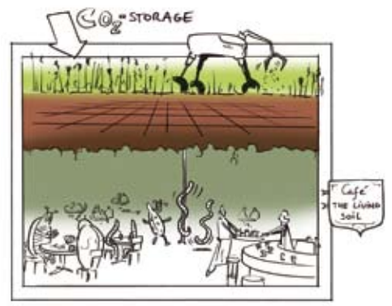
Cradle to cradle (C2C) is a new approach to sustainable design. After their life in one product, all materials must be put to use in a different product. Without loss of quality. Residual products must also be reused or at least be environment-neutral. The ideas have been developed in a book by William McDonough and Michael Braungart: *Cradle-to-Cradle: Remaking the Way We Make Things*.

Turnaround in thinking 3: capital and labour

Labour and capital assets such as land, buildings and machines are a major cost item in the total production costs of milk. Currently, the main strategy to reduce those costs is to increase the scale per farm, dividing the fixed costs over more cows. However, increases of scale are not always possible for reasons of finance or space. Moreover, in many cases the scope of the benefits remains limited and side effects occur, such as a further decrease in income per hour and longer periods that the cows are kept inside. For that reason it would be better to keep down costs through fundamental measures such as reducing investments in livestock housing, using machines such as a milking parlour together with other dairy farmers and substantially increasing the crop yield of the land. We can also automate simple labour and drastically reduce the time required for cow management by improving the cow's health and welfare, supported by automated sensor systems. That requires new cooperation frameworks, both mutually between dairy farmers and between farmers and other parties. In addition, financial support for this turnaround can be found in new functions, such as local energy production, that operate in synergy with the primary production process, and by combining functions, for instance by shared land use.

Turnaround in thinking 4: soil

The soil is a complex ecosystem in itself. A living, good quality soil is good for productivity and structure and improves the storage and use of nutrients. Such an ecosystem cannot, or cannot easily, be managed. It can also easily be destroyed if we consider the soil mainly to be dead matter, a place where you can get rid of minerals and where you have to work as quickly as possible with large machines.
The alternative is much trickier, but in the end the yield is greater: by striving after positive qualities of manure for the soil, maintaining the natural balance and applying fertilisers specifically and customised as to time and place, we utilise the productive capacity of the soil.



ACTING: four turnarounds

The four turnarounds in thinking require concrete changes to realise a type of dairy husbandry that is sustainable in every respect. But we do not know and cannot do everything yet. The development of knowledge and technology and their coherent application in a dairy husbandry system requires time and effort from various parties. But still, the course for sustainable dairy husbandry is clear.

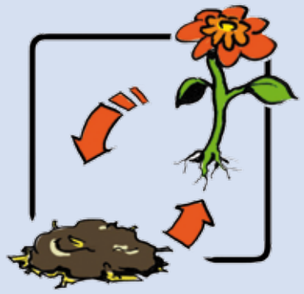
1. Cow
- create space for the cow throughout the year
- offer resting facilities
- give freedom of choice
- offer suitable floors
- offer exercise possibilities
- avoid interventions and stressful treatments
- provide sufficient and varied feed

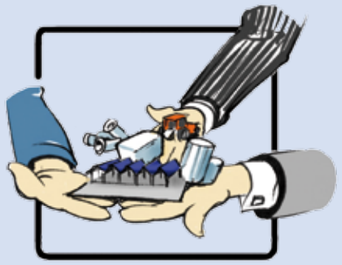
2. Nutrients cycle
- utilise available plant and residual products
- offer feed supplements but no feed concentrate
- keep faeces and urine separate
- process and fully utilise sub flows of 'manure' (C2C)
- make artificial fertilisers superfluous
- keep and accumulate organic matter in the soil

3. Capital and labour
- offer space for the cow without expensive housing
- share capital assets
- cooperate between farms
- put cheap by products to value
- increase yield of grassland and arable land
- generate energy with solar cell roofs
- increase labour quality and value
- put new functions to value

4. Soil
- utilise organic matter from manure
- apply intensive and extensive (low-input) farming practices at the same time.
- optimise the form of nitrogen fertiliser
- apply nutrients accurately
- minimise tillage
- prevent soil compaction

This coherent package of measures will have multiple positive effects and it will take away major bottlenecks that hinder reconciliation of the requirements of farmer, citizen, environment and cow.





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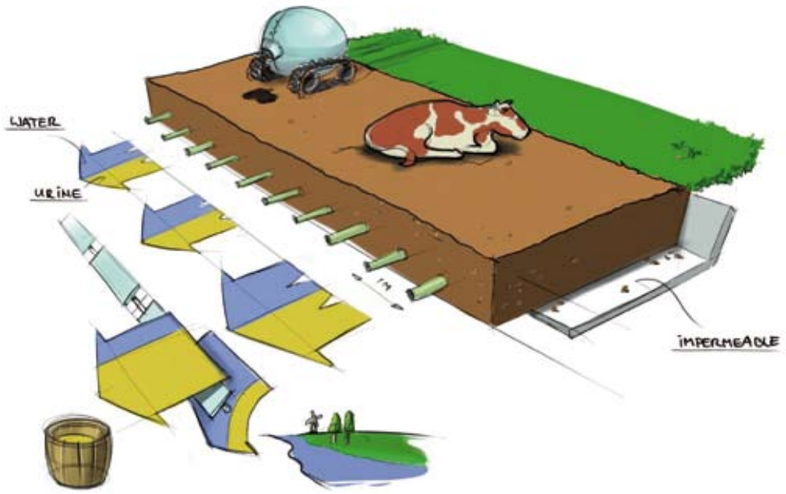
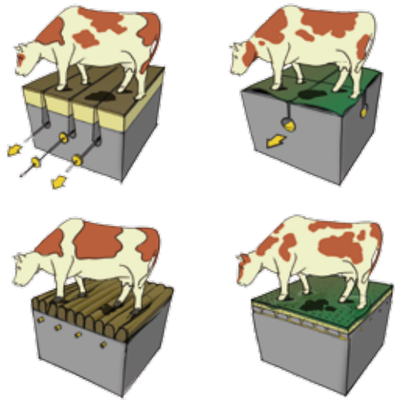
It is no problem to give the cows space, if at the same time we carry off urine and faeces quickly and separately. A sandy soil is a perfect place to lie down. The drawing shows how urine is harvested through drains. In case of heavy rain, the water is discharged.

A good floor for cows is soft, nonslip, and clean at the same time. There are many possibilities. These four combine those characteristics with provisions to keep faeces and urine separate. Some floor types are available already; others still require further development.

1) Turnaround in acting 1: the cow

If we want to satisfy the cow´s needs, we must give her sufficient space to perform all her behavioural characteristics out of her own free will. In summer as well as in winter. Resting is very important to the cow and she needs sufficient space and time to do that. A clean and dry floor will stimulate the cow to exercise and to show oestrus behaviour. That has a direct positive effect on the cow's welfare as well as an indirect effect on her health: much less stress, low infection pressure from the living environment and a properly functioning immune system. That reduces diseases and disorders, so the cow can be kept for a larger number of lactations. And in turn that simplifies management for the dairy farmer and reduces costs. With a varied diet, space and room to feed for all cows, lower-ranking cows can also produce milk without living on their reserves or permanently experiencing stress from herd fellows.





Turnaround in acting 2: the nutrients cycle

If we feed the cow mainly with plant material containing crude fibre, she can play an important role in utilising these residual flows, for instance from nature areas and from the food and beverage industry. At the same time we can considerably reduce the use of feed concentrate and focus on a diet aimed at health rather than production level.

Keeping faeces and urine separate creates two unique nutrient flows without expensive treatment: the faeces with organically bound nitrogen and phosphor, and the urine with mainly mineral nitrogen and potassium. The urine can be used directly, but it can also be processed into an artificial fertiliser substitute. In summer, the faeces can be used directly with minimal losses because it contains hardly any mineral nitrogen. In other periods it can be digested for biogas production. Adding additional biomass is not necessary because the dry matter content is much higher and there is no negative influence from mineral nitrogen.

This way, the dairy farm is able to produce high-quality nutrients and organic matter in various sub flows, simply and with limited investments, which can be completely utilised in various types of plant cultivation, on the own farm or in arable farming. This means a contribution to a reduction in the use of artificial fertiliser in Dutch agriculture. As such, dairy farmers will be storing and using various flows of nutrients on their farms and partly supplying them to arable farms.

