Nordisk Avlsværdi Vurdering
Nordic Cattle Genetic Evaluation

Review of Nordic Total Merit Index
Full Report
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Preface

During the past two decades, the cooperation between the Nordic dairy cattle breeding organisations VikingGenetics, VikingDenmark, SEGES, Växa Sweden and Faba co-op) has steadily increased with some of the landmarks being the establishment of the Nordic Cattle Genetic Evaluation (NAV) in 2002, publication of the first common breeding values in 2005, and the establishment of the Danish-Swedish-Finnish AI organisation VikingGenetics in January 2008. In November 2008, the Nordic Total Merit Index (NTM) was implemented.

NTM has – despite inclusion of claw health and young stock survival - remained nearly unchanged since 2008. Therefore, it was appropriate to perform a revision of the biological and economic assumptions behind NTM. Since the Original NTM index was created in 2008, the Nordic dairy sector has seen some major changes in the operation of dairy farms. The amount of produced milk has increased in all production systems. Sexed semen has been introduced and is now widely used, usually in combination with beef semen. This minimizes the number of surplus heifers and the number of animals for slaughter is maximized. Treatment of certain diseases such as mastitis by herd personnel is now possible in Denmark and will most likely also be possible in both Sweden and Finland in the near future. Consumer focus on animal welfare and climate changes has increased which has led to an increased attention to the improvement of feed efficiency and organic production systems. All these factors have been considered during the 2018 NTM review.

In preparation for this review, breed and AI organizations have supplied input and discussed future production circumstances for dairy production in the NAV countries. This was discussed at the January 2017 NAV Workshop. Following the discussions at the workshop, it became clear that the following topics should be considered in this NTM revision.

- The use of sexed semen (SS) and increasing amount of beef×dairy crossbreds
- Increased organic production
- Feed efficiency
- The value of increased frequency of polled cows

The results have been presented to the for AI- and breed organisations at joint NAV Workshops in January and May 2018. Furthermore, the results have been discussed at several meetings for farmers in Sweden, Finland and Denmark in the period from January to May 2018.

Important support and information has been supplied by Faba, Växä Sweden, SEGES, research institutions, and breed organizations in Finland, Sweden and Denmark.

Gert Pedersen Aamand

Skejby, November 2018

Content

Summary

Since the Nordic Total Merit (NTM) was introduced in 2008, the Nordic dairy sector has seen several large changes such as larger herds, greater proportion of organic milk production, introduction of genomic selection and use of sexed semen, and greater focus on animal welfare and environmental impact. These factors needed to be accounted for in the 2018 NTM review. Mainly the following factors have been investigated:

- The use of sexed semen and increasing amount of beef×dairy crossbreds
- Application of health agreement schemes
- Increased organic production
- Feed efficiency
- The value of increased frequency of polled cows

A detailed update of biological and economic assumptions regarding production circumstances in Danish, Swedish and Finnish conventional and organic dairy herds have been accomplished for Holstein (HOL), RDC and Jersey (JER). This forms the basis for calculation of economic values for the 90+ traits which combined provide information for the NTM index.

Generally, the economic values for the production traits have increased slightly compared to the Original 2008 values. The economic values of the health traits have decreased for traits where health agreement schemes allow the herd manager to perform disease treatments, and increased otherwise. Because of changed herd structure towards more older cows, the economic values for fertility of heifers have decreased and the value for cows has increased. The economic values for calving traits and young stock survival are affected by both changed herd structure and the use of sexed semen and production of beef×dairy crossbreds. The economic values for confirmation traits, incl. milkability and temperament, and claw health have increased slightly because of increased wages. Finally, the economic value of longevity has decreased considerably because replacement rate has decreased. Based on the new economic values, relative NTM weights were calculated.

Based on the results from sensitivity analyses and discussion at the May 2018 NAV Workshop, the NAV stakeholders proposed a final set of relative NTM weights for HOL, RDC and JER. For all breeds, the used price for milk was decreased by 10 % compared to the initial assumed milk price. This resulted in an increased economic value of one yield index unit for HOL and RDC whereas the value for JER is nearly unchanged compared to 2008. The final weights were modified slightly compared to the optimal economic weighting: For HOL, the weight on fertility was reduced slightly and the weight on udder conformation was increased. For RDC, the weights on udder conformation and udder health were increased. For JER, zero weight was put on growth.

In conclusion, the relative NTM weights have changed little for all breeds compared to 2008. We can expect small increases in genetic response for the production traits and a slight overall decrease in the expected response for the functional traits. The economic value of one NTM unit per annual cow has decreased in HOL to €9.89, whereas it has increased to €9.20 and €7.96 for RDC and JER, respectively.

1 Introduction

The aim of the 2018 revision of the Nordic Total Merit (NTM) index is fine-tuning of the Nordic breeding goals so they are well suited to meet future production circumstances. An economically optimized NTM results in the largest possible economic output (genetic response) for the Nordic dairy farmers. Each trait in the breeding goal is assigned a weight which specifies the direction and contribute to the relative speed of genetic improvement of the trait. The relative weight for each sub-index in NTM is based on the economic value of each sub-trait in the sub-indices, for example what is the value of improving fat yield in 1st parity HOL with 1 kg. The main work related to this NTM revision is about updating these economic values.

During the last decades, the cooperation between the Nordic breeding organizations has steadily become more intensive, with some of the landmarks being the establishment of the Nordic Cattle Genetic Evaluation (NAV) in 2002, publication of the first common NAV breeding values in 2005, the establishment of the VikingGenetics in January 2008, and the introduction of the common total merit index, NTM, in November 2008. NTM has remained nearly unchanged since then. Therefore, it is appropriate to perform a revision of the biological and economic assumptions behind NTM. When we in the remainder of this report refer to the 2008 (or Original) scenario, this also includes the later additions of the indices for claw health and young stock survival. In preparation for this review, breed and AI organizations have supplied input and discussed future production circumstances for dairy production in the NAV countries. This was discussed at the January 2017 NAV Workshop. Following the discussions at the workshop it became clear that at least the following topics should be considered in this NTM revision.

- **Use of sexed semen (SS):** Since the introduction of NTM in 2008, SS production of female (or male) calves has become commercially available in the NAV countries. Sexed semen is more expensive than conventional semen and conception rate is typically lower. Extensive use of SS in a herd will result in increased numbers of surplus heifers, if not controlled; thus, it is typically combined with the use of beef semen (BS) to limit the number of purebred dairy heifers and maximize the number of animals for slaughter. The use of SS in combination with beef semen could have effect on the economic value of calving traits, fertility traits and growth traits. Besides, there may be an interrelationship with longevity traits. Therefore, use of SS and BS should be included in the NTM 2018 calculations.
- **Organic milk production:** The number of dairy herds producing organic milk is steadily increasing (for example ~15 % of the total number of Danish dairy herds in 2017). In organic herds, some production costs are higher but also the product prices are higher. In this project, organic dairy farming was considered in a separate scenario where economics as well as biological aspects were considered to differ from conventional production systems.
- **Feed efficiency.** Given the current debate about climate changes and increased focus on cost reduction in dairy herds, it is logical to take a closer look at the possibility of inclusion of feed efficiency in the NAV breeding goal. Feed efficiency relates to weight of the cow and level of production but also to feed utilization. The latter is difficult to handle in breeding because it is expensive to measure at cow level. Nevertheless, it is possible to estimate the economic value of feed efficiency. This work was done concurrently with the NTM work in the REFFICO project (Robust and Effective Dairy Cows.
- **Increased frequency of polled cows.** In some countries dehorning of calves has meet political resistance, and in the future a total ban of dehorning may become the reality. In the NAV countries it is

mandatory to administer pain relief under and after the dehorning procedure. Currently, the economic value of polledness is unknown under Nordic production circumstances. Although, polledness may not affect the value of NTM or any NTM sub-trait it is worth knowing the economic value of increasing the frequency of polled animals in the NAV dairy populations.

Other changes to production circumstances in the NAV countries, since NTM was introduced, will also be dealt with during the NTM revision (see *chapter 3 and 4*). The NTM working group has assessed the Excel-based economic model used for the Original NTM calculations and agreed that it was possible to modify and use this model for the NTM revision. Therefore, work has focused on:

- Assessment and analysis of the economic conditions for milk production in Sweden, Finland and Denmark from a perspective of dairy cattle breeding.
- Estimate and analyze economic values of the traits of interest for the Nordic Holstein (HOL), the Nordic Red Dairy Cattle (RDC) and for the Jersey (JER) breed.
- Develop the economic model to enable the inclusion of SS and BS

Feed efficiency is not included in the current NTM model and will be treated separately in the section *Economic value of saved feed costs*. Likewise, the economic value of introducing polledness in a dairy population will be discussed in a separate section: *Polledness in the breeding goal*.

The updated economic values for each sub-trait within each NTM sub-index are presented in the *Results* section. The economic values are presented per breed and country and as means across NAV countries for each scenario and compared with the Original 2008 results. The relative weighting of each sub-index in NTM is presented for the Conventional and Organic scenarios. Finally, the expected genetic response for each sub-index is presented and compared with the Original 2008 NTM results.

Sensitivity analyses are done to study how output from a given model or system varies according to uncertainty or variation of input to the model or system. This kind of analysis is an important part of the NTM work; for example, what is the impact on the economic values and subsequent expected genetic response if the milk price changes (up or down) in the future. Proposals for the sensitivity analyses were presented and agreed on at the January 2018 NAV Workshop. Subsequently, additional breed-specific analyses were requested by the breed associations. The sensitivity analyses include alteration of both economic assumptions and assumptions related to biology or management.

The combined outcomes of the results for the main scenarios and the sensitivity analyses were presented and discussed at the May 2018 NAV Workshop. It served as the basis for a final assessment of the economic weights in the revised NTM. The establishment of the final weighting of each NTM sub-trait may also be based on specific breed policies as well as consumer-specific and ethical aspect which may change the economically optimal weights slightly.

In parallel with the NTM review, the weighting of fat, protein and milk yield in the yield index has been reviewed and updated. Also, the weighting of lactations in indices (yield, fertility, udder health, general health, claw health and confirmation), where data from different lactations are used, has been reviewed and updated. The result of this will be presented in separate reports but summaries of the results are presented in the appendix within this report.

2 General Methods and Assumptions

This section describes (briefly) the basic theory behind economic models used for calculation of economic values. The model framework for the 2018 NTM revision is presented including choice of economic model, which dairy breeds and countries to include in the calculations and the overall production circumstances such as the use of SS as mentioned in the *Introduction*.

2.1 Economic model theory

Different approaches exist for calculating economic values including objective and non-objective methods. Non-objective methods use subjective assessments of weights, for example based on desired or restricted gain methods. When using desired gain (or restricted gain) methods, a backward solution is made where the starting point is the desired gain for some key traits. Based on these desired gains, the economic weights are calculated such that the desired gains are fulfilled.

When objective methods are used, the economic values are based on simulations or modelling of the real world. The marginal value of improvement for each of the breeding goal traits is estimated as illustrated in Figure 2.1. Model assumptions should be based on the anticipated production circumstances when the breeding goal is realized (in the future). However, this is often a difficult task associated with large uncertainties; thus, present circumstances may be used as a compromise. Despite the model being objective in nature, it can be argued that the assumptions are not completely objective.

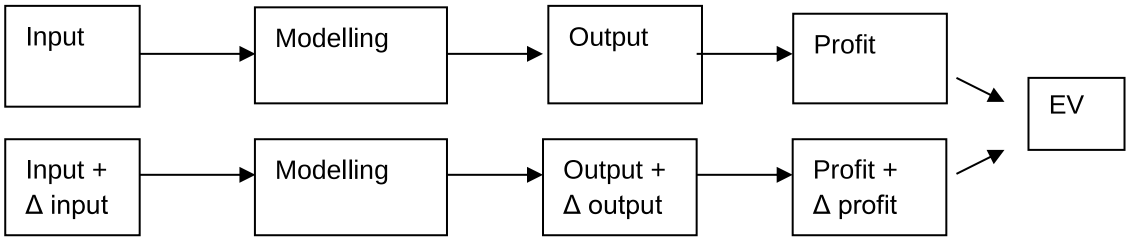

Figure 2.1. Derivation of economic values using a simulation model and partial budgeting. Modified by Nielsen (2004) after Groen (2001).

The basis for the present calculation of economic values is the estimation of marginal profit for the traits included in the breeding goal as described by Brascamp et al. (1985) and Groen et al. (1997). The economic values are marginal economic values, i.e. the economic value of one unit improvement of the trait while the remaining traits are kept constant. The value of milk protein, for example, is therefore calculated as the economic profit of improving milk protein yield by 1 kg whilst all other traits are kept constant.

When using an objective method for calculation of economic values, the starting point is simple profit calculations, e.g. income from sold milk minus feed costs. Usually advanced models can describe economic associations for a broad spectrum of assumptions and over a long time-span. Regardless of the level of complexity, models used for calculating economic values should meet the following requirements:

- The contribution of a trait to the profit must be well defined
- The contribution of a trait to the profit must be independent of changes in other traits
- The selection decisions made today will have an effect 8-10 years into the future – the assumptions must reflect this fact
- Since the time horizon for dairy cattle breeding is long, all costs must in principle be variable

Before the model is agreed on, the economic profit goal must be defined. The profit can be calculated at different levels, for example:

- Per herd
- Per animal (annual cow) within breed
- Per AI company
- For the whole dairy sector
- For the society (per citizen)
- Per unit of sold goods

Often the profit is calculated per herd and under most circumstances the estimated economic weights are independent of the chosen unit.

2.2 Model framework

The economic model used for calculation of economic values for the NTM revision is the same as the model used for the 2008 NTM calculations (Pedersen et al., 2008), although some modifications have been made. It is an objective and deterministic model mimicking the economic situation on a dairy farm. Economics are divided into the following areas in the model: cows, heifers until first calving and bull calves until slaughter, and herd level. The model includes all important factors which affect profit on a dairy farm. The model assumptions include basic values for milk price, feed costs and other income and cost factors, basic phenotypic levels for all traits, and labor associated with handling of cows, e.g. time used for a mastitis treatment or time used for an insemination. These figures are provided for each individual breed and production environment. The breeds considered in the present analyses are Holstein, RDC (RDM, SRB, FAY) and Jersey. The considered production environments are Denmark (DNK), Sweden (SWE) and Finland (FIN). As mentioned in the introduction there has been some developments in the production circumstances for dairy farming during the last decade:

- The number of dairy farms that produce milk according to the organic farming principles has increased such that currently ~15 % of the total amount of milk produced in DNK is organic – assumed to be similar in SWE and FIN.
- Sexed semen is now being used commercially on a large scale. The amount of SS being used for production of heifer dairy calves is steadily increasing.
- The use of SS is often combined with the use of BS. This limits the amount of surplus dairy heifers and enable production of beef×dairy crossbreds that can be sold at higher price compared to their purebred counterparts. The increase in use of SS has therefore also increased the use of BS.
- Health agreement schemes, which enables farmer treatment of certain diseases, have now been fully implemented in DNK and are currently being tested in SWE and FIN. This decreases the costs associated with these diseases.

Three main NTM scenarios were defined because it was necessary to separate effects caused by the different production circumstances, i.e. conventional vs. organic.

Conventional: Economic and biological assumptions are similar to assumptions in the Classic scenario (see below). However, the use of SS and BS was included in this scenario. It was assumed that ~52 % of all replacement heifers shall be born from SS and that the replacement rate would be reduced to 32 % in the future. These assumptions were identical across NAV countries and breeds. Also, assumptions about future health agreement schemes, i.e. herd personnel treatment of certain diseases, were made. We assumed that when the 2018 NTM is realized (in 8-10 years) health agreement schemes will be fully implemented in SWE and FIN at a level similar to the DNK level. This is described in more detail in *Disease traits*.