Turnaround in acting 3: capital and labour

A dairy farm that performs other functions in addition to the production of milk offers a sound foundation for a stable and sustainable sector. Cows may, for instance, eat certified residual flows such as those released during refining grasses and algae. These flows are likely to increase in future. An important new function of dairy husbandry could be the production of electric energy from solar cells on or as roofs, or from a new generation of small wind turbines, for instance.

Increasing the yield of specific sections of grassland and arable land saves costs and creates room for own cultivation of protein-rich crops, for nature or for grasslands with ecological value. The costs of housing dairy cows can greatly be reduced if we stop thinking in terms of conventional livestock houses and start searching for different solutions for slatted floors and slurry pits.

Other interesting possibilities to drastically reduce costs include sharing capital-intensive assets such as milking parlours, tractors and harvesting machines. Even far-reaching cooperation is an option - without loss of functionality. Automation and robotisation will further increase in the future. Then cows may, for instance, get their feed from autonomous vehicles without human intervention.

Giving the cows all the space they want, will make them happy, vital and healthy, so diseases will not bother them very much. They will have few problems with claws and the locomotor system and they can timely be inseminated to have the next calf. The much better hygiene will also make persistent problems such as mastitis a thing of the past. As a result, the dairy farmer's job will shift to high-quality, unique labour that pays well.

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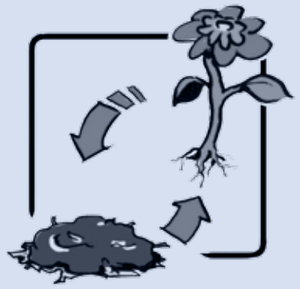
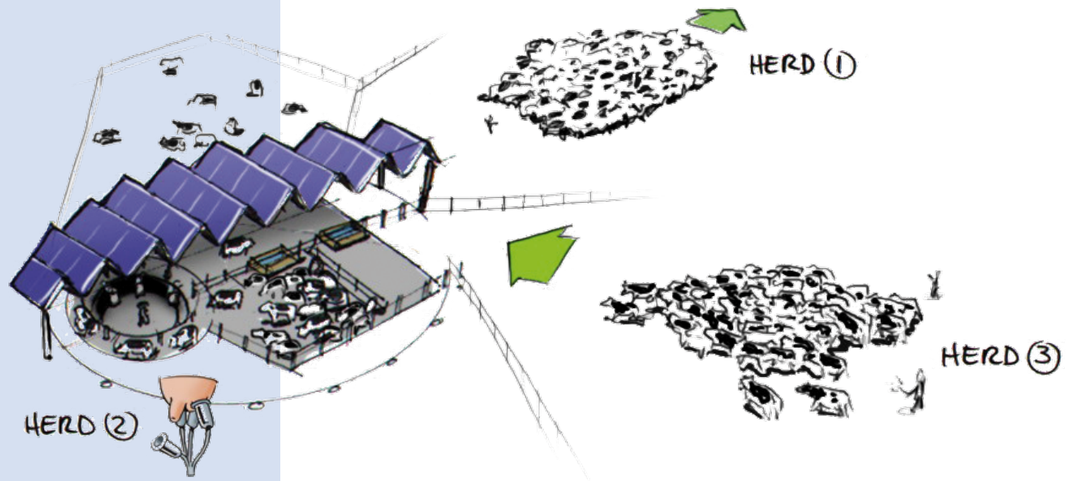


Expensive capital assets such as an advanced milking parlour can better be utilised to the full. A milking parlour shared by various farms considerably reduces costs and makes labour more flexible.



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Turnaround in acting 4: the soil

The soil and the crop can be supplied with organic matter and minerals from faeces and urine. That will require a new application method. Liquid mineral nitrogen from urine is applied to the soil several times during the growing season. Dependent on the plant's needs, soil and weather conditions, application is first in small quantities and close to the plant roots, later in greater volumes and broadcast. Organically bound nitrogen, phosphate and organic matter can be injected or incorporated in the soil according to crop and rotation.

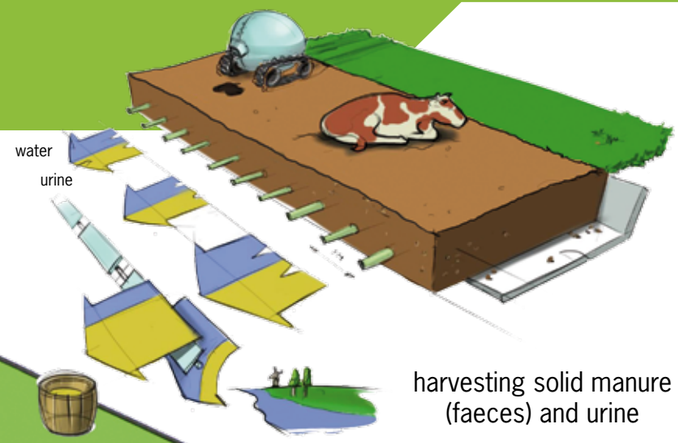
Minimising tillage operations such as ploughing and harrowing prevents undesired decomposition of organic matter. Accumulating organic matter will even make it possible to store carbon in the soil. These measures, in combination with avoiding soil compaction (no more heavy machinery), will stimulate aeration and soil life. That makes plants grow better and reduces nitrate leaching as well as the formation of the greenhouse gas nitrous oxide. Applying intensive farming on some fields and extensive farming (low-input) on others, gives possibilities to make an important contribution to the richness of species of plant and animals (biodiversity). Precision fertilisation and using irrigation tubes in the topsoil for watering will increase production on grassland, creating possibilities to compensate for production losses from low-input farming.

De Meent

Year-round space

A unit of 50 cows
Year-round space (360 m² per cow)
Three living ranges ● plus pasture ●
Welfare: 95% of maximum score (Cowel)
Keep faeces (solid manure) and urine separate
Ammonia emissions 75% lower
20 m² solar roof per cow
Economy: not more expensive

Space for physical exercise, free choice and social behaviour



harvesting solid manure (faeces) and urine

Spacious bedding and distance between cows

Protection from heat stress, strong winds and heavy rain

Design concepts for sustainable dairy husbandry

Four fundamental turnarounds in thinking and acting: those are the basis for De Meent, De Meent XL, De Bronck and Amstelmelk. The starting points are the same for these four designs for sustainable husbandry systems: only the detailing differs. The design of De Meent has the most comprehensive description. Many of the solutions presented there can also be found in the other designs. Once more, these designs are not blueprints but examples of how it could be done.

De Meent: year-round space

At De Meent - see previous page - 50 cows are kept together as a herd with all the space they need: 360 m² per animal in summer as well as in winter. A herd size of fifty heads offers the animals safety, social ranking order and the possibility to recognise all herd fellows. De Meent offers cows space for social interaction and play, to flee or to keep a proper distance. In this way, conflicts will develop less easily.

Some dairy farmers already keep their cows outdoors in the pastures throughout the year, also when it is cold. For instance, dairy farmers working according to the PureGraze system.

De Meent does not offer the herd a traditional barn. The cows have three functional areas that are interconnected over the full width: the green outdoor range, the shelter and the sand bedding. These three zones together offer the cow space for all natural patterns of behaviour.

As long it is dry and not too cold outside, cows prefer to be outdoors. Even at –10°C that is no problem for them. But cows do need shelter in strong wind, heavy rain, or blazing sun.

Own choice

In dry weather and good soil conditions, the three areas are permanently available. When it rains or when the soil is wet in the outdoor range, the cows can stand or lie under the shelter (20 m² per animal) or on the sand bed. That protects the sward. Actual pasturing with grazing takes place on the fields around De Meent.

1) The green outdoor range

The green outdoor range is the largest zone: a grass field, specially laid out, with an intensive drainage system and a very strong type of grass. This area is intended for lying and exercising. Grass production comes second here. In summer, the green outdoor range offers access to the pastures around it where the cows can graze. Drainage ensures discharge of rainwater and harvesting of urine.

2) The shelter

The shelter is what catches the eye. Most functions are concentrated here, such as resting, feeding and milking. For every cow there is a sheltered, spacious and soft bed. The resting places are grouped in islands. It means that subgroups of befriended cows can lie together. At the same time, it is easy for cows to find a resting place away from a higher ranking cow. Over the entire width there are ample numbers of easily accessible eating places. Fifty cows are milked in one automatic milking system. This also allows lower ranking cows to be milked without waiting time.

The superstructure of the shelter consists of a simple, self-supporting construction of some five metres high. Towards the south it is covered with solar panels, towards the north the roof is made of transparent perspex or canvas. That makes it light, but not hot under the shelter. This structure makes it possible to install solar cells in any building block with optimum orientation towards the south. Rollable wire mesh wind breakers around the shelter keep out the cold wind.

3) The sand bed

The uncovered sand bed lies between the green outdoor range and the shelter. That sand bed is intended as lying area and it is large enough for all cows to lie down on it, with a spacing of at least two metres, which cows regard as pleasant.

Harvesting faeces and urine

Loss of nutrients and emissions of harmful gases are limited in De Meent. After pasturing in the surrounding fields, the animals go back to the outdoor range to rest. In this way minimum quantities of faeces and urine end up in the pastures and maximum quantities can be harvested in the outdoor range. We expect that 50% of the faeces and urine will end up under the shelter, some 25% in the sand bed, 20% in the outdoor range, and 5% in the pastures.

Resting beds

Cows spend the better part of the day quietly ruminating. Therefore, it is important that there are sufficient places to lie down. De Meent has three types of beds.

1. Green outdoor range: here the cows can lie down under normal conditions at some 8-12 metres from each other.
2. Sand bed: a lying distance of at least 2 metres. Sand is a pleasant material to lie on. The sand bed is a good alternative when the soil in the outdoor range is too wet.
3. Under the shelter: here are sufficient spacious places to lie down where the animals lie a little closer together for a while. The beds are pitched, so the cows will automatically lie down with their head up and their bottom towards the technical floor. That makes it easy to collect faeces and urine.

Healthy cow

De Meent is a good place for a vital cow that likes to exercise actively, can stand her own in the herd and yet has a sizeable production. The cows no longer have to be dehorned - the social ranking order, the space and the husbandry system allow that. Because of the good life, the life expectancy of a dairy cow can easily be nine years. Good floors prevent claw problems and natural behaviour improves fertility. The lower infection pressure and clean surfaces, together with an ample ration and sufficient eating and resting facilities, will reduce mastitis and other farm-specific diseases. Since the cows do not eat much concentrate, De Meent is less suitable for highly productive dairy cattle. However, we expect that the considerably improved standard of animal welfare will also have a positive effect on the milk yield.

Very high animal welfare, good health and long life

- Cow welfare is considerably higher than in existing husbandry systems, see the graphs on page 33. This is the result of much more space to move, freedom of choice, and ample and sufficient lying places, among other things.
- Good health and low replacement rates of cows through clean and dry floors, exercise, rapid and separate discharge of faeces and urine, a production level suitable for farmer's management style, and calving in spring.
- With a suitable type of cow, the life expectancy of the cows will increase to the economically optimal age of nine years without any problem.

Harvesting minerals: three birds with one stone

De Meent is geared for harvesting minerals and reducing emissions. That is done by separating the faeces (solid manure) and the urine of the cows in the three areas and effectively carrying off the two products and storing them separately.

De Meent kills three birds with one stone by harvesting faeces and urine. Firstly: ammonia is formed when urine and manure get mixed. Keeping them apart reduces emissions considerably. Secondly, urine and faeces are separately suitable for processing into useful fertilisers. The urine can relatively easily be converted into a manageable nitrogen concentrate. The solid manure can be spread out over the land or digested first. That can be done in a smaller digester than usual and without co-digestion because no urine is mixed in. Use of a plug flow digester allows intensive digestion of the faeces with a high dry matter content at a higher temperature. Thirdly, quickly carrying off the faeces from the system promotes hygiene. It reduces the general infection pressure and the development of pathogenic germs.

Harvesting urine

Harvesting minerals takes place in a different way in each of the three zones. Under the sheltered area, where most functions are concentrated, there is a technical floor through which urine passes but solid manure does not. The shallow space below the floor is permanently kept at negative air pressure. In this way no ammonia from the pit will escape to the atmosphere. A small in-line air scrubber can strip the nitrogen from the urine and put it in a concentrated solution. This way the better part of the urine can be harvested as an artificial fertiliser substitute.

The sand bed also acts as a filter. The urine seeps through the sand, is discharged through the drainpipes and then stripped of nitrogen. As the sand bed is not covered, much more water will be carried off when it rains. The first rain will flush the urine from the sand bed. It will then be collected, processed and stored. In heavy rain the cows will be lying under the shelter, so no new urine will end up in the sand bed. Then, the discharge water contains so little urine, that it can be discharged without any problem.

Urine can also be harvested in the green outdoor range. Part of the minerals from the urine is taken up by the grass in summer. In addition, here too the urine can be collected and carried off using drainpipes under normal circumstances. In heavy rain, the first flow will be collected. In summer the highly diluted flow of water can be used for sprinkling or irrigating other fields and in winter it can be discharged. That minimises mineral losses.

Harvesting solid manure

One or more robots drive around 24 hours a day, pick up the manure throughout the system and bring it to one collection point. Those could be modified versions of the existing Scarab manure scraper, now still manned.

Such unmanned robots are currently under development and eventually they will be suitable for use in all three zones. As long as this technology is not yet available, an improved grooved floor system with holes is a good option. On the sandy bottom and in the green outdoor range, man-driven machines can remove the manure.

The main benefit of this approach is a hygienic system that produces hardly any ammonia and keeps minerals available in an easily utilisable form. In this way the dairy farm creates various flows of different nutrients that are stored separately. The farmer can then decide which fertiliser is the most suitable one at what moment for which crop. Moreover, he can also supply sub flows to arable farms.

Energy from sun and faeces

The roof of De Meent not only provides shelter for the cows: its structure also makes it possible to harvest solar energy. Photovoltaic cells, or PV cells, are an integrated part of a framework with space frame girders. Because of their sturdy triangular design, the bearing structure does not have to be heavy and they can always be positioned to the south in every building block. That makes this shelter cheap. The area of PV cells is 20 m^2 per cow. That is almost sufficient to compensate the greenhouse effect of the enteric methane emission of the cows themselves. In combination with other measures to reduce greenhouse gases, this system makes it possible to become energy-neutral at the start. With the expected doubling of the efficiency of solar cells over some ten years, dairy husbandry may even become climate-neutral through compensation.

Keeping faeces and urine separate has yet another major advantage: digestion makes it possible to generate biogas from the faeces without co-digestion. In fact, this is the only gas you can truly call 'green gas'. After all, co-products require a lot of energy for transport and in many cases they are valuable food products as such. That applies for instance to maize. On top of that, it makes the digestion process easier to control because there is much less mineral nitrogen. As a result, smaller installations will suffice.

The gas can be supplied directly to neighbouring residential areas or it can be used in a total energy system supplying heat for the farm (housekeeping and drying residues) and electricity to the mains.

Simple to expand

Because of its shape, De Meent can easily be expanded in width, allowing incremental growth. However, the main limiting factor is the capacity of the milking robot. For that reason a farmer who strives after step-by-step growth along the De Meent concept will opt for a milking parlour rather than a robot.

Growing crops

At De Meent or another nearby arable farm, maize and other crops will be grown in addition to grass for a varied and balanced ration. These crops could include fodder beet, alfalfa, peas, barley, fodder lupines and clover in the grass. The leguminous crops bind nitrogen from the air. Cultivation of the other crops does not require artificial nitrogen fertiliser because substitutes with mineral nitrogen have been produced from the harvested urine.

Precision fertilisation and shallow and deep injection make it possible to administer exact quantities and types of urine based liquid fertiliser. On top of that, it can also be done at the right place - at the plant's roots - at the right time and under the right weather conditions, so not outside the growing season and not on waterlogged soils. This method reduces nitrate leaching, almost completely eliminates ammonia emissions and considerably reduces the formation and emission of nitrous oxide and other nitrous gases. Thanks to the reduction of these losses, the nitrogen application rate can also be reduced drastically.

Developing fertiliser application technologies further

Existing technologies, such as the spoke wheel injector, are suitable to use and to develop further for accurate application of the liquids. In the long term we may even see autonomous vehicles delivering weekly small applications to the crops, for instance. The harvested faeces contain mainly organically bound nitrogen and phosphate as well as organic matter and in summer they can directly be used for the crops. During other periods of the year they can be sent to the digester and stored as digestate for use during the growing season.