Organic: The same assumptions with respect to the use of SS and BS and level of replacement rate were made for the Organic scenario as for the Conventional scenario. However, the Organic scenario was based on economic assumptions reflecting organic production circumstances. Biological assumptions were based on the conventional production circumstances, but were adjusted where clear differences can be seen between conventional and organic dairy herds. It was assumed that health agreement schemes are not introduced in organic production systems. However, personnel at organic farmers in SWE can still administer follow-up treatments.

Classic: Similar to the 2008 NTM setup (Pedersen et al., 2008) but with updated economic and biological assumptions. This scenario is only included to assess the effect of changed economic and biological assumptions for comparison with the 2008 results, is based on the conventional scenario but does not include the use of SS and BS.

The three scenarios above was combined with breed and production environment for a total of 27 different scenarios. The final economic value per trait unit was calculated as the mean of the three production environments within each combination of breed and NTM scenario.

In the economic model, the total number of needed replacement heifers is determined by the replacement rate (32 %). The amount of used SS is pre-defined as a certain proportion (~52 %) of born heifer calves being after SS. Knowing the total number of replacement heifers and the number of heifers born from SS, the amount of conventional semen resulting in 50 % heifer calves can then be determined. Once the required number of born replacement heifers is reached, the remaining cows are left to be inseminated with BS. This means that no surplus purebred dairy heifers are produced in the Conventional and Organic scenarios. A simple optimization procedure ensures that the number of surplus heifers is always kept at a minimum, preferable zero, because the number of born heifers or needed replacement heifers may change, when a trait is improved, to calculate marginal economic values. Thus, the number of heifers and cows inseminated with SS, conventional or BS semen may vary depending on combinations of country, breed and trait.

Regarding the use of beef semen for production of beef×dairy crossbreds, it should be noted that only purebred genes are evaluated in the NTM model; beef×dairy crossbreds only carry 50 % purebred dairy genes. This has an effect where the improvement of a trait result in more animals for slaughter. For example, there will be a clear difference between direct and maternal effects for calving when beef semen is used in contrast to purebred dairy semen.

3 Biological assumptions

The phenotypic level of the traits, which together constitute the revised NTM index, must reflect a future production system, i.e. when the revised NTM is realized. Phenotypic levels are important when comparing country-specific values and different scenarios, e.g. conventional vs. organic production systems, because they affect the overall profit of the model herd. However, for most traits, except calving traits and some claw health traits with more than two categories, the economic values are independent of the phenotypic level of the trait. Most phenotypic values shown in this report are based on the newest possible data used for estimation of NAV breeding values. In other cases, qualified guesses on future production circumstances have been made, e.g. use of SS.

3.1 Milk production traits

The economic values of production traits are calculated as sales price of product (milk or meat) minus costs directly related to production – in this case feed costs. The difference (profit) in revenue by increasing the output by one unit (e.g. 1 kg of protein in 1st lactation) will subsequently be used to determine the weight of the production traits in NTM.

Phenotypic levels for milk (and *Growth* traits) differ between country and breed. Differences between countries are mainly caused by different management practices. However, differences in breed composition – especially for RDC – may contribute as well. The assumptions made for yield in the NAV countries are shown in Table 3.1. These values are based on actual national statistics and used in the calculation of income from milk and for the determination of feed costs.

Table 3.1. 305-day yield (kg) in 1st, 2nd and 3rd lactation for RDC, HOL and JER in the NAV countries. Based on yield evaluation data for completed lactations in calving year 2016 (2014 for DNK data).

	Milk			Protein			Fat		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
					RDC				
DNK	7,899	9,018	9,457	278	319	329	334	381	400
SWE	7,870	9,209	9,480	282	329	337	345	400	411
FIN	7,926	9,421	9,959	280	332	342	352	411	428
					HOL				
DNK	8,689	10,162	10,582	292	344	354	343	404	422
SWE	8,719	10,544	10,971	298	359	370	355	426	447
FIN	8,661	10,560	11,197	296	359	374	356	426	452
					JER				
DNK	6,064	7,015	7,279	248	291	301	353	409	427

Additional information was needed to calculate 305-day yield for cows culled before 305 days in milk (DIM). In Table 3.2 the average DIM for culled cows and average days dry (all cows) are shown. 305-days yield for culled cows were estimated using lactation curves adopted from the main Danish management software for cattle (DMS). Culling ratios (established from replacement rate), average DIM, calving intervals and days dry were used to weigh complete and incomplete lactations to get an average lactation yield and annual production within parity for milk, fat and protein.

Table 3.2. Average days in milk (DIM) for culling for culled cows and average days dry in 1st, 2nd and 3rd lactation for RDC, HOL and JER in DNK, SWE and FIN. Based on data from the longevity evaluation for cows that calved in 2014.

	DIM			Days dry		
	1st	2nd	3rd	1st	2nd	3rd
			RDC			
DNK	218	238	224	62	64	64
SWE	236	250	233	65	65	65
FIN	212	233	215	65	65	65
			HOL			
DNK	222	245	225	64	69	69
SWE	237	251	229	65	68	68
FIN	213	229	198	66	66	66
			JER			
DNK	215	228	210	58	60	60

3.2 Growth traits

In DNK approx. 50 % of RDC and HOL bulls are slaughtered as bull calves (age at slaughter ≤ 10 months); there is a special pricing for this group of bulls. The remaining bulls in DNK and all bulls in SWE and FIN are slaughtered as young bulls (age at slaughter > 10 months). Assumed phenotypic levels for growth traits are shown in Table 3.3 and 3.4 for bull calves and young bulls, respectively. Live weight was calculated using the following formulas:

$$\text{Live weight} = \text{carcass weight} \times 100/\text{dressing percentage} \quad (3.1)$$

where

$$\text{Dressing percentage} = (45+2\times\text{carcass weight}/100+2/3\times\text{EUROP form score}+((\text{daily net gain}\times 2000-150)\times 0.005))/100 \quad (3.2)$$

Table 3.3. Growth data for bull calves – age at slaughter ≤ 10 months (DNK only). Based on evaluation data collected 12 months prior to June 21st, 2017.

	Age at slaughter, days	Live weight[1], kg	Carcass weight, kg	Daily net gain, g/day	Daily carcass gain, kg/day	Form EUROP	Fatness EUROP	Share of calves
					RDC			
DNK	295	382	201	1,153	0.612	4.06	2.42	35 %
					HOL			
DNK	293	383	204	1161	0.698	3.64	2.42	48 %
					JER			
DNK	296	306	153	943	0.516	3.00	2.17	6 %

[1]Calculated using formula 3.1

Table 3.4. Growth data for young bulls – age at slaughter > 10 months. Based on evaluation data collected 12 months prior to June 21st, 2017.

	Age at slaughter, days	Live weight[1], Kg	Carcass weight, kg	Daily net gain, g/day	Daily carcass gain, kg/day	Form EUROP	Fatness EUROP	Share of calves
					RDC			
DNK	376	439	235	1,056	0.628	4.20	2.61	64 %
SWE	598	596	331	931	0.564	5.33	2.39	100 %
FIN	613	612	339	930	0.562	4.91	2.40	100 %
					HOL			100 %
DNK	364	425	224	1,050	0.619	3.41	2.41	52 %
SWE	590	596	327	938	0.564	4.37	2.21	100 %
FIN	605	616	340	942	0.570	4.43	2.22	100 %
					JER			
DNK	422	379	190	835	0.453	3.02	2.33	94 %

[1]Calculated using formula 3.1

Beef×dairy crossbreds

For simplicity beef×dairy crossbreds were assumed to have the same slaughter weight and daily gain as pure-breds. However, a higher price can be expected because beef crosses have a higher form score. Using data from Beef×dairy crossesbreds - Results, added values for form score were assumed as presented in Table 3.5. Added values in SWE and FIN were assumed to be the same as the DNK values. Heifer beef crosses were handled in the same way as the bull crosses but they have a lower form score. Values were therefore calculated as the mean of heifer and bull crosses.

Table 3.5. Average added values for form score for beef crosses.

	RDC	HOL	JER
Calves, age ≤ 10 months	+3.00	+3.50	+2.25
Calves, age > 10 months	+4.00	+4.25	+2.75

3.2.1 Feeding

Determination of feed requirements depends on the feed evaluation system that is used. The feed evaluation system currently used in the NAV countries is called NorFor (Nordic Feed Evaluation System; www.norfor.info). This system replaced a simpler system in 2007. For the Original NTM calculations the latter was used for determination of energy and protein requirements (other requirements not considered). It is based on what is referred to as Scandinavian Feed Unit (SFU) as a measure of energy - 1 SFU = 7.89 MJ.

It is no simple task to replace the old SFU system with the NorFor system; however, the 2008 calculations of feed requirements were simple and can still be used for the 2018 calculations. Thus, the NTM working group agreed to re-use the Original calculations (formulas) with few modifications. Formulas for calculating energy and protein requirements for all animal groups can be found in Strudsholm et al. (1999) and Strudsholm and Sejersen (2003). An important aspect related to modelling profit of milk production is the *marginal feed utilization* (MFU) used for correction for declining yield gain with increasing feed energy level, i.e. utilization of the last added SFU is 65 %. Østergård et al. (1989) calculated MFU to be 65 % based on data from 108 Danish dairy herds from 1967 to 1986. This value was retained as in the Original NTM calculations.

Cows – energy and protein requirements

Energy and protein requirements for cows are divided into requirements for maintenance, milk production, growth and fetus. The following formulas were used for calculating energy requirements:

$$SFU_{maintenance} = (\text{mature weight}/200+1.5)\times 1.1 \quad (3.3)$$

Energy requirements for maintenance requirements are multiplied by 1.1 to account for loose housing with or without pasture time. It was assumed that most cows in the future will be housed in free stall barns or put on pasture during summer.

$$SFU_{milk} = 0.4 \text{ SFU per kg ECM} \times \text{kg ECM produced (lactation)} \quad (3.4)$$

$$SFU_{growth} = (\text{mature weight}-\text{weight at }1^{st}\text{ calving})\times 4 \text{ SFU per kg gain}\times \text{culling rate} \quad (3.5)$$

$$SFU_{fetus} = \text{mature weight}/242\times e^{(-0.14\times \text{week before calving})} \quad (3.6)$$

Formula 3.6 forms the basis for the standard energy requirement per pregnancy, 130 SFU for large breeds and 90 SFU for Jersey. Assumed mature weights for each breed are shown in Table 3.7.

The total SFU per cow based on formulas 3.3-3.6 was compared to what was used on average in Denmark in 2016 (reference: Ole Aaes, SEGES). The predicted value was in fact 2.9 % lower than observed. Thus, to reflect reality, the theoretical SFU was multiplied by 1.029.

The calculation of protein requirements (AAT or amino acids absorbed) was simplified compared to the Original NTM calculations. Instead of estimating protein requirement separately for maintenance, milk, growth and fetus, we used a fixed value of 90 g AAT per total SFU. These recommendations are generally accepted mainly because yield increase was observed up to 90 g AAT per SFU but no increase was observed when going above 90 g (Madsen et al., 2003).

Heifers – energy and protein requirements

Heifer growth is determined by age and weight at first calving. In 2008, the average age at calving was 26.9, 25.0 and 25.5 months for HOL, RDC, and JER, respectively. In 2016 these were 26.0, 26.8, and 24.5 (mean of DNK, FIN and SWE) for HOL, RDC, and JER, respectively. We used these figures for the NTM calculation. Weight at calving is not readily available from commercial farms. However, we had access to weight data from farms with automated milking systems (AMS) in DNK. From these, average weights (Table 3.6) for 1st parity cows and mature cows (3rd parity) were calculated for HOL, RDC and JER. Data from cows that had calved in 2016 with weight measurement from 0 to 10 days after calving (DIM) were used. Both weight at 1st calving and mature weight has increased since 2008, especially for JER. However, because JER and RDC weights were based on relatively few farms, validation of the values was needed. For the validation, slaughter data from Danish cows and weight data from the Feed Utilization in Nordic Cattle project (projects.au.dk/func) was used. The final adjusted weights are shown in Table 3.7.

Table 3.6. Average body weight for 1st and 3rd parity (mature) cows excluding the weight of the calf. Based on data from Danish AMS herds and Swedish RDC cows participating in the FUNC project that calved in 2016.

Breed		# obs.	# herds	Mean weight, kg[1]
HOL	1st parity	63,377	96	590
	3rd parity	41,771		690
RDC	1st parity	2,743	16	600
	3rd parity	1,597		670
JER	1st parity	5,476	9	400
	3rd parity	3,447		485

[1]rounded to nearest 5 kg

Table 3.7. Applied values for body weight for 1st and 3rd parity (mature) cows for the 2018 NTM calculations.

Breed		Mean weight, kg
HOL	1st parity	590
	3rd parity	680
RDC	1st parity	565
	3rd parity	655
JER	1st parity	375
	3rd parity	430

Energy requirement up to 100 kg body weight (75 kg for Jersey):

Large breeds $$\text{SFU per day} = 2.8-(100-V)\times 0.030 \quad (3.7)$$

Jersey $$\text{SFU per day} = 2.7-(75-V)\times 0.038 \quad (3.8)$$

where V is the average weight in interval from birth to 100 kg (75 kg for Jersey).

Energy requirements for the remaining time to calving depend on daily gain and were calculated using formula 3.9. Also, it was assumed that all heifers above 100 kg (75 kg for Jersey) were housed in free stalls or put on pasture in the summer time; this increased energy requirements by 5 %. For JER it was assumed that at a given daily gain at a given weight, energy requirements were 25 % larger compared to the large breeds (using results from formula 3.9 ×1.25). The reason for this is that JER at a given daily gain at a given weight is at relatively higher stage of development than HOL and RDC (Fisker et al., 2003). Finally, a feed utilization of 85 % was assumed for all breeds (not to be confused with MFU).

Large breeds $$\text{SFU per day} = e^{(\ln(T+1,738)/(3,079-258\times\ln(V)))/0.28} \times 1.05 \quad (3.9)$$

where T = daily gain in g per day and V = body weight

A heifer's growth period from weaning to calving was divided into several intervals and growth curves were applied to estimate the number of days in each interval. Average body weight and average daily gain were calculated for each interval and used for the calculation of daily energy requirements in each interval.

No AAT standard for heifers exists; usually, standards for digestible crude protein are used. However, for simplicity the AAT standard for cows, 90 gram AAT per SFU, was also applied to the heifers.

Bulls – energy and protein requirements

Energy requirement for bull calves that are not yet weaned - <100 kg (75 kg for Jersey) - were calculated using formulas 3.7 and 3.8 above. In contrast to heifers, energy requirements for weaned bulls are divided into requirements for growth and requirements for maintenance. None of the current traits in the NAV genetic evaluation involves heifer growth; thus, the approach can be simpler for heifers. Energy requirements were increased by 5 % to account for free housing systems. Also, it was assumed that energy requirements for JER bulls were 20 % higher than for the large breeds for a given daily gain at a given weight. The following formula was used to estimate requirements for maintenance:

$$SFU_{maintenance} \text{ per day} = 0.53 \times (0.9 \times V)^{0.67} / 7.89 \times 1.05 \qquad 3.10$$

Energy requirement for growth was estimated using the following formula:

$$SFU_{growth} \text{ per kg weight gain} = 2.17 \times e^{(0.00256 \times V)} \times 1.05 \qquad 3.11$$

where V is body weight.

Requirements for protein were estimated in same way as for heifers, 90 g AAT per SFU.

Dead calves

Some calves die at a young age due to disease or other causes than slaughter. If a calf dies when it is 3 months old there is still a cost associated with feed for the first 3 months. In the Original NTM calculation, these costs were only considered for bull calves. For the 2018 NTM calculations feed costs for dead heifers were also accounted for. Average age at death for dead bull and heifer calves within breed and country (Table 3.8) was calculated using young stock survival data. A dead bull calf was assumed to have died before 184 days of age, whereas a heifer calf was assumed to have died before 458 days or age. The two values were based on the definition of calf survival in the late period for the young stock survival index for bulls and heifer calves, respectively. The feed requirements were estimated using the formulas described above for heifers and bulls.

Table 3.8. Average age (days) at death for calves dying before day 184 and 458 for bulls and heifers, respectively, within breed and NAV country. Based on evaluation data for young stock survival on calves born in 2015 and assumed to be the same conventional and organic herds.