Reduced ploughing and harrowing

When growing grass and other crops, and for crop rotation, traditional tilling operations such as ploughing and harrowing are less applied. This considerably reduces the decomposition of organic matter in the soil. So, the organic matter content increases and the soil can be used for CO_2 storage through the accumulation of carbon. With further development of existing technology for minimum tillage - such as reseeding and local tillage - crop rotation without ploughing while maintaining proper weed control is increasingly possible. Combination of crops may then contribute to increasing the yield per hectare while at the same time reducing the environmental impact.

Lighter machinery

A well-aerated soil with sufficient organic matter contributes to improved rooting in the crops, fixing nitrogen in the topsoil, and a good soil water status. Consequently, it is important to prevent soil compaction by using less heavy machines. Automation should make that possible in future. When human labour is no longer necessary, many light machines can do the job of one large one.

Ammonia emissions are 75% lower as a result of:
– rapid separate discharge of urine and faeces to a closed storage
– separate application of urine (or concentrate) and faeces (or digestate)
– injection of urine (concentrate)

The cow's feed and pasturing

With a varied diet of fresh grass, grass silage, maize, untreated residual flows from the food industry and high-protein sources, the cow can receive optimum feed in all stages of her life. On the one hand this reduces the methane emissions by the cow, with the added advantage of a reduction in urine spots since the urine contains less nitrogen. With a proper diet it is no longer necessary to closely control the cow's nitrogen and phosphate efficiency, but instead focus should be on the quality and composition of the excreted faeces and urine. Residual heat from the digester and the total energy system are suitable for drying residual products or for improving the roughage quality.

If cows graze for short periods at a time on slightly older, long grass, this grass will have more structure and contain less nitrogen. The grass production will remain high as well. Contamination of the pasture grass with faeces is minimal because the cows rest in the green outdoor range. Application of an irrigation system with underground hoses at a depth of 30 to 40 centimetres makes it possible to supply water and nutrients and a yield of 16 tons of dry matter per hectare can be achieved.

Economy: competing with existing systems
The design concepts of Cow Power can compete with existing systems economically, and eventually even perform better. This does depend on the development of necessary technology, in particular, labour-saving robotics and precision fertiliser application, and the development of an attitude towards intensive cooperation between farmers in dairy husbandry. Cost reductions and new yields in the designs compensate the additional costs and lower yields elsewhere. Major yields and savings are achieved by the cheaper infrastructure - cheaper roof with a double function, no slurry pits - a higher crop yield per hectare, a longer cow life, major reduction of the concentrate supply and fertiliser application and sharing capital assets (at De Bronck and Amstelmelk). An overview is shown below.

New costs
- Green outdoor range and promenade with lower grass production (De Meent and De Bronck)
- Drainage of outdoor range (De Meent and De Bronck)
- Faeces collection robot
- Irrigation of pastures
- Lying space on sand
- Storages for urine and faeces
- Storage facilities and, if necessary, processing of residual flows from the food industry

New yields
- Higher grass production of pastures
- Grass production from nature areas
- Electricity production
- Sale of artificial fertiliser substitutes
- Compensation for carbon storage in the soil

Higher costs
- Lower occupation rate of milking robot (De Meent and De Meent XL)
- Low-emission floor that separates faeces and urine
- Development of different management methods by the farmer (mainly De Bronck)

Savings
- Longer life of dairy cows will reduce the need for rearing young stock
- No expensive slurry pits
- Cheap and light roof structure
- Optimum utilisation of milking parlour (De Bronck and Amstelmelk)
- Smaller digester without biomass; no purchase of co-products
- Minimum processing of feed concentrates
- No artificial fertiliser required
- Minimal tillage
- Less labour per cow
- More flexible use of labour
- Less diseases and stress for the cow

De Meent XL: if you want more
De Meent XL is a combination of three De Meent-units of 50 cows. The herds live in separate areas so as to minimise any ranking order conflicts. Farmhouse, farmyard and storage facilities are at the centre of the system. De Meent XL fits well into a 1-hectare building block.

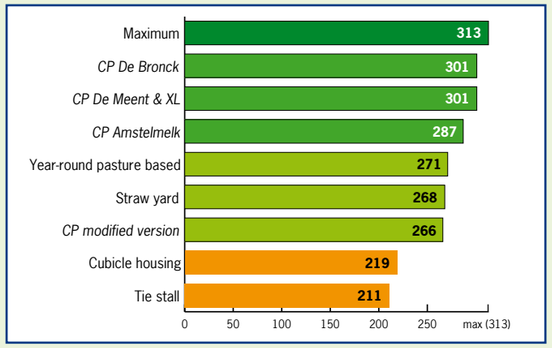
From a spatial and functional point of view it is no problem to enlarge the design of De Meent without affecting the design principles; the additional yields and costs apply here as well. Keeping spacious transition areas between the shelter, the sand bed, and the green outdoor range is important for De Meent XL, too, since the cows are completely free to go outside or, conversely, to find shelter.

De Meent XL can benefit from the size of scale in a number of ways: purchasing, supplying, storing and processing residual flows from the food industry, processing faeces and urine into specific nutrient flows and infrastructure for transport of the generated energy.

Energy-neutral systems through:
- no use of artificial fertiliser, keeping tillage to a minimum
- feed concentrate only from minimally processed residual products from regional sources
- local and regional application of minerals (limited transport)
- solar cells
- energy production from digestion without co-digestion

The welfare score of the designs in Cowel
The graph below shows a comparison between four relatively favourable practical situations of existing husbandry systems for cows (tie stall, cubicle house, straw yard and year-round pasture based), the four design concepts, and the modified version of Cow Power (CP). The graph shows that the Cow Power designs score 16 to 30 points higher than the existing best system for animal welfare, which is year-round grazing.

The De Meent & XL and De Bronck designs only fall 12 point short of the maximum possible score (313). The difference is caused by the lack of cow-calf contact, the milking system and the lower milking frequency, three characteristics closely connected with the production purpose of the system. In the Amstelmelk design, the score is also lower because of the application of dehorning and the more limited space per cow in winter. The modified version of an existing cubicle house, in particular, scores lower because we have based the assessment on the - though modified - still concrete floor in the barn, standard lying beds and dehorning.

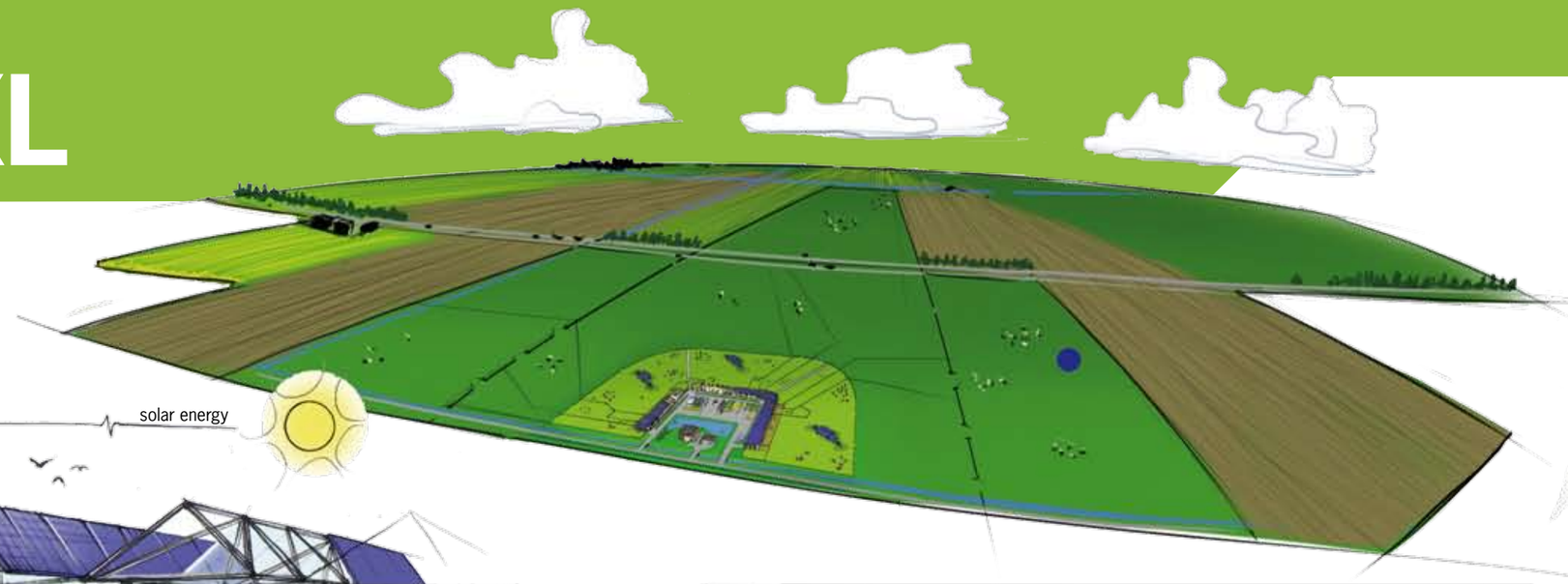


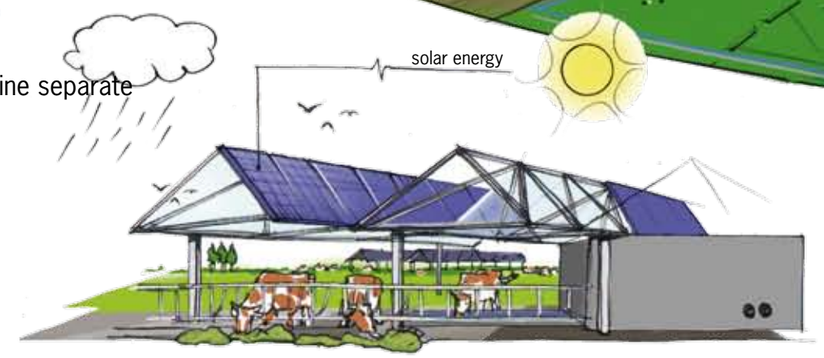
Cowel evaluation

De Meent XL

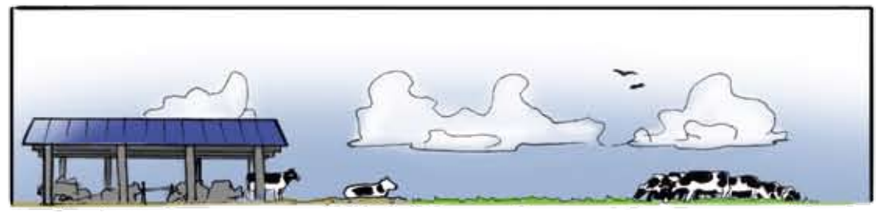
If you want more

Three times 50 cows
Year-round space (360 m² per cow)
Three ranges ● plus pasture ●
Welfare: 95% of maximum (Cowel)
Keep faeces (solid manure) and urine separate
Ammonia emissions 75% lower
20 m² solar roof per cow
Economy: not more expensive



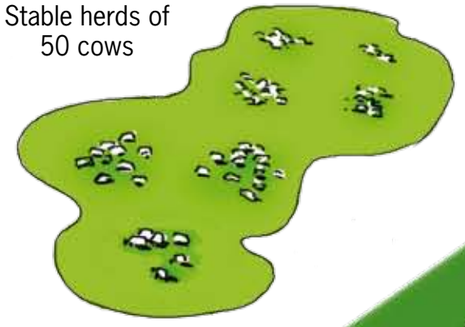


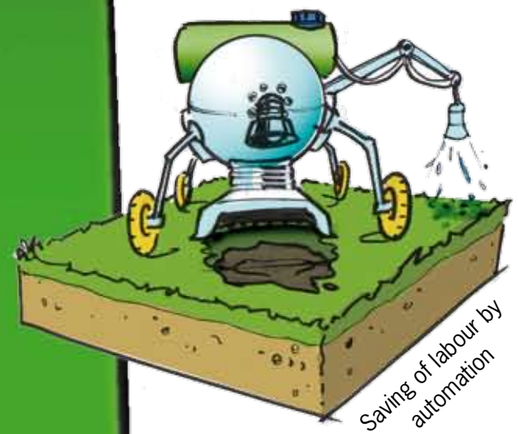
Protection from heat stress, strong winds and heavy rain



Space for physical exercise, free choice and social behaviour

Stable herds of 50 cows





Dry, soft, non-slip floors

De Bronck: movement in the landscape

The emphasis at De Bronck is on the ability of the cows to move around. The main functions of the husbandry systems are placed at a distance of several hundreds of metres from each other. Feeding, resting, milking and young stock rearing are all done at different locations. The specifications for De Bronck are based on a herd of 200 cows.

These different locations are permanently connected through a green outdoor promenade, a combination of a cow path surrounded by broad strips of grass. In summer as well as in winter the cows can use the promenade to stroll from one location to the other, and to lie outdoors. The promenade is similar in character to that of the green outdoor range at De Meent and De Meent XL, but here it is dispersed in the landscape. Manure and urine are harvested here as well.

Migrating cows

By nature, cows are nomadic animals without a favourite spot. And this is still apparent despite thousands of years of domestication. It is most obvious in the pastures: cows are gathering their food while moving from one place to the other. A good amount of physical exercise every day is vital to a cow's health and well-being. No difference with humans on that point. The cow's natural resistance and locomotor system thrive on it.

De Bronck fits the cows like a glove. Every day, so in winter, too, the cows stroll one to three kilometres, a distance described in literature as desirable and possible. The cows are more or less forced to exercise because it is good for their health. It poses the interesting question whether the freedom of choice for cows to exercise or not is more important than their health and well-being. We have opted for the latter in this design.

At De Bronck the cows themselves may decide when they will be milked. We expect that they will move to the milking parlour in smaller groups of between eight and sixteen companions, to be milked automatically. This means that the milking parlour will have to be a rotating parlour where a robot can milk such numbers simultaneously.

Basically, De Bronck is suitable for cows with a currently standard or high milk yield. But the cows also have to be mobile and vital so they have sufficient time left to rest. Depending on the location, the system is highly suitable for the use of residual flows as feed concentrate and nature grass as a high-structure diet. We expect the major improvements in the field of welfare to have a positive effect on the milk yield.

50 to 75% reduction of greenhouse gases through:

- 40% reduction of methane from manure through rapid and separate storage of faeces end urine and less raising of young stock
- 10% reduction of enteric methane emission by means of feed measures
- 75% reduction of CO_2 by reduction of fossil energy use (mainly artificial fertiliser and feed concentrates, and tillage). In addition, carbon storage in the soil.
- 75% lower nitrous oxide emission by abolishing artificial fertiliser, separate storage of faeces and urine, precision fertilisation, no more ploughing of grassland, adequate drainage, and limiting access to pastures in wet weather conditions.

Changing management

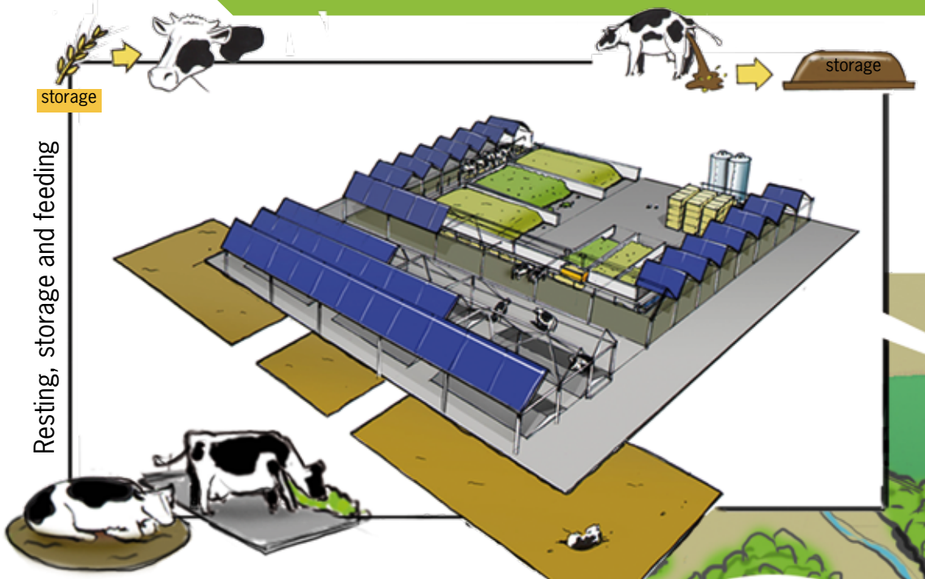
Management by the farmer will change drastically. The cows will never all be in the same place at the same time any more. So the farmer has to move with his cows. Cows can excellently be localised with the aid of modern GPS technology. Checking out the cows means a bicycle ride or a drive through the pastures and the promenades. If cows should fail to move towards the milking parlour of their own accord, they can be trained to do that on the sound of a whistle or a different signal.