	Bulls			Heifers		
	DNK	SWE	FIN	DNK	SWE	FIN
RDC	70.5	49.0	56.3	92.1	114.5	87.4
HOL	52.1	41.9	43.5	88.0	112.7	80.4
JER	48.8	-	-	89.9	-	-

3.2.2 Feeding schemes

The way dairy cattle are fed differs between the NAV countries; for example, a greater proportion of dairy cows are put on pasture during the summer in FIN and SWE compared to DNK. Also, feed rations fed indoors differ between the countries. The used feeding scheme affects the costs related to milk and growth and should be accounted for. Cattle nutrition experts at SEGES, Växa Sweden and Faba were asked to supply information about average feeding schemes in their respective country. The applied feeding scheme for each NAV country was specified separately for conventional and organic production systems.

In Table 3.9 the basic feeding schemes consisting of roughage + concentrates are presented. Roughage is further divided into pasture (fresh grass), grass silage and maize silage.

Table 3.9. Basic feeding schemes for cows – 2016 figures. Reference: SEGES, Växä Sweden, and Faba.

			Proportion of roughage type in basic ration		
Country	Production system	Proportion of roughage in ration, %	Pasture (fresh grass), %	Grass silage, %	Maize silage, %
DNK	Conventional	60	0	40	60
	Organic	65	20	80	0
SWE	Conventional	60	15	65	20
	Organic	65	20	80	0
FIN	Conventional	55	15	85	0
	Organic	65	20	80	0

3.3 Fertility

The input parameters for the NTM model are conception rate (CR) and insemination rate (IR). The two parameters were estimated based on statistics on length of insemination period (IFL) and number of inseminations (AIS). Actual phenotypes on fertility for heifers and cows are shown in Table 3.10 and 3.11, respectively.

Table 3.10. Assumed phenotypic values for fertility parameters for heifers. Based on fertility evaluation data and calving year 2016

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Age at 1st AI, days	487	549	476	473	544	472	436
1st-last AI (IFL), days	23.8	26.9	23.0	24.6	24.0	21.2	27.4
Number of AI (AIS)	1.60	1.68	1.60	1.64	1.55	1.62	1.67
Age at 1st calving, months	25.7	27.3	25.8	25.3	26.9	25.5	24.1

Table 3.11. Assumed phenotypic values for fertility parameters for cows (mean across parity 1-3). Based on fertility evaluation data and calving year 2016.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Calving-1st AI (ICF), days	74.3	79.6	89.1	76.5	83.3	94.2	71.0
1st-last AI (IFL), days	42.1	46.2	46.6	49.2	52.1	46.7	39.7
Number of AI (AIS)	1.89	1.80	2.01	2.05	1.88	2.01	1.87
Calving interval (CI)	396	406	415	405	415	420	393

The interval from calving to first insemination is lower for RDC compared to HOL. A similar pattern can be seen for IFL. Insemination of heifers starts at the age given in Table 3.10, and insemination of cows starts from 71 to 94.2 days after calving depending on breed and country (Table 3.11). For both heifers and cows, it was assumed that the insemination period continued until pregnancy or until day 168 (8 insemination periods) after first insemination. Animals not pregnant at day 168 were assumed to be slaughtered.

3.3.1 Effect of using SS

The Conventional and Organic scenarios include the use of SS in combination with conventional semen (CS) and BS. The proportions of SS used for first inseminations in the NAV countries in 2017 are shown in Table

3.12. It was assumed that when SS was used, it was used for the first two inseminations before switching to CS or BS.

Table 3.12. Proportions (%) of sexed semen used for first insemination in heifers and cows within breed and country. Based on first inseminations in 2017

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Heifers	30	5	5	30	9	8	42
Cows	4	2	4	3	2	5	20

The values in Table 3.12 do not necessarily reflect the future use of SS (when the revised NTM is realized), i.e. the proportions in SWE and FIN are expected to increase. Based on SimHerd simulation results and a thorough discussion in the NTM group, it was agreed that the following should be implemented for the calculations:

- Approximately 52 % of replacement heifers must be born from SS (proportion of SS used for heifers in the NTM model was increased until this is achieved)
- Proportion of SS used in cows: fixed at 10 % (20 % for JER)
- The same for all countries

Achieved calving statistics when the above requirements were used for RDC, HOL and JER in DNK, SWE and FIN based on conventional assumptions are shown in Table 3.13. The actual proportion of replacement heifers born from SS (bold values in Table 3.13) deviates slightly from 52 % because of differences in stillbirth rate and survival of heifers between countries.

Table 3.13. Achieved calving statistics for RDC, HOL and JER in DNK, SWE and FIN based on the conventional assumptions, herd size = 100 cows.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Number of calving per year	117.5	113.7	114.0	115.4	111.7	113.0	118.8
1st calvings	35.2	35.2	35.2	35.2	35.2	35.2	35.2
2nd calvings	29.2	28.8	28.8	29.0	28.5	28.7	29.3
+3rd calvings	53.2	49.7	50.1	51.2	48.0	49.1	54.4
Replacement heifers out of all calves born, %	33.9	35.6	34.6	34.9	36.2	34.9	36.2
Replacement heifers from 1st parity cows, %	67.4	66.2	67.9	66.5	66.3	68.0	62.3
Replacement heifers from SS, %	**55.4**	**53.4**	**52.1**	**51.9**	**51.6**	**53.1**	**58.9**
Replacement heifers born from heifers inseminated with sexed semen, %	46.4	45.5	46.7	45.8	45.7	46.8	42.9
Replacement heifers from 2+ cows, %	32.6	33.8	32.1	33.5	33.7	32.0	37.7
Replacement heifers from 2+ cows inseminated with SS	9.0	7.9	5.4	6.1	5.9	6.3	16.1

Some fertility parameters are affected negatively when SS is used compared to CS because of decreased viability of SS. It was assumed (based on results from the NAV fertility project 2015-2016) that conception rate, when SS was used, was 90 % of the conception rate when CS is used (both heifers and cows). No evidence was found that conception rate is affected when BS is used.

Number of heifer calves born from SS is defined above and fixed but may differ between countries and breeds due to differences in fertility performance. The proportions of CS and BS were calculated simultaneously using an iterative procedure by adding increasing proportion of CS in each round. For each iteration round the number of available heifers (heifers born from SS + heifers born from CS) was calculated and compared with the number of heifers needed to ensure stable herd size. When the difference was zero or positive, i.e. a surplus of heifers was reached, the procedure was stopped and the proportion of BS was calculated as:

`1-proportion of SS-proportion of CS` (simplified for clarity).

This means that the number of surplus heifers was always minimized in scenarios including SS and BS.

Results from a Danish study indicate that gestation length on average is increased when a beef bull is used compared to a purebred dairy bull. This should be accounted for in the NTM program. Table 3.14 shows the assumed values for extended gestation length when a beef sire is used. The reason that the added gestation length is lower for DNK is because Danish Blues are used extensively in DNK but not in SWE and FIN. On average Danish Blue×dairy crossbreds have a gestation length that is only 1 day longer than dairy purebreds.

Table 3.14. Extended gestation length when beef sires are used compared to when purebred sires are used.

	DNK	SWE	FIN
RDC	+3.45 days	+5.80 days	+5.80 days
HOL	+3.45 days	+5.80 days	+5.80 days
JER	+1.55 days		

3.4 Longevity

The economic value for longevity is based on the economic gain of increasing survival rates, i.e. re-calculating survival rates within parity when the replacement rate is reduced by 1 %-unit. In Table 3.15 and 3.16 survival rates are shown for conventional and organic production systems, respectively, together with the replacement rates. Cow mortality was also included in the calculations to distinguish between dead and slaughtered cows; this has a small effect on the amount of total profit in the model herd. For simplicity only cow mortalities in 1st lactation and later lactations were implemented.

The proportion of cows that survive each lactation is based on data used for genetic evaluation of longevity. However, in the future the proportion of cows in each lactation may be affected by the increased use of SS and BS which tends to decrease the number of replacements needed, i.e. the replacement rate is lowered. Together with increased focus on reducing cow mortality and increasing longevity, this means that the population replacement rate is expected to be lower in the future. Recommendations for a future replacement rate were based on results from SimHerd simulations and subsequent discussions in the NTM group. It was agreed to use replacement rate of 32 % for all breeds and countries. Several herds already have replacement rates below 32 % but the population level is currently higher. The replacement rate level will be further investigated in the sensitivity analyses.

Table 3.15. Lactation survival rates for conventional productions systems, replacement rates and cow mortalities (both conventional and organic). Based on longevity evaluation data from cows that calved in 2014.

	Pct. Survival			Replacement	Pct. Cow mortality	
	1st lact	2nd lact	3rd+ lact	Pct 1st calvings	1st lact	2nd+ lact
				RDC		
DNK	74.4	64.6	51.0	40.5	1.7	4.1
SWE	75.7	67.2	51.7	37.6	2.6	4.1
FIN	79.0	70.6	53.7	35.1	3.3	7.0
				HOL		
DNK	78.6	68.1	51.4	37.1	2.8	4.9
SWE	77.3	67.5	52.8	35.9	4.0	4.9
FIN	81.4	73.0	56.2	32.5	3.7	8.7
				JER		
DNK	78.3	74.8	58.7	33.8	2.7	6.3

Table 3.16. Lactation survival rates for organic productions systems, replacement rates and cow mortalities (both conventional and organic). Based on longevity evaluation data from cows that calved in 2014.

	Pct. Survival			Replacement	Pct. Cow mortality	
	1st lact	2nd lact	3rd+ lact	Pct 1st calvings	1st lact	2nd+ lact
				RDC		
DNK	72.5	64.7	60.6	37.3	1.7	4.1
SWE	77.1	70.0	55.4	35.1	2.6	4.1
FIN	81.5	71.3	55.7	33.4	3.3	7.0
				HOL		
DNK	78.5	70.7	56.7	34.5	2.8	4.9
SWE	78.0	72.4	58.0	32.6	4.0	4.9
FIN	84.4	77.7	57.3	30.1	3.7	8.7
				JER		
DNK	81.6	80.1	67.0	27.8	2.7	6.3

3.5 Calving and birth traits

The applied phenotypic levels for stillbirth and calving ease (Table 3.17) are mean values based on farmer registrations used for the breeding value estimation for calving traits.

Table 3.17. Phenotypic levels for stillbirth and calving ease in 1st and later lactation. Based on evaluation data from cows that calved in 2016.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Stillborn heifer calves, 1st (%)	3.5	3.0	4.9	5.2	5.3	6.9	4.6
Stillborn bull calves, 1st (%)	5.8	6.0	6.4	9.6	9.8	9.4	4.6
Stillborn heifer calves, later (%)	1.9	2.3	4.0	2.1	2.5	3.0	2.3
Stillborn bull calves, later (%)	3.1	3.9	4.9	4.2	5.1	3.8	2.1
Easy, 1st (%)	84.3	90.8	65.5	74.8	88.9	63.4	95.5
Easy with help, 1st (%)	12.5	6.7	27.2	21.6	8.3	29.3	3.4
Difficult without vet. ass. 1st (%)	2.8	2.2	7.1	3.0	2.5	7.1	0.7
Difficult with vet. ass., 1st (%)	0.40	0.3	0.1	0.5	0.3	0.2	0.3
Easy, later (%)	92.5	95.1	79.7	86.8	95.0	80.4	97.9
Easy with help, later (%)	6.1	3.6	17.7	11.6	3.8	17.3	1.5
Difficult without vet. ass., later (%)	0.9	1.0	2.4	1.1	0.9	2.1	0.4
Difficult with vet. ass., later (%)	0.4	0.3	0.2	0.5	0.4	0.2	0.2

The economic value of stillbirth depends on profit (or costs) from rearing both heifers and bull calves. The difference in profit between heifers and bulls is quite substantial. There are also differences in stillbirth rates between the sexes. Therefore, in the calculations a distinction is made for stillbirth rate for heifers and bulls. Generally, stillbirth rates are of similar magnitude in the NAV countries. However, FIN has a slightly higher stillbirth rate for RDC compared to DNK and SWE.

Calvings are grouped in 4 different groups depending on degree of calving difficulties: 1) easy calving without help; 2) easy calving with help; 3) difficult calving without veterinarian assistance; and 4) difficult calving with veterinary assistance. The last group includes both cesareans and dissections of dead calves. The easiest calvings were seen in JER. For HOL and RDC it seems like FIN has a much lower proportion of easy calvings compared to DNK and SWE.

3.5.1 Effect of using BS

The use of BS does affect calving traits and calf viability because of larger calves, and this may affect the economic values of the calving traits. We looked at results on calving ease and stillbirth for beef×dairy crossbreds based on calving data from 2016. It was assumed that BS was used for 2nd parity and later cows only. The size of calf was ignored as larger calves are likely to be expressed as more difficult calvings. Table 3.18 shows mean stillbirth rates for beef×dairy crossbreds (heifers and bull calves, respectively), and mean scores of calving ease for purebred dairy and beef ×dairy crossbreds, respectively.

Table 3.18. Observed results for stillbirth in beef crosses and mean scores for calving ease in purebred dairy and beef×dairy crossbreds (1 = easy calving without help). Based on data from cows that calved in 2016.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Stillborn heifer calves, later (%)	2.1	1.6	4.1	2.5	1.6	3.2	3.1
Stillborn bull calves, later (%)	2.9	3.7	6.0	6.1	4.4	4.3	5.5
Calving ease, purebred, score	1.09	1.07	1.23	1.15	1.07	1.22	1.03
Calving ease beef×dairy, score	1.16	1.12	1.30	1.28	1.15	1.29	1.19

Stillbirth was not affected negatively in RDC and HOL when a beef sire was used to produce beef×dairy heifer calves. Small negative effects were seen for beef×dairy bull calves for FIN RDC and DNK HOL. In JER stillbirths among beef×dairy heifer crossbreds were approximately 50 % higher than their purebred dairy counterparts. For JER bull calves the stillbirth rate more than doubled when a beef sire was used. Mean score for calving ease was affected negatively for all breeds in all NAV countries; a shift towards more difficult calvings was seen (results not shown) most likely because of large calves.

3.6 Young stock survival

This index consists of four traits: heifer survival 1-30 days after birth (HP1), heifer survival 31-458 days (HP2), bull survival 1-30 days (BP1), and bull survival 31-184 days (BP2). The input parameters include mortality rates (1-survival rate) for both periods for heifers and bulls, respectively. Because differences were expected between organic and conventional herds, mortality rates were calculated for conventional (Table 3.19) and organic (Table 3.20) herds, separately.

Table 3.19. Mean mortality rates for young stock (heifers and bulls) for conventional herds. Based on evaluation data from birth years 2012 to March 2017

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
HP1, %	3.5	2.7	2.1	3.6	2.6	1.8	6.5
HP2, %	4.2	6.3	3.4	4.0	5.2	2.6	7.2
BP1, %	4.1	3.0	3.7	5.3	3.7	3.3	9.8
BP2, %	6.7	4.3	5.0	5.3	3.4	3.3	8.3

In most cases mortality rates were slightly higher in the organic herds – the only exceptions were for JER HP2, BP1, BP2, and RDC BP2 for FIN. No information about organic bull calves for SWE was available; thus, values from conventional herds were used.

Table 3.20. Mean mortality rates for young stock (heifers and bulls) from organic farms. Based on evaluation data from birth years 2012 to March 2017

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
HP1, %	3.7	3.0	2.4	4.5	2.7	1.9	6.7
HP2, %	4.2	5.7	3.9	4.5	5.0	3.1	6.9
BP1, %	4.5	3.0	3.9	5.9	3.7	3.7	8.6
BP2, %	8.5	4.3	4.0	6.0	3.4	4.4	6.4

Mortality of beef×dairy crossbreds may be different from purebred dairy. Data from 2000-2016 was used to calculate mean mortality rates for beef×dairy crossbreds (Table 3.21). Unfortunately, only DNK data was available for this; we assumed that mortality rates in SWE and FIN were the same. RDC beef×dairy crossbreds had higher mortality rates for both heifers and bulls compared to purebred RDC calves. The pattern was also the same for HOL except for bull calves 1-30 days after birth which was lower in the beef×dairy crossbreds. For JER, the beef×dairy crossbreds had lower mortality rates for both heifers and bulls except bull calves 1-30 days after birth.