The herd size at De Bronck can be realised by giving existing farm locations specific functions in a greater setting, rather than concentrating all functions in one place. That means breaking with the existing ways of thinking of farm expansion. The cow gets the necessary exercise, the investment efficiency is maintained and, on top of that, it will result in a dairy farm that is in harmony with the landscape. For larger herds there are new possibilities for sharing functions such as feed production and feed storage, labour and transport in a network of adjacent farms.

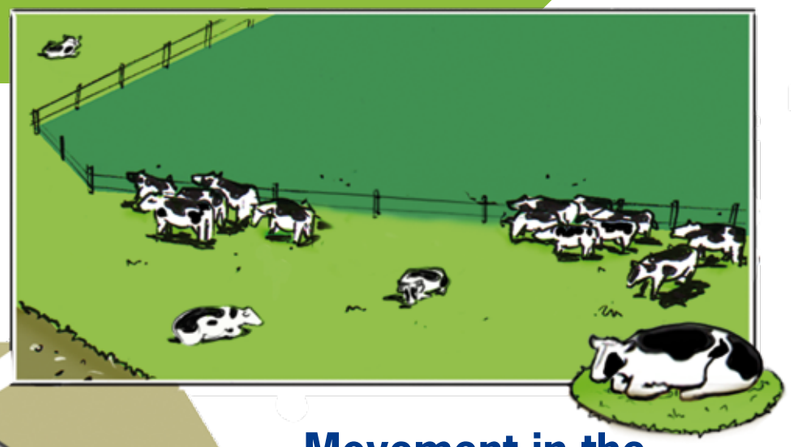
Part of the landscape

The cows become a fundamental part of the small-scale landscape because of the system's daily dynamics. You will also always see them from your car, from your bicycle or when walking your dog. Where human traffic and cow traffic intersect, cattle grids or a cow tunnel under a thoroughfare are possible. The design not only requires a reconsideration of the relationship between farmer and herd, but also a reconsideration of what is efficient and what is not. For local municipalities it may be a solution for a different approach to the trend towards increases of farm size in their region.

De Bronck

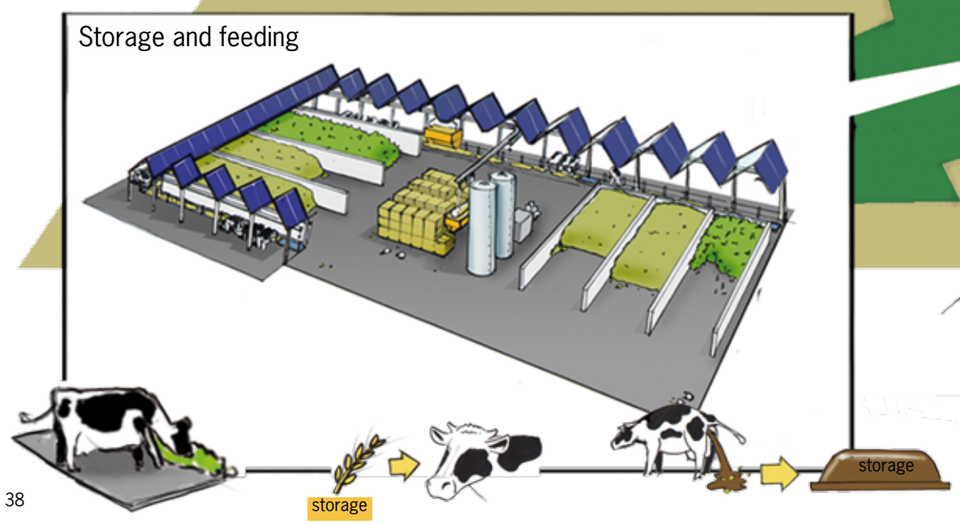


Young stock rearing



Movement in the landscape

200 cows roaming the grounds every day. Farms have been converted for feeding, resting, finding shelter, rearing young stock or automated milking. Throughout the year cows are roaming the green outdoor promenade of 360 m² per cow, and in summer they are in the pastures.



100 m

Amstelmelk: The power of cows near the city

Amstelmelk is a network of farms at a stone's throw from an urban area. They cooperate in the field of feed production, feeding, milking and the operation of machines and installations. That allows the introduction of labour-saving modernisations without every separate farm having to grow to be able to afford it. This brings flexibility in labour requirements and labour provision. This design also focuses on the physical exercise of the cow.

The design shows Middenwaard, an area of some 150 hectares of peat land east of the city of Amstelveen and west of the river Amstel. In the design - so not in reality - this area houses six farms, each with an average of fifty cows.

Farmers near urban centre

It seems that serious farming in or near the city is becoming more and more problematic. Land is expensive, or not available, and municipalities impose strict regulations with regard to odour nuisance. It is a pity, for at the same time city-dwellers are more and more interested in the source of their food. In addition, at higher energy prices it pays to limit the numbers of food kilometres. There is also a clear market for regional or local products, as appears from the recent success of the supermarket formula Marqt in Amsterdam. The Amstelmelk design starts from the potential of urban areas for serious dairy husbandry and from the reverse, taking a different approach to the limitations by exploiting opportunities.

The six herds are stable, social communities that remain separate from each other. Each herd has their own barn. From there, they take the broad cow path to the communal milking unit and back once or twice a day. It is located centrally in the area. As every farm gets a different timeslot, the unit is in operation from early in the morning till late in the evening. The work is carried out by two permanent assistants, for instance from the city. Just like De Bronck, physical exercise for the cows is an integrated part of their performance. Good for the cow as well as efficient use of an expensive installation.

Less outdoor space

In wintertime, the cows at Amstelmelk have 13.5 m^2 per cow, all under the shelter. In winter the peat soil is too soft and too wet to keep the outdoor range green and in use like in the other designs. So this means a deliberate deviation from the brief of requirements of the cow (at least 360 m^2 per cow). Consequently, for the winter months the design is based on the second level in the Cowel model, of which we know that it is considerably better than most current situations. It also leads to a slightly lower animal welfare score than the other designs (287 instead of 301).

No nitrate leaching and phosphate accumulation

- No excess nitrate and phosphate application through precision fertilisation as to time, place and crop requirements using various mineral flows from the husbandry system
- Use of soil phosphate surplus by deep-rooting crops

Livestock houses

The livestock houses are elliptical, open to all sides and have a central feeding passage with a mobile feeding rack. Once every three or four days one of the network partners can deposit roughage there. He makes his rounds along all farms as from the central feed storage.

Around the feeding rack there is a technical floor, surrounded by a large sand bed. In both areas urine and faeces are separated and harvested. That makes the ammonia emissions, and also the odour nuisance, very low. The six farms together convert the faeces into gas. Together with the electricity from the solar panels, this yields sufficient energy to heat and light the adjacent residential quarter. Since there is no need for co-digestion, you can really call this green gas. The farmers can apply digestate on the soil as organic fertiliser, using a trailing hose applicator, with less odour nuisance.

Function for the urban area

It will be obvious that this system in a near-urban setting offers all kinds of possibilities to intertwine dairy husbandry with other functions around and for the city. The farms have entered into a partnership with the municipality that realises the importance of green 'wedges', green lungs that reach into the city. These wedges connect the nature within the city with the nature around it and they provide coolness in a warming climate. Grassland will not be ploughed, no artificial fertiliser is required and the farms strive after a high organic matter content in the soil. This results in a high species diversity in and around the pastures, making it a pleasant area to cycle through.

Good grass, good feed

Grass production is high with an excellent grass quality thanks to the very accurate application of the minerals harvested from urine and faeces. The cows' diet is supplemented with low-grade, but high-structure nature grass from nearby nature compensation areas.

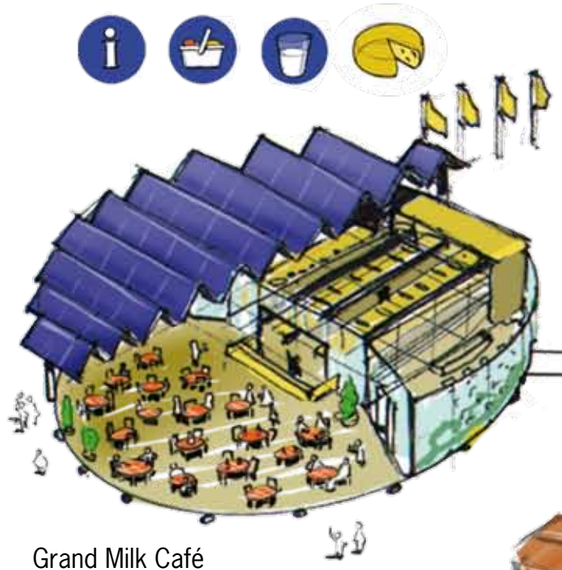
Cooperation

The land has been acquired by a cooperative in which the municipality, adjacent property owners and farmers themselves have equal shares. It is the financial expression of their common interest in a green open space. This scheme offers benefits. For instance, a takeover of one of the farms will be much easier because the capital costs are lower. One of the farmers can buy out his neighbour and then leave the care for the herd to an ex-ICT specialist from the city, who would like to be a farmer for at least five years. The latter has invested part of his capital and is now learning the tricks of the trade from an experienced farmer. Though he will make less money, he will be much happier.

The cooperative and the dairy husbandry system in itself are cost-effective in this design. On top of that, of course the location near the city offers a unique chance to strengthen the ties between city and countryside and to sell the milk and milk products at a higher price.

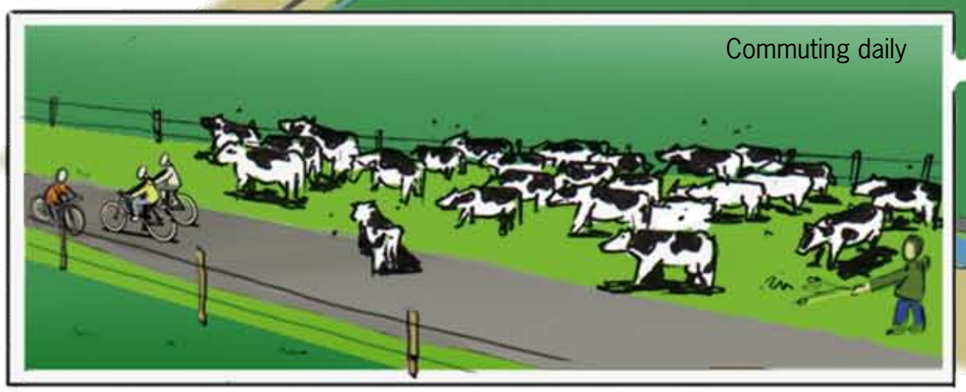
Amstelmilk and Amstelcheese, whose production and consumption is climate-neutral and local, fetches 50 cents a litre. This is more than sufficient to cover the additional labour and costs of processing and marketing.

Amstelmelk



Grand Milk Café

Shared milking parlour



Winter residence

Cow power near the city

Dairy husbandry on the fringes of the city. Every day 300 cows of six farms move back and forth to the common milking parlour. Every farm has a stable herd of 50 animals. In summer cows are in pasture, in winter they have a living space of at least 13.5 m² each. Land, labour and capital are shared, with each other and with the nearby city. Direct sale of products offers an opportunity, but it is not economically necessary.

Modifying an existing farm

We considered the possibilities of modifying an existing farm on the basis of a number of principles from the above designs. There appear to be surprisingly many. It is perfectly possible to comply with the dairy cow's BoR and to a substantial degree to the environment's BoR (particularly ammonia and methane). We have based that on a practical situation, a farm with fifty cows in an old cubicle house. The farmer wants to expand to eighty cows.

Main measures

The main measures are opening the barn on all sides and adding a sandy floor (1) at the long front in the transition to the green outdoor range (2). The roof is replaced by two space frame girders with PV cells (3), extended and raised about two metres for ventilation and the passage for the tractor along the feeding passage.

The three types of floors - indoors and outdoors - that we saw in the other designs are found here as well. The technical floor under the roof is a grooved floor, with holes to drain urine and a scraper to collect faeces. The urine is collected in the existing manure pits where negative air pressure is created by fans of an air scrubber that strips the ammonia (see drawing bottom right). The concentrated mineral nitrogen fraction is used as a substitute for artificial fertiliser in spring. The remainder can be spread directly on the land or first be mixed with the dry faeces or the digestate.

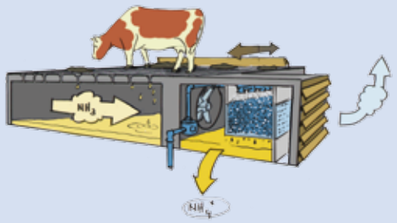
The drained sand bed is not covered and offers excellent lying space for the cows. Urine is harvested here as well. Once a day the manure is manually removed from this area and brought to the grooved floor. The green outdoor range is provided with drainage and small longitudinal ridges for improved surface water discharge, and a hard-wearing type of grass is sown.

The drawings show the existing situation (drawing on the left, 50 cows) and the situation after modification (drawing below, 80 cows).

Practical tests

This design can be used to test a number of objectives of the Cow Power project and their effects in a practical situation, without a complete conversion being required. It offers the opportunity to test the effects of the dairy cow's BoR on cow welfare. They include the effects of the sand bed on cow health and welfare as well as the possibility of no longer needing to dehorn the cows. In addition, the effect on the life expectancy or the life production can be measured, the performance of the outdoor range can be tested and the environmental effects can be assessed.

In short, this modified version shows that also in existing situations there is much room for experiments with regard to elements without having to create a completely new situation. That is vital to the realisation of learning experiments, for designs on paper may look promising, the proof of the pudding is in the eating.



Manure and urine are separated with the aid of a modified grooved floor and the nitrogen from the urine is harvested with a small air scrubber.

6 In conclusion

With a combination of clever interventions, dairy husbandry in the Netherlands can make a major contribution to the sustainability of our society and its own future: dairy husbandry that can be kept for a long time.

We are not going to manage that with minor modifications to existing operations. Welfare, environment, and economy can be reconciled much better if we think differently and act differently. Inspired by a succession of pioneers from the field and by research, we present you a coherent combination of proposals in this brochure. These are not only concerned with better livestock housing, or a better, low-emission floor, but they are geared to the entire livestock husbandry system, including the cultivation of crops and the input of products.

Breakthroughs

The main breakthroughs refer to 1) offering the cow enough space, 2) preserving valuable minerals such as nitrogen and phosphate, 3) making cleverer use of capital assets and labour, and 4) respecting and utilising the soil ecosystem.
Four design concepts show how concrete, coherent solutions can in principle realise major objectives, including healthier dairy cattle that live longer and have a high quality of life, some 75% lower ammonia emissions, 50-75% lower greenhouse gas emissions, 75% reduced eutrophication, an energy-neutral system through net production of green energy, and a climate-neutral system in the not too distant future (ten years). Realisation of these objectives at farm level is a feasible option.

Different type of growth

Although an incontestable calculation of the economic consequences of this package is not possible, it is our firm belief that – in the end - these objectives will not necessarily affect the competitive position of Dutch dairy husbandry. Considerable investments will certainly be required - mainly in developing the soil and in different machinery, though their eventual operational costs may be equal or even lower - but those will be compensated for by a whole range of savings, new proceeds and development opportunities (see page 32).

Dairy farming in the Netherlands is expected to grow by 25% after milk quotas will be repealed. This will mainly be caused by the favourable climate, the entrepreneurial spirit and the strong dairy sector in the Netherlands. However, this potential growth may be hampered by environmental restrictions and the prices of land. The 'manure surplus' and uncertainty about the derogation could very well take over the restricting effect of the milk quota.

The proposals in this brochure remove the technical aspects of that restriction. When we combine this with the increased yield of the land that we consider to be possible in the Netherlands and with a reduced import of concentrate raw materials, the expected growth of the branch can be realised without burdening land and nature elsewhere in the world. However, it will have to be a different type of growth than most people think.

Parties to take action

Although the designs and solutions are within the frameworks of dairy husbandry, neither the innovation challenge nor the investment risks are solely the responsibility of individual dairy farmers. The majority of the welfare and environmental objectives exceed the statutory minimum and in some cases they cannot always be attributed to individual farms. That applies for instance to the indirect production of greenhouse gases. In knowledge and technology development, the funding of such activities and in the creation of a facilitating environment when it comes to policy and tax measures, other parties have a definite responsibility. Developers of animal housing technology, consultants and energy companies, but also the commodity board for dairy products (Productschap Zuivel) and local, regional and national governments may have an important role in developing Dutch dairy husbandry with long-term sustainability in 2023, the Year of Verburg (the Minister of Agriculture anno 2009).