Table 3.21. Mean mortality rates for young stock sired by beef breeds. Based on data from birth years 2000 to September 2017 – no data available from SWE and FIN.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
HP1, %	3.6	-	-	4.0	-	-	5.8
HP2, %	5.0	-	-	4.3	-	-	5.3
BP1, %	4.6	-	-	4.7	-	-	10.0
BP2, %	6.9	-	-	6.8	-	-	6.5

3.7 Disease traits

The assumptions for the phenotypic levels of disease traits were based on registrations used for the routine breeding value estimation and shown for conventional and organic production systems separately. The exact specification of each data set, from which frequencies are calculated, is given in the tables for each of the six categories of diseases/disorders: udder health (Table 3.22 and 3.23), early reproductive diseases (Table 3.24 and 3.25), late reproductive diseases (Table 3.26 and 3.27), metabolic diseases (Table 3.28, 3.29, 3.30, and 3.31), feet and legs diseases not included in claw health (Table 3.32 and 3.33) and claw health (Table 3.35, 3.36, 3.37, 3.38, 3.39, and 3.40). Disease frequencies are shown as first treatment within period (used in routine evaluation) and all treatments within category. The latter was edited such that re-treatments were removed; if there was less than 8 days between two records then the second treatment was considered a re-treatment. No distinction was made between types of records within category, e.g. the udder health category in DNK consists of 12 possible disease/disorder codes. Before removing re-treatments, all codes were "translated" to the same udder health code.

Table 3.22. Phenotypic levels (%) of recorded udder health treatments for each breed within each NAV country in conventional production systems. Based on udder health evaluation data from cows that calved in 2014-2015.

	Evaluation results				Total cases			
	1st lact -15-50 d	1st lact 51-300 d	2nd lact -15-150 d	3rd lact -15-150 d	1st lact -15 – 50 d	1st lact 51-300 d	2nd lact -15-150 d	3rd lact -15-150 d
					RDC			
DNK	6.0	6.7	12.0	14.5	6.9	8.2	21.4	25.6
SWE	2.7	3.1	6.3	9.2	2.9	3.4	10.8	15.5
FIN	2.9	3.4	7.5	9.9	3.1	3.7	11.4	17.9
					HOL			
DNK	6.7	6.2	12.7	17.0	7.7	7.6	23.7	32.1
SWE	3.4	3.8	8.2	12.4	3.6	4.1	13.8	20.2
FIN	2.9	3.9	8.5	12.5	3.1	4.3	16.0	22.8
					JER			
DNK	10.0	6.5	9.5	11.8	11.3	8.2	14.4	24.1

Table 3.23. Phenotypic levels (%) of recorded udder health treatments for each breed within each NAV country in organic production systems. Based on udder health evaluation data from cows that calved in 2014-2015.

	Evaluation results				Total cases			
	1st lact -15-50 d	1st lact -1-300 d	2nd lact -15-150 d	3rd lact -15-150 d	1st lact -15 – 50 d	1st lact 51-300 d	2nd lact -15-150 d	3rd lact -15-150 d
				RDC				
DNK	3.4	4.3	7.7	8.7	3.6	5.3	12.1	11.7
SWE	2.4	2.7	5.8	8.7	2.6	2.9	9.8	14.4
FIN	1.9	3.1	7.1	9.3	1.9	3.3	12.2	15.1
				HOL				
DNK	4.8	4.3	9.7	13.3	5.1	4.8	16.2	21.6
SWE	3.1	3.3	7.8	11.2	3.2	3.5	13.1	18.0
FIN	1.4	2.2	5.0	8.8	1.4	2.2	10.8	14.3
				JER				
DNK	8.7	3.9	6.8	9.7	9.0	7.5	11.2	15.0

Table 3.24. Phenotypic levels (%) of early reproductive diseases for each breed within each NAV from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact 0-40 d	2nd lact 0-40 d	3rd+ lact 0-40 d	1st lact 0-40 d	2nd lact 0-40 d	3rd+ lact 0-40 d
			RDC			
DNK	5.9	7.9	9.9	6.4	8.8	11.0
SWE	0.9	1.3	1.7	1.0	1.3	1.7
FIN	2.2	2.7	3.7	2.4	3.0	4.0
			HOL			
DNK	10.7	11.2	14.2	11.9	12.5	16.1
SWE	1.3	1.8	2.3	1.3	1.8	2.4
FIN	2.3	2.3	3.0	2.4	2.5	3.3
			JER			
DNK	2.5	3.1	3.4	2.7	3.3	3.8

Table 3.25. Phenotypic levels (%) of early reproductive diseases for each breed within each NAV country in organic production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact 0-40 d	2nd lact 0-40 d	3rd+ lact 0-40 d	1st lact 0-40 d	2nd lact 0-40 d	3rd+ lact 0-40 d
			RDC			
DNK	3.0	3.5	5.1	3.1	3.7	5.1
SWE	0.8	0.8	1.2	0.8	0.8	1.2
FIN	1.3	1.7	2.0	1.3	1.8	2.0
			HOL			
DNK	4.2	5.9	7.9	4.4	6.1	8.4
SWE	1.2	1.5	1.7	1.2	1.6	1.7
FIN	1.0	0.5	1.4	1.1	0.5	1.4
			JER			
DNK	0.5	2.2	2.6	1.0	2.5	2.9

Table 3.26. Phenotypic levels (%) of late reproductive diseases for each breed within each NAV country in conventional production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact 41-300 d	2nd lact 41-300 d	3rd+ lact 41-300 d	1st lact 41-300 d	2nd lact 41-300 d	3rd+ lact 41-300 d
			RDC			
DNK	1.4	1.9	2.44	1.6	2.3	2.9
SWE	4.5	5.5	6.01	5.1	6.3	6.7
FIN	10.1	11.1	12.42	12.6	13.9	15.9
			HOL			
DNK	1.9	3.0	3.88	2.2	3.4	4.6
SWE	5.6	7.1	7.56	6.5	8.8	9.3
FIN	10.9	12.7	13.39	13.9	16.3	17.6
			JER			
	1.7	2.2	2.64	2.0	2.7	3.2

Table 3.27. Phenotypic levels (%) of late reproductive diseases for each breed within each NAV country in organic production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact 41-300 d	2nd lact 41-300 d	3rd+ lact 41-300 d	1st lact 41-300 d	2nd lact 41-300 d	3rd+ lact 41-300 d
			RDC			
DNK	1.0	0.6	1.7	1.0	0.6	2.0
SWE	4.2	5.4	5.3	4.7	6.0	5.8
FIN	5.8	6.7	8.7	6.5	7.5	11.2
			HOL			
DNK	1.1	1.4	2.1	1.2	1.5	2.4
SWE	4.3	6.6	5.7	5.0	8.1	7.0
FIN	4.4	6.8	6.2	4.8	9.0	7.4
			JER			
	0.9	1.8	3.0	1.9	3.0	3.4

Records of metabolic diseases are included as a sub-index in the General Health index that was changed in November 2017. Metabolic diseases were split into a sub-index containing treatments of ketosis and a sub-index containing treatments of metabolic disorders other than ketosis. Ketosis represents between 11 and 55 % of the total number of metabolic disease treatments depending on country and parity.

Table 3.28. Phenotypic levels (%) of metabolic diseases other than ketosis for each breed within each NAV country in conventional production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd + lact -15-300 d
			RDC			
DNK	1.0	2.8	73	1.1	2.9	7.6
SWE	1.0	2.2	5.2	1.1	2.3	5.5
FIN	1.4	2.5	5.8	1.4	2.7	6.2
			HOL			
DNK	1.6	3.8	8.9	1.7	4.0	9.4
SWE	1.3	3.0	7.4	1.4	3.1	7.9
FIN	1.6	23.0	7.8	1.7	3.2	8.4
			JER			
DNK	2.4	6.7	15.1	2.6	7.1	16.1

Table 3.29. Phenotypic levels (%) of metabolic diseases other than ketosis for each breed within each NAV country in organic production systems. Based on general health evaluation from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd + lact -15-300 d
			RDC			
DNK	0.5	0.5	1.8	0.7	0.5	2.1
SWE	1.0	1.7	5.4	1.0	1.8	5.7
FIN	0.9	1.3	3.1	0.9	1.3	3.1
			HOL			
DNK	1.4	2.0	6.1	1.5	2.1	6.3
SWE	1.2	2.8	7.7	1.2	3.0	8.2
FIN	0.5	1.7	4.2	0.5	1.8	4.5
			JER			
DNK	2.0	4.1	9.7	2.8	4.2	10.8

Table 3.30. Phenotypic levels (%) of ketosis for each breed within each NAV country in conventional production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d
			RDC			
DNK	1.3	2.1	4.4	1.4	2.2	4.9
SWE	0.4	0.7	1.1	0.4	0.7	1.2
FIN	0.6	1.0	1.2	0.6	1.1	1.3
			HOL			
DNK	2.1	2.8	4.8	2.2	2.9	5.2
SWE	0.3	0.5	1.0	0.3	0.6	1.0
FIN	0.6	1.1	1.9	0.7	1.2	2.1
			JER			
DNK	3.1	1.9	2.7	3.3	2.0	2.8

Table 3.31. Phenotypic levels (%) of ketosis for each breed within each NAV country in organic production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d
				RDC		
DNK	0.1	0.1	0.4	0.1	0.1	0.4
SWE	0.3	0.4	0.8	0.3	0.4	0.8
FIN	0.6	0.6	0.9	0.7	0.6	1.0
				HOL		
DNK	0.3	0.5	1.0	0.3	0.5	1.0
SWE	0.2	0.3	0.5	0.2	0.3	0.6
FIN	0.2	0.8	0.6	0.2	0.8	0.8
				JER		
DNK	0.5	0.9	0.3	0.9	1.0	0.2

Table 3.32. Phenotypic levels (%) of feet and leg diseases for each breed within each NAV country in conventional production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d
				RDC		
DNK	7.2	5.3	6.3	8.8	6.2	7.4
SWE	1.8	1.6	2.4	1.9	1.6	2.4
FIN	1.6	1.2	1.4	1.8	1.3	1.5
				HOL		
DNK	7.9	7.7	8.6	9.5	9.4	10.6
SWE	1.6	1.6	2.7	1.7	1.7	2.7
FIN	1.6	1.4	1.9	1.8	1.5	2.2
				JER		
DNK	7.3	5.3	5.9	8.8	6.2	6.9

The much higher frequencies of feet and leg diseases in DNK compared to SWE and FIN can be explained by an increase in treatments of foot root after introduction of health agreement schemes in DNK. This is one of the diseases where treatment can be initiated by the herd manager.

Table 3.33. Phenotypic levels (%) of feet and leg diseases for each breed within each NAV country in organic production systems. Based on general health evaluation data from cows that calved in 2014-2015.

	Evaluation data			Total cases		
	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d	1st lact -15-300 d	2nd lact -15-300 d	3rd+ lact -15-300 d
			RDC			
DNK	4.2	4.0	2.88	5.0	4.9	3.0
SWE	1.5	1.3	1.73	1.6	1.3	1.8
FIN	1.7	0.7	0.93	1.8	0.7	1.0
			HOL			
DNK	3.9	3.1	3.29	4.4	3.4	3.5
SWE	1.5	1.2	2.22	1.5	1.2	2.3
FIN	1.5	1.1	1.69	1.7	1.1	1.9
			JER			
DNK	5.0	4.7	3.82	8.0	4.4	4.3

3.7.1 Claw Health

Records of 7 different claw health categories are defined for the genetic evaluation of claw health (Table 3.34). Three categories include two disorders (none/sick) and 4 categories can be scored as either none, mild or severe. For DE (dermatitis), digital dermatitis was considered the severe form and interdigital dermatitis the mild form. In DNK, only one category is recorded for DE, i.e. no severe cases.

In Table 3.35, 3.36, 3.37, 3.38, 3.39, and 3.40 frequencies of the 7 claw health categories are shown for RDC, HOL and JER in 1st to 3rd parity cows that calved in 2014-2015 for conventional and organic production systems, respectively.

Table 3.34. Claw health disorders included in the routine genetic evaluation of claw health.

Disorder	Abbreviation	Severity levels
Sole ulcer	SU	3
Sole hemorrhage	SH	3
Heel horn erosion	HH	3
Dermatitis (digital dermatitis + interdigital dermatitis)	DE	3
Skin proliferation (interdigital hyperplasia + verrucose dermatitis)	SP	2
White line separation (white line separation + double sole)	WLS	2
Cork screw claw	CSC	2

Table 3.35. Phenotypic levels (%) of claw health disorders in conventional RDC herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.			2nd parity			3rd parity		
	DNK	SWE	FIN	DNK	SWE	FIN	DNK	SWE	FIN
					Mild cases				
SU	3.4	4.3	1.8	3.4	2.4	1.2	2.6	2.4	1.8
SH	14.7	17.9	13.3	11.3	11.7	9.2	7.5	7.8	10.4
HH	7.6	16.1	6.1	6.0	15.6	7.2	5.0	10.8	8.4
DE	28.3	8.6	1.6	24.2	7.7	1.1	15.6	5.9	1.3
CSC	1.2	2.9	8.5	1.6	3.5	9.8	1.0	2.2	10.5
SP	7.1	2.6	1.3	10.7	4.6	2.5	9.2	5.4	2.4
WLS	11.3	3.7	6.7	14.3	4.7	7.8	13.5	4.9	10.9
					Severe cases (for CSC, SP and WLS only one severity class)				
SU	3.2	1.4	0.3	4.5	1.3	0.3	5.0	1.1	0.5
SH	6.5	6.5	1.4	6.5	4.6	0.7	5.5	4.1	0.9
HH	1.8	2.3	0.8	2.5	3.0	1.2	1.8	2.5	1.6
DE	0.0	6.5	1.0	0.0	4.9	1.0	0.0	3.2	1.1

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

Table 3.36. Phenotypic levels (%) of claw health disorders in organic RDC herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.			2nd parity			3rd parity		
	DNK	SWE	FIN	DNK	SWE	FIN	DNK	SWE	FIN
					Mild cases				
SU	2.0	3.4	6.0	1.0	1.8	0.0	0.0	1.9	0.0
SH	19.8	13.4	14.7	14.2	8.4	5.9	2.9	6.8	4.6
HH	5.1	9.6	2.6	3.6	10.7	7.6	0.0	7.4	9.1
DE	5.8	5.4	2.6	11.2	4.7	0.0	14.7	3.8	1.1
CSC	0.8	2.6	10.3	0.5	3.7	14.4	5.9	2.5	15.9
SP	2.7	2.1	0.9	6.6	3.2	0.0	8.8	2.1	2.3
WLS	9.3	3.9	8.6	12.2	5.3	7.6	8.8	7.6	11.4
					Severe cases (for CSC, SP and WLS only one severity class)				
SU	1.2	1.2	0.0	0.5	0.7	0.9	5.9	0.4	4.6
SH	3.5	4.6	0.0	1.0	2.3	0.9	2.9	2.3	1.1
HH	1.2	0.8	0.9	2.0	1.1	1.2	0.0	1.1	1.1
DE	0.0	2.5	0.0	0.0	2.4	1.7	0.0	1.0	0.0