The next steps

The design concepts of Cow Power offer a long-term perspective for integrated sustainable dairy husbandry. But these perspectives will not become reality overnight. This scenario requires further development: of knowledge, technology and experience, of organisational frameworks and supporting policy instruments. An outline agenda for the follow-up is given here.

We will make a distinction between what may yield results in the short term and what will bear fruit in the more distant future.

This agenda not only aims at new research. Knowledge and efforts are required from many different parties, including dairy farmers, supply companies, social organisations, funding bodies, governments, conservation organisations and managers of the rural area. Looking forward with the prospect of the perspectives described here, we hope to stimulate cooperation between all these parties for the years to come.

Cow

Measures in the field of space for exercising and resting, freedom of choice, clean floors, and natural behaviour can already be tested and incorporated in practical situations in the short term. The anticipated positive effects on the welfare and the life expectancy, and particularly on claws and behavioural expressions regarding fertility, can then be tested.

The indirect effect of these measures should be assessed experimentally and fundamentally, for instance on health, resistance, and mastitis. In addition, the suitability of current and possibly new cow breeds for systems like the ones presented here should be studied.

Finally, a number of questions remain for fundamental research. First of all there is the added value of grazing for cows, secondly the controllability of defecating and urinating behaviour of cows, and thirdly there is the search for positive manure qualities for an optimum soil life and less excretion of nitrogen and phosphates.

Nutrients and minerals

Closing the nutrients cycles, at any level of scale, requires drastic minimisation of uncontrolled losses to the environment, mainly of nitrogen and phosphate compounds. Nitrogen and phosphate are valuable nutrients. These only become ‘waste’ in the wrong place, at the wrong moment and in the wrong quantities. For keeping faeces and urine separate, various workable floor concepts are available that can be further developed and subjected to additional testing. In connection with this it is vital to further develop the present manure robots that take up and collect faeces to bring them to a closed storage facility.

It is necessary to further develop the use of pure urine in crops and the potential of existing machines for precision fertilisation. Concentrating the ammonia in an artificial fertiliser substitute is in line with current policies and practical developments. The direct application of faeces with organic matter for crops has to be tested as regards technology, emissions, compatibility with cultivation systems, and availability of nutrients for crops. Further study should be made of new digestion systems for faeces without co-digestion.

Finally, further study is important of ways of making precision fertilisation and irrigation through underground conduits feasible and cost-effective.

Sharing capital & labour

Major savings on slurry pits with new floors and superstructures can be studied and tested in practice in the short term. New types of cooperation concerning the joint use of a milking parlour invoke problems in the field of local compatibility, hygiene, cow behaviour and maximum walking distances. Other opportunities involve new milking systems, either manually or robotised.

Further development of intelligent sensors with control signals may provide solutions to the practical problems of getting the cows to the milking unit in time. In combination with improved cow welfare and health, it will make it possible to significantly reduce the amount of labour required and to greatly simplify management of the husbandry system.

Finally, it could be possible to create a design for a partly mobile milking unit that can travel along herds farther away, so cows do not have to walk to the milking location.

Cooperation between dairy farmers, and between dairy farmers and other parties in the rural area is another major opportunity for development. Sharing land, capital assets and labour may be a real and better alternative to increases of scale per farm and contribute to reducing the takeover problems. Yet, that will require a cultural turnaround that is going to take time.

Soil and crops

Management of an outdoor range that is available to cows throughout the year, must be tested and developed further under field conditions, with the aim to keep it dry and green.

In the long run the further development of technologies and growing systems for grass and maize with no or only limited tillage is important. Yet experiments in this respect can also be carried out in the short term to explore the positive effects of a higher organic matter content and reduced soil compaction.

Cultivation of existing and new crops and processing and utilisation of residual flows as supplements to the diet of cows are vital as an alternative for imported concentrates. Possibilities include nature grass, new residual flows from bio-based refineries and high-protein crops.

The development of small, unmanned machines seems an interesting opportunity to avoid soil compaction. Increasing the biodiversity in an area requires further study and design on ways to combine intensive and extensive farming.

Integrated pilots and experiments

In addition to experiments regarding these single aspects, there is a specific requirement for integrated practical experiments. Experiments that combine measures and investigate mutual effects and interrelations, with the aim to develop and improve the designs, should be initiated. As discussed earlier, making dairy farming more sustainable is not just about improved housing or an improved cow. Major leaps are possible if we do look beyond the farm. Consequently, for such practical learning experiments a setting must be created in which not just dairy farmers are actively involved, but also parties such as municipalities, provinces, technical industry, consultants and landscape managers. This setting must offer sufficient protection against the disproportionate risks of new technologies and practices as well as the extraordinary investments that they will require. The collective interest of a major increase in sustainability also justifies the use of collective funds.

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What can we achieve in 2011?

The Government's objective is to have 5% sustainable livestock husbandry in 2011. In view of the above agenda it is clearly not realistic to also have 5% integrated sustainable husbandry systems by 2011. That not only requires more development, but also the willingness among dairy farmers to invest.

Yet the Government could stimulate the application of major aspects of these integrated sustainable husbandry systems in existing farm situations, for instance through tax measures linked to Maatlatten Duurzame Veehouderij (a regulation to improve sustainable livestock husbandry).

The modified version of an existing farm described above provides excellent points of departure in this respect. The suggestions below are all in line with the course towards integrated sustainability and, consequently, they will not hinder this development in the long run.

Major gains in animal welfare and health in existing farm situations can be achieved by the following:

1. Increasing the space inside livestock houses to 13.5 m^2 per cow.
2. Offering sufficient and good lying space for every cow. At least one spacious resting place per animal, but preferably a little more.
3. Offering sufficient possibilities for physical exercise in summer and in winter.
4. Stimulating the development of more systems that quickly and preferably separately carry off faeces and urine to a closed storage facility.
5. Rewarding ample room to move about and pasturing.
6. Abolishing the premium on winter milk (by the milk processing companies), promoting calving in spring and replacement by a meaningful premium on pasturing or permanent access to a spacious outdoor range.

Major environmental gains in existing farm situations can be achieved by the following:

1. Stimulating the use of alternatives to feed concentrates with very little processing and limited transport.
2. Quickly and separately carrying off faeces and urine to a gas-tight storage facility.
3. Substantially limiting the application of artificial fertilisers and using urine concentrate as alternative.
4. Application of minimal tillage.
5. Facilitating solar energy on barn roofs financially and by local governments.
6. Abolishing grants on co-digestion and moving towards digestion without mixing in additional biomass.

Major economic gains can be achieved by the following:

1. Stimulating mutual cooperation between dairy farmers, and between dairy farmers and their environment, for instance by making the sharing of capital assets such as land and milking installations much more attractive from a legal, practical, technical, fiscal and cultural point of view.
2. Promoting the use of nature grass and other available residual flows instead of concentrates.
3. Extending the life expectancy of dairy cows.
4. Greatly reducing the application of artificial fertiliser.

In addition, together with the branch, the Government could set as a target for 2011 the realisation of at least ten striking and different practical examples of integrated sustainable dairy husbandry as a practical experiment and as a demonstration project.

Response

Above all, this brochure wants to be an invitation. An invitation to anyone who is inspired by the possibilities of integrated sustainable dairy husbandry and wants to seize the opportunity to make a contribution. The Cow Power project team will continue as an intermediary for people who want to develop this image of the future. Of course, we will welcome all suggestions, ideas and initiatives that can bring this image of the future closer and we would like to collaborate and participate in realising those ideas.

For questions and information:
go to **www.krachtvankoeien.wur.nl**. Here you will find background information on the Cow Power project, new initiatives and developments, and possibilities for discussion and presentations.

For ideas and project initiatives: please contact us through the addresses below. We do not hand out money, but together with you we can investigate how your idea can be realised and connected to the concept of sustainable development of dairy husbandry in the Netherlands.

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The many participants of the workshops on future visions dairy husbandry (Toekomstbeelden Melkveehouderij) and the Workshop on new floor systems (Nieuwe Vloeren)

The Platform of Cow Power with the following people:
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We would also like to thank the following people for their critical reflection and contributions:
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Designs for System Innovation

This brochure and the Cow Power project was commissioned by and received support from the Ministry of Agriculture, Nature and Food Quality (LNV) as part of the research programme 'Towards Sustainability in Production and Transition' (Verduurzaming Productie en Transitie) (BO-07-009-005).

Ministry of Agriculture, Nature and Food Quality