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

Table 3.37. Phenotypic levels (%) of claw health disorders in conventional HOL herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.			2nd parity			3rd parity		
	DNK	SWE	FIN	DNK	SWE	FIN	DNK	SWE	FIN
					Mild cases				
SU	2.5	3.9	2.7	3.0	3.8	2.8	2.6	2.7	3.9
SH	19.1	20.1	15.9	15.2	14.6	13.2	11.2	9.7	13.5
HH	10.8	15.0	7.3	10.6	14.5	8.7	8.4	9.8	9.2
DE	37.7	9.9	2.9	32.8	10.0	2.0	23.5	6.8	2.0
CSC	1.0	1.8	5.1	1.3	2.3	7.1	1.0	1.3	7.9
SP	6.6	3.5	2.2	9.6	5.8	3.4	9.3	7.7	4.7
WLS	11.9	4.1	10.0	14.2	6.1	11.7	11.9	5.4	15.8
					Severe cases (for CSC, SP and WLS only one severity class)				
SU	2.5	1.8	0.7	3.8	1.9	0.8	3.5	1.7	1.35
SH	8.9	7.8	1.7	8.6	5.5	0.9	6.7	4.7	1.09
HH	1.9	2.3	1.0	3.0	2.5	1.5	2.8	1.7	1.86
DE	0.0	11.7	2.1	0.0	7.8	1.6	0.0	4.8	1.20

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

Table 3.38. Phenotypic levels (%) of claw health disorders in organic HOL herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.			2nd parity			3rd parity		
	DNK	SWE	FIN	DNK	SWE	FIN	DNK	SWE	FIN
					Mild cases				
SU	2.0	3.4	6.0	1.0	1.8	0.0	0.0	1.9	0.0
SH	19.8	13.4	14.7	14.2	8.4	5.9	2.9	6.8	4.6
HH	5.1	9.6	2.6	3.6	10.7	7.6	0.0	7.4	9.1
DE	5.8	5.4	2.6	11.2	4.7	0.0	14.7	3.8	1.1
CSC	0.3	1.0	7.6	7.2	2.1	9.5	0.4	0.9	14.8
SP	1.9	2.0	0.0	4.0	3.9	4.8	5.0	6.5	3.3
WLS	7.8	4.5	12.6	9.6	6.1	16.2	8.7	6.9	21.3
					Severe cases (for CSC, SP and WLS only one severity class)				
SU	3.0	1.8	0.6	2.5	0.8	1.0	2.6	0.6	1.6
SH	8.0	6.7	2.5	5.5	5.7	0.0	6.1	5.9	0.0
HH	0.6	0.9	0.8	1.1	1.8	0.0	2.5	0.9	1.6
DE	0.0	3.9	0.8	0.0	2.9	0.0	0.0	1.7	1.6

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

Table 3.39. Phenotypic levels (%) of claw health disorders in conventional DNK JER herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.	2nd lact.	3rd lact.
		Mild cases	
SU	4.3	4.2	3.2
SH	11.6	9.5	6.4
HH	7.5	7.1	5.2
DE	18.9	14.7	10.0
CSC	1.2	2.3	1.4
SP	1.3	1.9	1.5
WLS	8.0	10.7	8.7
		Severe cases	
SU	3.4	4.7	4.7
SH	2.6	2.8	2.3
HH	0.3	0.7	0.7
DE	0.0	0.0	0.0

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

Table 3.40. Phenotypic levels (%) of claw health disorders in organic DNK JER herds. Based on claw health evaluation data from cows that calved in 2014-2015.

	1st lact.	2nd lact.	3rd lact.
		Mild cases	
SU	1.2	2.0	0.0
SH	24.1	15.0	15.0
HH	9.9	3.8	2.5
DE	6.2	7.8	15.0
CSC	0.2	0.9	2.5
SP	0.2	0.3	0.0
WLS	7.6	14.7	17.5
		Severe cases	
SU	0.7	1.7	5.0
SH	2.1	7.8	12.5
HH	0.2	0.0	0.0
DE	0.0	0.0	0.0

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

4 Economic assumptions

The economic values that are calculated should reflect the future economic production circumstances, e.g. milk price and feed costs. This, however, is very difficult to obtain for some traits/factors, especially if prior values have fluctuated a lot. National and international (EU) statistics, statements from experts in each NAV country and other relevant sources were used to get the most realistic picture of the economic circumstances in each country.

4.1 Cost of labor

Cost of labor is included in the calculation of economic values for several NTM traits (specified below) and should preferably reflect future labor costs when the changes to the breeding goal are realized in 8-10 years. However, it is very difficult to predict a future hourly wage rate; thus, the hourly wage rates used for the NTM calculations are based on 2017 circumstances. For the 2008 NTM calculations the cost of labor was based on Danish circumstances. The hourly wage rates shown in Table 4.1 are based on budget calculations at SEGES (DNK) and a combination of EU statistics and discussions with Växa Sweden and Faba/Luke (FIN) experts.

Table 4.1. Hourly wage rates 2017 for SWE, DNK and FIN

	SWE	DNK	FIN
Hourly wage rates for 2017, €	21.50	25.33	20.07

4.2 Milk and feed pricing

The economic value of milk, fat and protein depend on the relationship between milk price and feed costs. The milk price in each country was constructed as the sum of the following components: price for protein, price for fat, price for (residual) milk, and additional values, e.g. quality payment, payouts to cooperative members or subsidies.

For the 2008 NTM calculations, 2007 prices were used for both milk and feed because of a stable relationship between milk price and feed. For the current NTM calculations, a similar approach was not possible because milk price has fluctuated for the last 6-7 years (Figure 4.1). The project group has discussed the challenge of finding the correct balance between milk price and feed costs intensively. We looked at what experts believe the future milk price would be and what future feed costs would be. Using profit per annual cow as a guide to find a suitable balance between countries and production systems, we settled on the values presented below (Table 4.2).

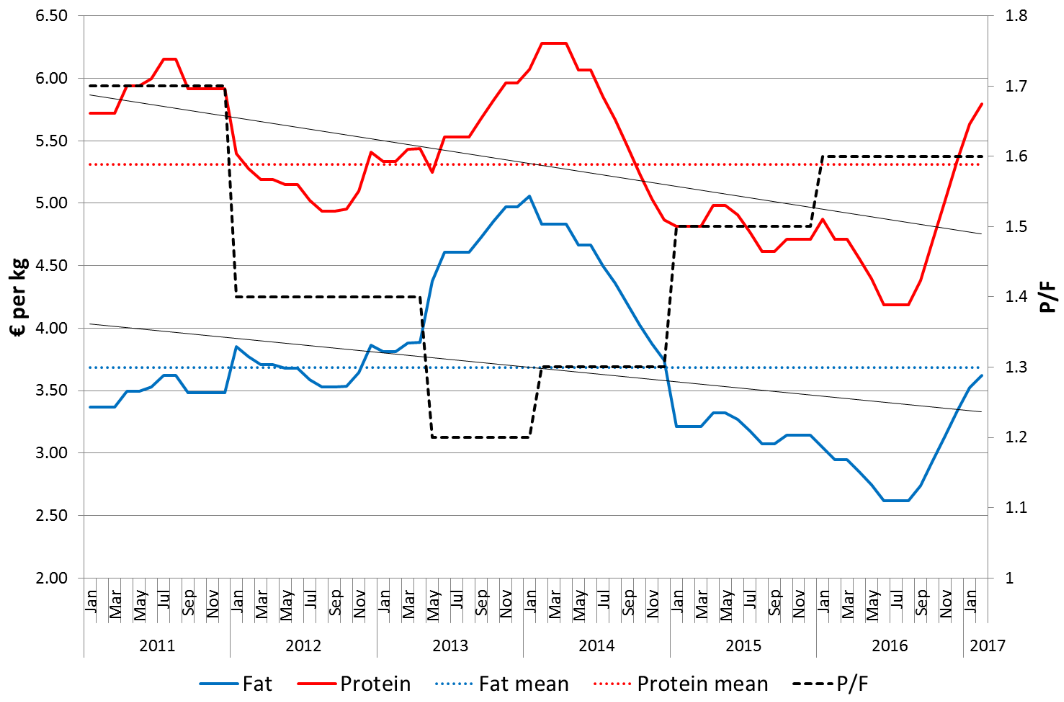

Figure 4.1. Fat and protein prices and fat-protein relationship from 2011 to 2017. Based DNK milk prices (ARLA). Regression lines (grey) for both fat and protein show the overall price trend.

Standard milk expresses the price per kg milk with 3.40 % protein and 4.20 % fat. A calculated average milk price will be presented in the *Results* section. The standard milk values also contain added values such as quality payment, payouts to cooperative members, regional subsidies etc. In Finland, the added value for organic milk compared to conventional milk is fixed at 0.145 € per kg. This value was transformed and distributed on the price of fat and protein.

Table 4.2. Assumptions for the price of conventional and organic milk.

	Unit	Sweden	Denmark	Finland
			Conventional	
Milk	€/kg	-0.016	-0.016	0.00
Fat	€/kg	4.14	4.14	2.52
Protein	€/kg	5.97	5.97	6.93
"Standard milk"	€/kg	0.359	0.359	0.341
			Organic	
Milk	€/kg	-0.016	-0.016	0.00
Fat	€/kg	5.17	5.17	4.06
Protein	€/kg	7.44	7.44	9.28
"Standard milk"	€/kg	0.452	0.452	0.486

Forecasted feed prices for 2018 in DNK were used to represent future feed costs in conventional and organic herds; they are shown in Table 4.3 Values were partly provided by experts at SEGES, Växa Sweden and ProAgria but EU statistics on e.g. grain prices were also used to determine the final values.

Table 4.3. Assumptions for conventional and organic feed costs.

	Unit	Sweden	Denmark	Finland
			Conventional	
Concentrates	€/kg	0.243	0.243	0.250
Grain	€/kg	0.150	0.165	0.190
Milk powder	€/kg	1.73	1.91	1.91
Calf mixture, starter	€/kg	0.357	0.272	0.340
Calf mixture	€/kg	0.180	0.195	0.220
Silage[1]	€/SFU	0.157	0.147	0.179
			Organic	
Concentrates	€/kg	0.487	0.457	0.520
Grain	€/kg	0.259	0.348	0.360
Calf mixture, starter	€/kg	0.548	0.653	0.590
Calf mixture	€/kg	0.379	0.468	0.448
Silage[1]	€/SFU	0.188	0.178	0.217

[1]Weighted average of grass and maize silage for conventional and grazing and grass silage for organic. Scandinavian feed unit: approx. 7.89 MJ energy per SFU.

4.3 Beef pricing

Beef pricing in the NAV countries follows the EUROP classification scheme for form, fatness and color. Prices are country-specific and divided into four categories. Figure 4.2 and 4.3 show the development of beef prices (form EUROP form class R3) for DNK, SWE and FIN from 2008 to 2017 for bull calves and young bulls, respectively. Bull calves are required to be between 8 and 10 months of age at slaughter and young bulls are at least 10 months old at slaughter. Large fluctuations in prices were observed for young bulls especially for SWE, which is currently at a very high level compared to DNK and FIN. Less fluctuation was seen for bull calves. Mean values for the shown time periods were calculated. For DNK and FIN the mean price was used as input for the NTM program. SWE is currently at a very high value but the SWE price has also been considerably lower than the prices in DNK and FIN in the past. The SWE beef producers mainly produce for the home market and can only meet approx. 50 % of the demand. This indicates that the SWE price may stay at a high level for a while. We took a conservative approach to this and adjusted the mean SWE price upwards compared to the mean SWE price with half the difference between the current DNK and SWE prices. Finally, all prices were adjusted to the EUROP form class O2 level using DNK figures – the difference between R3 and O2 is currently -19.33 € per 100 kg carcass.

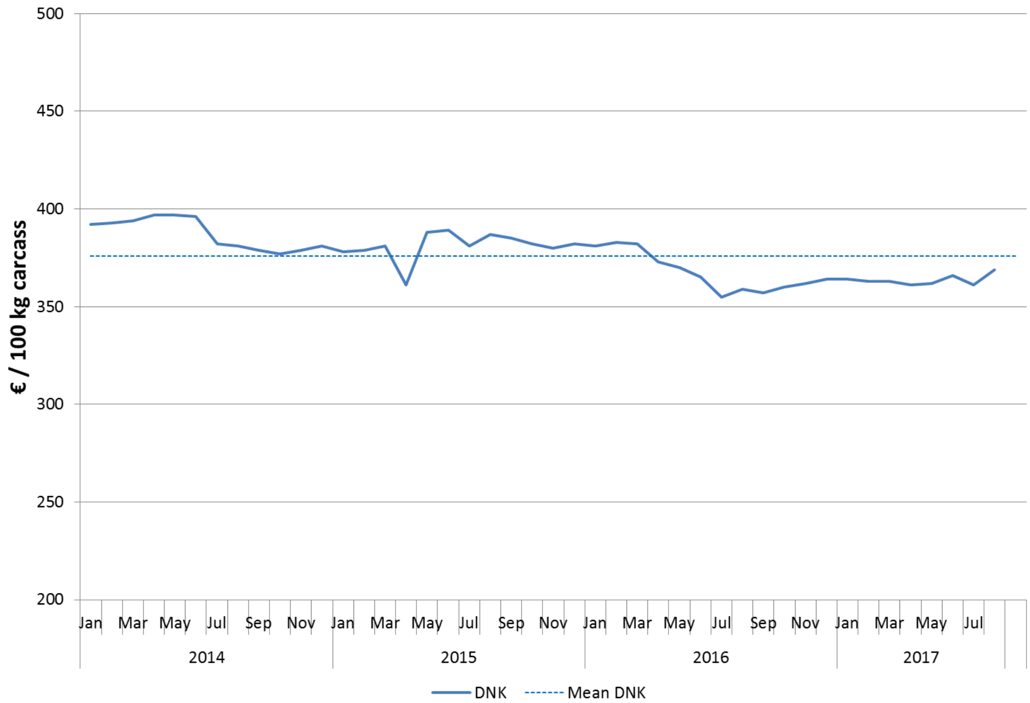

Figure 4.2. Beef price (EUROP form class R3) for bull calves (≤ 10 months) for DNK 2014-2017. Dashed line shows mean price across years. Source: EU.

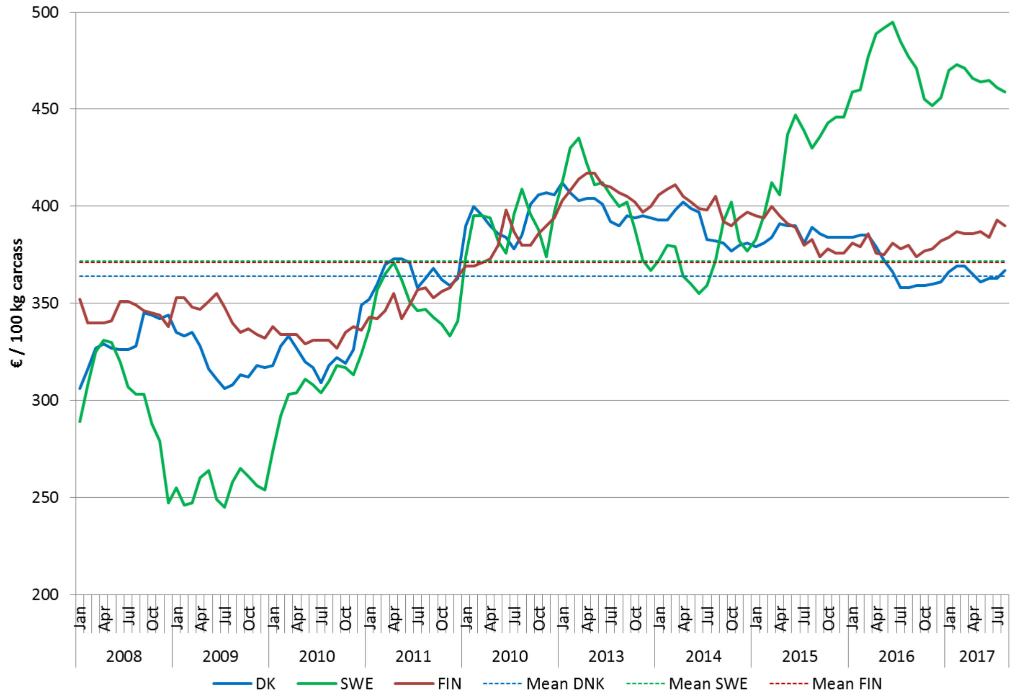

Figure 4.3. Beef prices (form class R3) for young bulls (>10 months) for DNK, SWE and FIN 2008-2017. Dashed line shows mean prices across years. Source: EU.

The standard prices used as input in the NTM program are shown in Table 4.4 for EUROP form class 5 (O2), fatness class 3, and color class 3. Prices for heifers and cows were calculated in a similar manner (details not shown).

Under organic production circumstances no bulls are slaughtered before 10 months of age. For the remaining groups, it has been difficult to find useable prices as they vary a lot depending on slaughter house, the types of contract and quality requirements. Again, we took a rather conservative approach and used the prices from the conventional scenario + a fixed added value for each group based on values from Friland A/S, Europe's largest organic meat company; thus, added values for organic beef were assumed to be similar in DNK, SWE and FIN. The final values for organic beef production are also shown in Table 4.4.

Table 4.4. Assumptions on beef price, € per kg carcass, for conventional and organic beef for standard classification, form class 5 (O), fatness class 3, and color class 3. Source: EU.

Animal category	Production system	Country		
		SWE	DNK	FIN
Bull calves	Conventional	-	3.76	-
(≤ 10 months)	Organic	-	-	-
Young bulls	Conventional	3.98	3.45	3.52
(> 10 months)	Organic	4.65	4.12	4.19
Heifers	Conventional	4.20	3.12	3.01
	Organic	5.60	4.52	4.41
Cows	Conventional	3.63	2.77	2.24
	Organic	4.30	3.44	2.91

4.4 Fertility

Costs related to fertility consists of the extra workload related to heat detection and performing AI if done by the herd personnel. Costs related to inseminations performed by the AI technician are based on 2016 prices from VikingGenetics (`visiting fee on week days + fee per AI + production costs per dose of semen = €26.60`) – costs in SWE and FIN were assumed to be 20 % higher than DNK. Costs related to selection, i.e. choosing a specific bull, was not included because this is a management decision and not common for all herds. Also costs related to selection at population level, i.e. breeding planning, was not included. The average costs related to AI depend on the proportion of inseminations by herd personnel in each NAV country. Based on actual statistics and assumptions about the future, the proportion of inseminations by herd personnel in DNK, SWE, and FIN was assumed to be 20, 60, and 30 %, respectively. Labor related to one AI for herd personnel was assumed to be `0.25 hours + proportion of owner inseminations × 0.25 hours`. Labor related to heat observation was assumed to be 42 seconds per day a cow is observed (similar in all countries). Sexed semen is more expensive to produce than conventional semen resulting in a higher price per dose. This needs to be considered when SS is used in the NTM calculations. These assumptions resulted in the values presented in Table 4.5.

Table 4.5. Assumed costs related to one AI in each NAV country

	SWE	DNK	FIN
Cost per AI, €	17.45	23.08	23.78
Cost per AI (SS), €	28.45	34.08	34.78
Labor related to one AI (herd personnel), hours	0.40	0.30	0.33

4.5 Longevity

The value of longevity was estimated based on changes in culling rates (% cows surviving a lactation), for example by decreasing culling rate in 3rd lactation by 10 %. The economic value of improving longevity by surviving 1 day longer in 3rd lactation is impacted by numerous factors because changing the distribution of cows among lactation affects many other traits. Thus, economic value of longevity is affected by the economic assumptions for the traits that are affected when culling rate is changed.

4.6 Calving and birth traits

The economic value of calving ease is associated with the extra labor required for assisted calvings and depend on the severity. Assumed labor for the herd personnel is presented in Table 4.6. It was assumed that *easy calving without help* did not cause extra labor. A stillborn calf also requires extra labor. For FIN, it was assumed that 75 % of all stillborn calves were buried which resulted in a much higher work load for stillborn calves in FIN. Also, cost of destruction should be accounted for. For FIN destruction costs were adjusted to account for only 25 % of the stillborn calves being destructed; the remaining calves were burried. It was assumed that destruction cost in SWE was twice the DNK value.

Table 4.6. Assumptions on extra labor for the herd manager related to calvings and handling of stillborn calves.

	SWE	DNK	FIN
Easy calving with help, hours /calving	0.20	0.20	0.20
Difficult calving without vet. ass, hours/calving	1.50	1.50	1.50
Difficult calving with vet. ass., hours/calving	3.35	3.35	3.70
Stillborn calf, hours/calf	0.25	0.25	0.63
Destruction, €/calf	15.80	7.90	17.30

Veterinary costs related to difficult calving include veterinary fees and medicine for calving assistance (80 %) and veterinary fees and medicine related to cesareans and dissections of dead calf (20%). Finally, it was assumed that milk was retained for 1.2 days following a difficult calving with veterinary assistance. The values are shown in Table 4.8, 4.9, and 4.10 below.

4.7 Young stock survival

The economic values related to keeping young stock alive depend primarily on income and costs related to rearing heifers and bulls – the latter for slaughter – but also on the amount of produced beef×dairy crossbreds. Thus, economic values for young stock also depend on the amount BS (indirectly on SS) used in the calculations because it affects the number of animals for slaughter. For calculation the economic values for the young stock survival traits, it was also taken into consideration that only 50 % of the purebred genes are expressed in beef×dairy crossbreds.

4.8 Disease traits

The costs related to disease consist of treatment costs (veterinarian fee + medicine and materials), extra labor for the herd personnel and the amount of retained milk in case of antibiotic treatment. Long-term effects on yield caused by disease (e.g. in case of mastitis) are assumed to be captured by the breeding values for yield and not considered as costs related to diseases. Since the 2008 NTM calculations, health agreement schemes have been introduced in Denmark and are on a trial basis in Sweden and Finland. In Finland medicine can be bought for re-treatments after prior agreement with the herd veterinarian. In Sweden, standard practice (trials with health agreement schemes excluded) is that the herd veterinarian performs the diagnosis of an infectious disease (e.g. mastitis) and the initial treatment. After that the herd personnel can do re-treatments (or follow-up treatments) for the most common diseases in both conventional and organic production systems.

The costs related to a disease depend on which health agreement scheme are used. In DNK a health agreement scheme is mandatory when a herd consists of more than 100 cows or 200 young stock but it is also possible to join on a voluntary basis. Three main schemes are used:

1. Basic agreement – all treatments are done by the herd veterinarian
2. Basic agreement + module 1 - all diagnoses and initial treatments are done by the herd veterinarian. The herd personnel can perform re-treatments for certain diseases and initiate treatments of young stock. This scheme is assumed to be like the prescription scheme in FIN.
3. Basic agreement + module 2 – the herd personnel can initiate treatment of certain diseases for a limited or unlimited time period. Further instructions and authorization also allow the herd personnel to initiate treatment of milk fever and/or retained placenta.

The distribution of the different health agreement schemes (linked to herd number) in DNK on December 31st, 2016 was calculated using data from the Danish Cattle Database. The distribution was 0.10, 0.37 and 0.53 for schemes 1, 2, and 3, respectively. The treatment authorization for milk fever and retained placenta (linked to person) was assumed to be 50 % participation for the herds with module 2. This was based on information from The Danish Ministry of Environment and Food (more than 2,000 authorizations have been given since the introduction in 2014). Organic herds in DNK can only participate in the basic agreement scheme – all treatments are done by the herd veterinarian.

Regarding the future when the NTM index is realized, a few assumptions had to be made about participation in the various health agreement schemes. For DNK it was assumed that the present schemes will continue. Thus, the figures above regarding distribution of the different schemes were assumed to be similar in the future. For SWE and FIN, it was assumed that health agreement schemes similar to the Danish setup will be implemented in the future with similar distributions except that the basic scheme will not exist under Swedish circumstances. For FIN, it was assumed that 50 % of the Finnish herds participating in the basic scheme take advantage of the possibility of performing re-treatments after initial treatment by the herd veterinarian.

Assessment of average treatment costs incl. re-treatments was done by collecting information from each country. In DNK, for example, 3 veterinary practices were asked to specify the costs of veterinary work (incl. mileage or time spend) and medicine + materials for a list of common diseases/disorders used for breeding value estimation. For SWE, national guidelines for veterinary pricing were used. For FIN, actual invoices send from veterinarians to farmers were used to deduct treatment prices In Table 4.8, 4.9, and 4.10 treatment costs, the amount of extra labor and amount of retained milk (in days) are shown for organic and conventional production systems in DNK, SWE and FIN, respectively. Similar types of antibiotics were assumed to be used in all 3 countries resulting in similar milk retaining periods (based on DNK information).

For the disease groups used in the index for General Health only the most frequent diseases/disorders in each group were used to estimate the cost of that group - the following assumptions were made:

- Metabolic diseases: 50 % replaced abomasum + 50 % milk fewer
- Feet & Legs: 100 % foot root
- Early reproductive diseases: 50 % retained placenta + 50 % metritis
- Late reproductive diseases: 65 % hormonal treatment + 35 % metritis

Overall, veterinary treatment costs have increased substantially in all countries compared to the values used in the 2008 NTM calculations. For certain diseases, veterinary fees can be discarded in conventional production systems when health agreement schemes are employed. Not being allowed to perform treatments by herd personnel makes the costs for these diseases much higher under organic production circumstances. Annual fees for participating in a health agreement scheme are considered as part of the fixed costs which are not considered in the NTM calculations.

Table 4.7. Average treatment costs, extra labor and the number of days with retained milk for conventional and organic dairy production in DNK for diseases/disorders used in the NTM calculations.

Disease/disorder	Vet. fee, €	Medicine, €	Total, €	Extra labor, h	Retained milk, d
			Conventional		
Mastitis	40	47	87	2.0	8.0
Ketosis	72	32	104	1.3	-
Metabolic diseases	136	55	191	1.5	3.5
Feet and leg diseases	34	23	56	2.0	3.0
Early reprod. disease	63	25	88	1.6	4.0
Late reprod. disease	65	19	84	0.9	2.0
Difficult calving[1]	188	21	209	3.7	1.2
			Organic		
Mastitis	169	47	216	1.4	14.0
Ketosis	72	32	104	1.3	-
Metabolic diseases	151	55	206	1.3	7.0
Feet and leg diseases	115	23	146	1.5	6.0
Early reprod. diseases	121	25	146	1.1	8.0
Late reprod. diseases	99	19	118	0.8	4.0
Difficult calving[1]	209	21	230	3.4	2.4

[1]With vet assistance (20 % cesarean + dissection)

Table 4.8. Average treatment costs, extra labor and the number of days with retained milk for conventional and organic dairy production in SWE for diseases/disorders used in the NTM model.

Disease/disorder	Vet. fee, €	Medicine, €	Total, €	Extra labor, h	Retained milk, d
			Conventional		
Mastitis	40	86	126	2.1	8.0
Ketosis	73	17	89	1.3	-
Metabolic diseases	242	44	179	1.9	3.5
Feet and leg diseases	29	30	59	2.0	3.0
Early reprod. disease	114	28	142	1.6	4.0
Late reprod. disease	119	10	129	1.0	2.0
Difficult calving[1]	214	18	232	3.70	1.2
			Organic		
Mastitis	87	86	172	1.9	14.0
Ketosis	73	17	89	1.3	-
Metabolic diseases	272	44	208	1.3	7.0
Feet and leg diseases	61	30	92	1.6	6.0
Early reprod. disease	133	28	162	1.5	8.0
Late reprod. disease	119	10	129	0.9	4.0
Difficult calving[1]	214	18	232	3.7	2.4

[1]With vet assistance (20 % cesarean + dissection)

Table 4.9. Average treatment costs, extra labor and the number of days with retained milk for conventional and organic dairy production in FIN for diseases/disorders used in the NTM model.

Disease/disorder	Vet. fee, €	Medicine, €	Total, €	Extra labor, h	Retained milk, d
			Conventional		
Mastitis	44	100	144	2.5	8.0
Ketosis	78	33	111	1.5	-
Metabolic diseases	113	46	165	1.7	3.5
Feet and leg diseases	28	38	66	1.9	3.0
Early reprod. disease	58	21	79	1.8	4.0
Late reprod. disease	65	17	79	1.0	2.0
Difficult calving1	122	43	165	4.1	1.2
			Organic		
Mastitis	210	100	310	2.5	14.0
Ketosis	78	33	111	1.5	-
Metabolic diseases	129	46	175	1.7	7.0
Feet and leg diseases	98	38	136	1.9	6.0
Early reprod. disease	120	21	141	1.8	8.0
Late reprod. disease	107	17	124	1.0	4.0
Difficult calving[1]	144	43	187	4.1	2.4

[1]With vet assistance (20 % cesarean + dissection)

4.9 Claw Health

The latest economic values for claw health were calculated in 2011 (Pedersen et al., 2011). Regarding costs related to treatment of each of the 7 claw health disorders, a comprehensive study was made in 2011 that investigated the costs related to extra labor by claw trimmers (basic costs of claw trimming not included), extra work by the herd manager, possible veterinary treatment costs, and costs related to materials. A few Danish claw trimmers were contacted to verify the current treatment costs. It was found that the economic assumptions used in the 2011 study regarding claw trimmer costs and time consumption are still valid. However, labor costs per hour have increased compared to the 2008 NTM calculations, and treatment costs for some claw health disorders (sole ulcer, sole hemorrhage, heel horn erosion and dermatitis) are frequency dependent, i.e. frequencies of the disorders with 3 categories have changed. Thus, treatment costs have changed slightly; the updated costs and time consumption related to claw health are shown in Table 4.10. Assumptions for organic and conventional productions systems were the same.

Table 4.10. Assumed treatment costs and time consumption related to claw health disorders (per case) in DNK, SWE and FIN.

	Treatment, €			Extra claw trimmer labor, minutes			Extra herd personnel labor, minutes		
Claw disorder	SWE	DNK	FIN	SWE	DNK	FIN	SWE	DNK	FIN
SU	17.65	28.77	16.28	4	3	4	76	93	73
SH	-	-	-	3	3	3	15	15	15
HH	5.00	5.00	5.00	3	3	3	15	15	15
DE	5.00	5.00	5.00	3	3	3	15	15	15
CSC	-	-	-	5	5	5	-	-	-
SP	10.00	10.00	10.00	5	5	5	30	30	30
WLS	-	-	-	3	3	3	15	15	15

SU: sole ulcer; SH: sole hemorrhage; HH: heel horn erosion; DE: dermatitis; CSC: cork screw claw; SP: skin proliferation; WLS: white line separation

4.10 Conformation traits

The weights allocated to the individual linear type traits included in each of the conformation indices, Frame, Feet & Legs and Udder, have been discussed, proposed and agreed upon by the DNK, SWE and FIN breed associations. The weights can be found on NAV homepage.

The task of the NTM project group was not to change these weights – but only to estimate the economic importance of the main conformation indices Frame, Feet & Legs and Udder relative to other traits in the NTM. Therefore, the set up for these trait groups is somewhat atypical compared to the other trait groups. Because phenotypes for Frame, Feet & Legs and Udder had be constructed and analyzed.

The basic economic assumptions are made by (subjective) assessments of the extra labor in an average herd. The current figures in the NTM program wereadopted from the Danish 2002 report on economic weights (Pedersen et al., 2003):

- Frame: There is no impact on the work load if all traits included in "Frame" were linearly scored 1 point away from the optimum.
- Udder: If all traits included in Udder were linearly scored 1 point away from the optimum, the extra labor was assumed to be 15 minutes per day per 110 cows.
- Feet & Legs: If all traits included in Feet & Legs were linearly scored 1 point away from the optimum, the extra labor was assumed to be 10 minutes per day per 110 cows.

The above assumptions were retained

4.11 Milkability and temperament

Milkability and temperament are recorded directly in the dairy herds and are less complicated to analyse compared to the conformation traits because the recorded scores can be evaluated directly in contrast to the conformation traits where the “index” is evaluated. If milkability of all cows is one unit less, it is assumed that the extra labor would be 10 minutes per day per 110 cows. If the temperament of all cows is 1 unit lower, the extra labor was assumed to amount to be 5 minutes per day per 110 cows.

5 Results - economic value of individual traits

The results are presented as € per unit change of the trait, for example per kg protein or per percent unit change in incidence (i.e. from 15 % mastitis to 16 % mastitis).

In Table 5.4, 5.5, and 5.6 means of economic values per trait unit are compared for the different scenarios for HOL, RDC and JER, respectively: (1) Original NTM (economic values calculated 2008-2012); (2) Classic, as (1) but with new economic and biological conventional assumptions, fixed replacement rate of 32 % and use of health agreement schemes; (3) Conventional as (2) but including use of both SS and BS (52 % of replacement heifers born SS); and (4) Organic, as (3) but with economic and biological assumptions reflecting organic production systems. In Table 5.7 and 5.8 country-specific conventional, economic values are presented for HOL and RDC, respectively. In Table 5.9 and 5.10 country-specific organic, economic values are presented for HOL and RDC, respectively.

5.1 Explaining differences in economic values

There can be many reasons why the new economic values differ from the Original economic values. The most obvious reasons are updated assumptions about income and costs, but also biological factors have an effect if they change the structure of the model herd. For example, lower culling rates affect replacement rates and therefore the distribution of parities which in turn will affect the economic value of a wide range of traits. The use of SS and BS has a similar effect, affecting the distribution of born purebred dairy heifers and bull calves and beef×dairy crossbreds calves. Below are short explanations for each trait group regarding changes in the economic values. The conventional scenario will be compared with the Original results, and the Organic scenario will be compared with the Conventional scenario.

Yield: Both the assumed milk price and feed costs have increased –the milk price has increased relatively more than the feed costs. For the economic value of improving yield only the marginal feed costs matter. For example, when fat yield is increased by 1 kg, extra feed is required which is covered by increasing the amount of concentrates. The amount of roughage is unchanged. The costs of concentrates have increased between 9 and 22 % since 2008 depending on country. Overall, profit per kg milk has increased resulting in a higher economic value per kg standard milk. Also, the assumed P:F pricing (protein fat ratio) has decreased from 1.70 to 1.44 in DNK and SWE resulting in a relatively higher payment for fat. For FIN, the P:F is unchanged. Overall, the relative increase in economic values for the yield traits is largest for fat. The profit per kg milk is generally lower in the Organic scenario because the higher milk price cannot compensate for the increased feed costs (higher price for concentrates); thus, a lower economic value for standard milk can be seen for the Organic scenario. The high organic feed costs in Finland have a large effect on the overall (mean of DNK, SWE and FIN) economic values for fat and protein. Because of the "low" fat value it is not profitable to improve fat in FIN whereas the opposite is the case for protein; thus, the economic value of fat is lower in the organic scenario and higher for protein compared to the Conventional scenario.

Growth: Overall, the mean economic values of the growth traits have increased considerably. There are 3 main reasons for this: (1) It is more profitable to produce beef (largest effect on the economic values), especially in SWE. (2) The use of SS and BS and a much lower replacement rate compared to the Original 2008 scenario results in an increased number of animals for slaughter and fewer heifers that start AI (Table 5.1; SWE is used as an example because there we observe the largest change in economic values for the growth traits), and (3) a higher slaughter price for beef×dairy crossbreds, i.e. beef×dairy crossbreds grow faster and have increased form score. The differences between countries are quite large for the economic values of growth traits. This is mainly because of a different production system in SWE and FIN - animals are much older and heavier at slaughter compared to DNK, resulting in a higher form score and carcass price. The economic values in the Organic scenario are much lower mainly because the higher slaughter price cannot compensate the increased feed costs. In practice, few animals are raised for slaughter in organic production systems; instead they are sold to conventional beef producers. Also, the organic beef market is highly specialized making it challenging to settle on a fixed slaughter price for organic beef.

Especially for JER the increase in economic value for the growth traits are large. The higher slaughter price compared to 2008 has a positive effect, but also the calculation of required feed has been changed slightly for *JER*. This has resulted in a slightly lower feed requirement for JER compared to 2008.

Table 5.1. Numbers of animals in each category and profit per slaughter animal for scenarios Original, Classis and Conventional for SWE HOL.

Scenario	Calvings per year, N	Heifers started on AI, N	Slaughter animals, N	Profit per slaughter animal, €
Original	118.4	52.3	49.3	254
Classic	111.7	49.9	48.5	534
Conventional	111.7	35.7	62.3	563

Calving traits: The economic value of calf survival rate has decreased in 1st parity and increased in later parities when comparing the updated economic values from the Classic scenario with the Original scenario. This is due to the lower replacement rate that results in fewer 1st calvings and more later parity calvings, i.e. the trait is expressed fewer times in 1st parity. Additionally, the value for 1st parity decreases slightly when SS and BS is used in the Conventional scenario as more heifer calves are born, which results in easier calvings and less stillborn calves. With more heifer calves being born from heifers (because of the use of SS), the benefit of a lower stillbirth rate decreases. The economic value increases in later parities mainly because of a higher number of beef×dairy crossbred calves; survival rate is lower in heifer beef×dairy crossbred calves but higher in bull beef×dairy crossbred calves compared to purebred dairy heifers and bulls, respectively (c.f. Table 3.17 and 3.18). The reason for the increased economicvalues, when the survival rate is improved, is the increased number of beef×dairy crossbred that are slaughtered at a higher slaughter price compared to purebred dairy bulls. The economic values for survival rate are lower in the organic scenario because feed costs are much higher compared to the conventional scenario which reduces the economic benefit of improving survival rate.

Calving ease (CE) is recorded in 4 categories and especially the categories difficult and difficult with vet. assistance affect the economic value because costs related to these two categories are much higher than an easy calving with help (see Table 4.6). If the distribution of these categories changes, the economic value will also change, e.g. if there are no longer any cases of difficult with vet assistance then the economic benefit of improving CE becomes smaller. The frequency of difficult calvings has in fact decreased compared to the Original scenario. This explains the lower economic value of CE in 1st parity. Also, the number of first calvings has become lower because of a lower replacement rate.

For later parities, the economic value of CE is only slightly higher in the Classic scenario compared to the Original. The number of difficult calvings has decreased slightly but the veterinary costs related to difficult calvings have increased considerably and the number of later calvings has increased due to the lower replacement rate.

When beef×dairy crossbred calves introduced (Conventional scenario), the economic value of CE in later parities increases considerably. This is because many of the calves born at later calvings are beef×dairy crossbreds that on average induce more calving difficulties compared to purebred dairy calves. Especially for beef×JER crosses there are more difficult calvings – 0.2 % of purebred dairy calvings require vet assistance whereas the value is 1.0 % for beef×JER crossbreds. This results in a considerable increase in the economic value of CE at later calvings as improvement of calving ease saves expensive vet costs (vet costs for calving assistance is €232 per case in DNK). The economic values for CE in the organic scenario are nearly the same as in the conventional scenario; there is a slight increase because of higher veterinary costs.

For calving traits, the economic values for direct and maternal calving traits in 1st parity are similar because we assume that beef×dairy crossbred calves are born by cows only. However, for later parities a lower economic value is seen for the direct effect. In the NTM calculations we only evaluate improvement of the purebred dairy genes, and because beef×dairy crossbreds carry only 50 % purebred dairy genes, the effect of improving a trait is halved, i.e. the economic value is lower. This is the case for direct effect of the calving traits but also for other traits such as growth.

Female fertility: In general, differences between the Original results and results from the Classic scenario are small. The largest change is observed for JER where the value of interval from first to last insemination (IFL) for heifers has increased.

IFL for heifers: Improvement of IFL for heifers increases the number of pregnant heifers. This saves AI costs, and the age at 1st calving will be lower. In the Classic scenario, all heifers including surplus heifers are inseminated whereas in the Conventional scenario only the heifers needed for replacement are inseminated. Because of the decreased number of animals (because replacement rate is lower) that express this trait, the economic value is lower in the Conventional scenario.

IFL for cows: Improving IFL results in shorter calving intervals which increases the number of annual calvings and saves costs for AI. Thus, in the Classic scenario the number of surplus heifers, which are not profitable, and bull calves is increased. In the Conventional scenario, it will result in more cows being inseminated with BS, which results in more beef×dairy crossbreds for slaughter. Aside from saving AI costs, milk production will also be reduced a little because of shorter lactations.

Interval from calving to first insemination (ICF): Improving ICF will decrease calving intervals, and the number of annual calvings will increase. In the Classic scenario, the number of surplus heifers will increase but in the Conventional and Organic scenarios, it will make room for more beef×dairy crossbreds whilst the number of surplus heifers is unchanged around zero. The annual milk production will be slightly reduced. The economic value of ICF in the Organic scenario is lower than in the Conventional scenario because profit from production of beef×dairy crossbreds is lower in the Organic scenario.

Udder health: The assumed veterinary costs for treating udder diseases have increased considerably in all three NAV countries. However, participation in health agreement schemes, which enables owner treatments, causes economic values to decrease in the Conventional scenario compared with the Original scenario. In the Organic scenario, legislation regarding treatments by herd personnel are very different – in most cases, except follow-up treatments in SWE, treatments must be performed by the herd veterinarian. This causes a large increase in the economic value for udder health in the organic scenario compared to conventional. Also, compared to the Original scenario the distribution of cow-lactations is different with fewer 1st parity cows; thus, in the Conventional scenario the economic values increase relatively more in 2nd and 3rd parity whereas the values for 1st parity decrease.

General health: The situation for traits included in the general health index is similar to the udder health case. In general, treatment costs have increased considerably. For diseases, where treatment by herd personnel is allowed, the economic value of the disease group decreases compared to the Original economic values.

The opposite is seen for diseases that must be treated by a vet, which is the case for most diseases. In the Organic scenario, the economic values are generally higher than in the Conventional scenario, mostly because farmers can perform follow-up treatments in the Conventional scenario for diseases initially treated by a vet, but this is not possible under organic circumstances. The most noticeable difference from the original results is the separation of ketosis and other metabolic diseases. Thus, the 2018 results are not completely comparable with the original results for metabolic diseases.

Longevity: Improvement of cow longevity changes herd structure by increasing the proportion of older cows. As a result, replacement rate is decreased and fewer replacement heifers are needed. In the Classic scenario, more surplus heifers can be sold, when longevity is improved, because the number of calvings is unchanged. Although the total revenue from heifers has dropped 35-45 % compared to the Original scenario, the main reason for a lower economic value for longevity is the reduction (up to 10 %-points) in replacement rate compared to 2008, i.e. the biological assumptions regarding replacement rate affect the economic value of longevity directly and because the economic value is shown per day. If the replacement rate is lowered the economic value of longevity decreases and *vice versa*. The following describes the relationship between replacement rate and economic value of longevity using an example.

In the NTM program, the economic value of longevity (€ per day) is calculated by reducing the replacement rate with 1 %-unit (replacement rate = 31 %). Total revenue is calculated for this situation and compared with the total revenue from the default situation (replacement rate = 32 %). Finally, the difference (€ per %-unit change in replacement rate) is converted to € per day by dividing with the difference in longevity days (constructed variable that expresses the average "age" of the cows) between the two situations. The number of longevity days increases with reduced replacement rates, because the cows are getting older. Replacing an old cow means that the survivors need to increase their age more to keep the number of cows constant in the herd. Thus, the economic value of longevity decreases with lower replacement rates, i.e. replacement costs are non-linearly related to replacement rate.

Table 5.2. Key figures related to calculation of economic value of longevity at different replacement rates. Example based on SWE HOL.

Replacement rate	**26**	**27**	**Diff.**	**36**	**37**	**Diff.**
Longevity days	1,401	1,349	53	1,015	987	28
Prop. in 1st lact.	0.25	0.26	-0.01	0.34	0.35	-0.01
Prop. in 2nd lact.	0.22	0.23	-0.01	0.27	0.27	0.00
Prop. in 3rd+ lact	0.53	0.51	0.02	0.39	0.38	0.01
Total profit, €	177,805	176,657	1,148	166,692	165,577	1,116
Profit cows, €	157,786	156,739	1,047	147,679	146,668	1,011
Profit heifers, €	8,734	8,601	133	7,420	7,285	135
Profit bulls, €	11,284	11,317	-32	11,593	11,623	-30
Profit per cow per day, €			**0.219**			**0.402**
Profit per cow per %[1], €			11.3			11.0

[1]Changing replace rate by one %-unit

Example: In Table 5.2**Table 5.2.** Key figures related to calculation of economic value of longevity at different replacement rates. Example based on SWE HOL., some key figures related to calculation of economic value of longevity at different replacement rates are shown. The economic value was calculated for two situations: (1) changing replacement rate from 27 to 26 %, and (2) changing replacement rate from 37 to 36 %. The difference in total profit is slightly higher in situation (1). Thus, profit per cow per % change in replacement rate is almost the same in the two situations, i.e. replacement costs are linearly related to changes in replacement rate. This is reflected in the difference in longevity days between situation (1) and (2); it is almost twice as large in situation (1). Because of this, the economic value is approx. 50 % lower in situation (1), division by a higher number, compared with situation (2).

The breeding value for longevity is heavily influenced by fertility, udder health, general health, claw health and to a certain degree by conformation of udder and feet & legs, but not be yield. Due to model limitations, the effect of reduced culling on the economic value of these traits was not included in our calculations. Therefore, a proportion of the NTM weight for longevity was transferred to these other traits in the NTM index. The transfer was based on analyses of the relationship between longevity and the remaining traits in NTM (regression analysis). The proportion of the variance of longevity that can be explained by other traits and their relative importance are shown in Table 5.3. The re-distribution is illustrated for HOL in the following example. The relative NTM weight for longevity for conventional HOL was 0.21 of which 67 % is explained by variance in other traits that should be transferred, i.e. 0.14 should be transferred and 0.07 is the remaining relative NTM weight for longevity. The re-distribution of the 0.14 for HOL is:

- 24 % of 0.14 = 0.03 added to the total economic value for fertility
- 33 % of 0.14 = 0.05 added to the total economic value for udder health
- 16 % of 0.14 = 0.02 added to the total economic value for general health
- 9 % of 0.14 = 0.01 added to the total economic value for feet & legs
- 18 % of 0.14 = 0.02 added to the total economic value for claw health

Table 5.3. The amount of longevity explained by other traits and their relative importance.

	HOL	RDC	JER
% of longevity value to be transferred to other indices	67 %	65 %	65 %
Most important traits and their relative importance			
Fertility	0.24	0.32	0.36
Udder health	0.33	0.33	0.23
General health	0.16	0.06	0.08
Feet & legs	0.09	0.18	0.25
Udder	-	-	0.09
Claw health	0.18	0.11	-

Conformation traits: The calculation of economic values for the conformation traits was only based on the amount of saved labor when conformation was improved. Wages in all three countries have increased compared with the Original scenario causing the economic values of the conformation traits to increase.

Claw health: The method for calculating economic values for the claw health traits was unchanged for the 2018 calculations. Because the average wage has increased, the economic values increase slightly. Differences in wages also explains some of the differences between the countries. Also, a different distribution of claw disorders with three categories (e.g. sole ulcer) results in differences between countries, e.g. the proportion of severe cases is lower in SWE and FIN compared to DNK.

Young stock survival: The value of heifer survival decreased in the Classic scenario compared with the Original results because profit from producing surplus heifers was higher in 2008. For bull calves, the situation was the opposite; the profit from beef production is higher in the Classic scenario and therefore the value of bull calf survival is higher, mostly in FIN and SWE.

In the Conventional scenario, the total number of purebred dairy heifer calves decreased because of the use of SS, and the number of bull calves increased. However, most of the bull calves were beef×dairy crossbreds (heifer beef×dairy crossbreds also included here). For the beef×dairy crossbreds, genetic improvement of survival only has 50 % impact as they only express 50 % of the purebred dairy genes. For heifer calves the values of survival increases because survival of one heifer will make room for an extra beef×dairy crossbred calf. Under organic settings, the value of survival for bull calves decreased because profit from organic beef production is lower than from conventional beef production.

Table 5.4. Average economic values for HOL across DNK, SWE, and FIN for the three 2018 scenarios. Original economic values added for comparison. Values presented as Euros (€) per trait unit.

		Scenario			
Trait	Unit	Original	Classic	Conventional	Organic
MILK PRODUCTION					
Milk[1]	kg	-0.030	-0.049	-0.049	-0.087
Fat[1]	kg	1.28	1.65	1.65	0.95
Protein[1]	kg	4.60	5.02	5.02	5.57
Standard milk[2]	kg	0.181	0.191	0.191	0.143
GROWTH					
Net daily gain	kg/day	0.171	0.219	0.213	0.077
EUROP form score	score	13.3	14.2	11.1	12.0
CALVING TRAITS					
Survival rate, 1st parity	%-unit	1.92	1.64	1.61	1.40
Survival rate, later parities maternal	%-unit	3.10	3.64	3.92	3.05
Survival rate, later parities direct	%-unit	3.10	3.64	2.55	2.01
Calving ease, 1st parity	points	10.99	5.63	5.63	5.85
Calving ease, later parities maternal	points	14.86	15.03	26.58	28.00
Calving ease, later parities direct	points	14.86	15.03	15.67	16.58
FEMALE FERTILITY[3]					
IFL, heifers	day	1.07	0.99	0.80	0.63
ICF, cows	day	0.55	0.48	0.54	0.16
IFL, cows	day	3.95	4.18	4.24	3.87
UDDER HEALTH					
Udder health, 1st parity, 1st period	%-unit	1.50	0.86	0.86	1.56
Udder health, 1st parity, 2nd period	%-unit	1.55	0.91	0.91	1.67
Udder health, 2nd parity	%-unit	1.13	1.28	1.28	2.39
Udder health, 3rd parity	%-unit	1.44	2.20	2.20	4.12
GENERAL HEALTH					
Other metabolic, sum all lact	%-unit	1.88[4]	3.16	3.16	4.06
Ketosis, sum all lact	%-unit	-	1.45	1.45	1.43
Feet & legs disorders, sum all lact	%-unit	1.75	1.61	1.61	2.78
Early repro disorders, sum all lact	%-unit	2.00	2.10	2.10	3.25
Late repro disorders, sum all lact	%-unit	1.05	1.81	1.81	2.50
LONGEVITY					
Average herd life[5]	day	0.53	0.30	0.31	0.29
CONFORMATION A.O.					
Frame	point	0.00	0.00	0.00	0.00
Udder	point	25.55	29.07	29.07	29.07
Feet & legs	point	17.03	19.38	19.38	19.38
Milkability	point	17.03	19.38	19.38	19.38
Temperament	point	8.52	9.69	9.69	9.69
CLAW HEALTH					
Sole ulcer, sum all lact	%-unit	0.494	0.586	0.586	0.586
Sole hemorrhage, sum all lact	%-unit	0.087	0.096	0.096	0.096
Heel horn erosion, sum all lact	%-unit	0.140	0.148	0.148	0.148
Digital dermatitis, sum all lact	%-unit	0.140	0.148	0.148	0.148
Cork screw claw, sum all lact	%-unit	0.088	0.077	0.077	0.077
Interdigital hyperplasia, sum all lact	%-unit	0.265	0.295	0.295	0.295
White line disease, sum all lact	%-unit	0.087	0.096	0.096	0.095
YOUNG STOCK SURVIVAL					
Survival heifers, 1-30 days	%-unit	3.58	2.87	3.43	3.14
Survival, heifers, 31-458 days	%-unit	4.29	3.68	3.68	3.67
Survival, bulls, 1-30 days	%-unit	1.78	2.51	1.72	1.24
Survival, bulls, 31-184 days	%-unit	2.79	2.65	2.29	1.75

[1]Sum all lact of 1st, 2nd and 3rd lactation

[2]4.20 % fat and 3.40 % protein

[3]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[4]In 2008 metabolic diseases was the sum all lact of ketosis and other metabolic diseases

[5]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.5. Average economic values for RDC across DNK, SWE, and FIN for the three 2018 scenarios. Original economic values added for comparison. Values presented as Euros (€) per trait unit.

		Scenario			
Trait	Unit	Original	Classic	Conventional	Organic
MILK PRODUCTION					
Milk[1]	kg	-0.029	-0.048	-0.048	-0.086
Fat[1]	kg	1.33	1.64	1.64	0.94
Protein[1]	kg	4.82	4.95	4.95	5.50
Standard milk[2]	kg	0.190	0.189	0.189	0.141
GROWTH					
Net daily gain	g/day	0.187	0.251	0.230	0.092
EUROP form score	score	12.9	14.6	11.3	12.6
CALVING TRAITS					
Survival rate, 1st parity	%-unit	1.85	1.59	1.63	1.45
Survival rate, later parities maternal	%-unit	3.11	3.59	3.92	3.21
Survival rate, later parities direct	%-unit	3.11	3.59	2.55	2.09
Calving ease, 1st parity	points	11.39	5.79	5.79	6.00
Calving ease, later parities maternal	points	15.69	16.88	25.01	26.36
Calving ease, later parities direct	points	15.69	15.69	14.97	15.79
FEMALE FERTILITY[3]					
IFL, heifers	day	0.94	1.03	0.94	0.77
ICF, cows	day	0.48	0.52	0.64	0.31
IFL, cows	day	2.91	3.34	3.46	3.13
UDDER HEALTH					
Udder health, 1st parity, 1st period	%-unit	1.46	0.85	0.85	1.53
Udder health, 1st parity, 2nd period	%-unit	1.50	0.89	0.90	1.61
Udder health, 2nd parity	%-unit	1.05	1.22	1.22	2.23
Udder health, 3rd parity	%-unit	1.49	2.15	2.15	3.95
GENERAL HEALTH					
Other metabolic, sum all lact	%-unit	1.87[4]	3.17	3.17	4.10
Ketosis, sum all lact	%-unit	-	1.49	1.49	1.43
Feet & leg disorders, sum all lact	%-unit	1.70	1.62	1.62	2.82
Early repro disorders, sum all lact	%-unit	1.93	2.09	2.09	3.17
Late repro disorders, sum all lact	%-unit	1.04	1.76	1.76	2.40
LONGEVITY					
Average herd life[5]	day	0.39	0.25	0.28	0.26
CONFORMATION A.O.					
Frame	point	0.00	0.00	0.00	0.00
Udder	point	25.55	29.07	29.07	29.07
Feet & legs	point	17.03	19.38	19.38	19.38
Milkability	point	17.03	19.38	19.38	19.38
Temperament	point	8.52	9.69	9.69	9.69
CLAW HEALTH					
Sole ulcer, sum all lact	%-unit	0.493	0.595	0.595	0.595
Sole hemorrhage, sum all lact	%-unit	0.086	0.097	0.097	0.097
Heel horn erosion, sum all lact	%-unit	0.139	0.154	0.154	0.154
Digital dermatitis, sum all lact	%-unit	0.139	0.154	0.154	0.154
Cork screw claw, sum all lact	%-unit	0.087	0.077	0.077	0.077
Interdigital hyperplasia, sum all lact	%-unit	0.261	0.296	0.296	0.296
White line disease, sum all lact	%-unit	0.086	0.096	0.096	0.096
YOUNG STOCK SURVIVAL					
Survival heifers, 1-30 days	%-unit	3.40	2.52	3.30	3.19
Survival, heifers, 31-458 days	%-unit	4.06	3.26	3.66	3.77
Survival, bulls, 1-30 days	%-unit	1.89	2.70	1.92	1.44
Survival, bulls, 31-184 days	%-unit	2.96	2.92	2.09	1.76

[1]Sum all lact of 1st, 2nd and 3rd lactation

[2]4.20 % fat and 3.40 % protein

[3]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[4]In 2008 metabolic diseases was the sum all lact of ketosis and other metabolic diseases

[5]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.6. Economic values for JER (DNK only) for the three 2018 scenarios. Original economic values added for comparison. Values presented as Euros (€) per trait unit.

		Scenario			
Trait	Unit	Original	Classic	Conventional	Organic
		MILK PRODUCTION			
Milk[1]	kg	-0.046	-0.051	-0.051	-0.084
Fat[1]	kg	1.55	2.12	2.12	1.48
Protein[1]	kg	4.15	4.52	4.52	4.89
Standard milk[2]	kg	0.160	0.191	0.191	0.145
		GROWTH			
Net daily gain	g/day	0.019	0.216	0.192	0.007
EUROP form score	score	8.5	7.8	6.1	6.5
		CALVING TRAITS			
Survival rate, 1st parity	%-unit	0.65	0.86	0.85	0.25
Survival rate, later parities maternal	%-unit	1.20	2.07	3.13	0.55
Survival rate, later parities direct	%-unit	1.20	2.07	1.87	0.35
Calving ease, 1st parity	points	15.74	10.76	10.76	11.57
Calving ease, later parities maternal	points	33.73	26.36	120.95	130.13
Calving ease, later parities direct	points	33.73	33.73	64.72	69.69
		FEMALE FERTILITY[3]			
IFL, heifers	day	1.13	1.72	1.26	1.01
ICF, cows	day	0.19	0.21	0.18	-0.38
IFL, cows	day	2.60	2.59	2.56	2.00
		UDDER HEALTH			
Udder health, 1st parity, 1st period	%-unit	1.35	0.78	0.79	1.41
Udder health, 1st parity, 2nd period	%-unit	1.35	0.88	0.86	1.56
Udder health, 2nd parity	%-unit	1.01	1.25	1.13	2.28
Udder health, 3rd parity	%-unit	1.75	2.37	2.08	4.33
		GENERAL HEALTH			
Other metabolic, sum all lact	%-unit	1.70[4]	3.10	3.10	4.18
Ketosis, sum all lact	%-unit	-	1.56	1.56	1.89
Feet & leg disorders, sum all lact	%-unit	1.69	1.79	1.79	3.40
Early repro disorders, sum all lact	%-unit	1.91	2.03	2.03	4.39
Late repro disorders, sum all lact	%-unit	0.94	1.65	1.65	3.23
		LONGEVITY			
Average herd life[5]	day	0.41	0.37	0.36	0.31
		CONFORMATION A.O.			
Frame	point	0.00	0.00	0.00	0.00
Udder	point	25.55	33.02	33.02	33.02
Feet & legs	point	17.03	22.01	22.01	22.01
Milkability	point	17.03	22.01	22.01	22.01
Temperament	point	8.52	11.01	11.01	11.01
		CLAW HEALTH			
Sole ulcer, sum all lact	%-unit	0.664	0.795	0.795	0.795
Sole hemorrhage, sum all lact	%-unit	0.090	0.114	0.114	0.114
Heel horn erosion, sum all lact	%-unit	0.145	0.168	0.168	0.168
Digital dermatitis, sum all lact	%-unit	0.145	0.168	0.168	0.168
Cork screw claw, sum all lact	%-unit	0.128	0.091	0.091	0.091
Interdigital hyperplasia, sum all lact	%-unit	0.241	0.336	0.336	0.336
White line disease, sum all lact	%-unit	0.090	0.114	0.114	0.114
		YOUNG STOCK SURVIVAL			
Survival heifers, 1-30 days	%-unit	1.92	1.96	1.56	0.66
Survival, heifers, 31-458 days	%-unit	2.38	2.70	2.05	1.36
Survival, bulls, 1-30 days	%-unit	0.19	1.27	0.75	0.08
Survival, bulls, 31-184 days	%-unit	0.73	1.42	0.73	0.24

[1]Sum all lact of 1st, 2nd and 3rd lactation

[2]4.20 % fat and 3.40 % protein

[3]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[4]In 2008 metabolic diseases was the sum all lact of ketosis and other metabolic diseases

[5]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.7. Economic values (€) for HOL (mean of DNK, SWE and FIN) and country-specific values for Conventional scenario.

Trait	Unit	€ per unit, mean	Denmark	Sweden	Finland
MILK PRODUCTION					
Milk	kg	**-0.049**	-0.053	-0.055	-0.039
Fat	kg	**1.65**	2.14	2.26	0.55
Protein	kg	**5.02**	4.58	4.84	5.64
Standard milk[1]	kg	**0.191**	0.193	0.205	0.176
GROWTH					
Net daily gain	g/day	**0.213**	0.200	0.297	0.141
EUROP form score	score	**11.1**	4.8	13.8	14.8
CALVING TRAITS					
Survival rate, 1st parity	%-unit	**1.61**	0.86	2.18	1.81
Survival rate, later parities maternal	%-unit	**3.92**	3.27	4.42	4.07
Survival rate, later parities direct	%-unit	**2.55**	2.00	3.04	2.60
Calving ease, 1st parity	points	**5.63**	6.64	6.32	3.94
Calving ease, later parities maternal	points	**26.58**	30.27	34.64	14.82
Calving ease, later parities direct	points	**15.67**	17.81	20.57	8.63
FEMALE FERTILITY[2]					
IFL, heifers	day	**0.80**	0.67	0.84	0.90
ICF, cows	day	**0.54**	0.10	0.90	0.62
IFL, cows	day	**4.24**	4.08	4.96	3.70
UDDER HEALTH					
Udder health, 1st parity, 1st period	%-unit	**0.86**	0.81	0.86	0.91
Udder health, 1st parity, 2nd period	%-unit	**0.91**	0.89	0.88	0.97
Udder health, 2nd parity	%-unit	**1.28**	1.21	1.22	1.41
Udder health, 3rd parity	%-unit	**2.20**	2.19	2.03	2.37
GENERAL HEALTH					
Other metabolic, sum all lact	%-unit	**3.16**	3.04	3.88	2.58
Ketosis, sum all lact	%-unit	**1.45**	1.55	1.25	1.57
Feet & leg disorders, sum all lact	%-unit	**1.61**	1.77	1.45	1.63
Early repro disorders, sum all lact	%-unit	**2.10**	2.09	2.38	1.82
Late repro disorders, sum all lact	%-unit	**1.81**	1.60	2.15	1.68
LONGEVITY					
Average herd life[3]	day	**0.31**	**0.24**	0.30	0.41
CONFORMATION A.O.					
Frame	points	**0.0**	0.0	0.0	0.0
Udder	points	**29.07**	33.02	28.03	26.16
Feet & legs	points	**19.38**	22.01	18.69	17.44
Milkability	points	**19.38**	22.01	18.69	17.44
Temperement	points	**9.69**	11.01	9.34	8.72
CLAW HEALTH					
Sole ulcer, sum all lact	%-unit	**0.586**	0.771	0.514	0.472
Sole hemorrhage, sum all lact	%-unit	**0.096**	0.111	0.091	0.086
Heel horn erosion, sum all lact	%-unit	**0.148**	0.163	0.142	0.137
Digital dermatitis, sum all lact	%-unit	**0.148**	0.163	0.142	0.137
Cork screw claw, sum all lact	%-unit	**0.077**	0.089	0.073	0.069
Interdigital hyperplasia, sum all lact	%-unit	**0.295**	0.326	0.284	0.275
White line disease, sum all lact	%-unit	**0.096**	0.111	0.091	0.086
YOUNG STOCK SURVIVAL					
Survival heifers, 1-30 days	%-unit	**3.43**	1.38	4.79	4.12
Survival, heifers, 31-458 days	%-unit	**3.68**	2.01	4.82	4.22
Survival, bulls, 1-30 days	%-unit	**1.72**	1.19	2.28	1.68
Survival, bulls, 31-184 days	%-unit	**2.29**	1.55	3.09	2.23

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.8. Economic values (€) for RDC (mean of DNK, SWE and FIN) and country-specific values for Conventional scenario.

Trait	Unit	€ per unit, mean	Denmark	Sweden	Finland
MILK PRODUCTION					
Milk	kg	**-0.048**	-0.052	-0.054	-0.038
Fat	kg	**1.64**	2.11	2.24	0.56
Protein	kg	**4.95**	4.50	4.75	5.61
Standard milk[1]	kg	**0.189**	0.190	0.201	0.176
GROWTH					
Net daily gain	kg/day	**0.230**	0.204	0.332	0.155
EUROP form score	score	**11.3**	4.8	15.0	14.1
CALVING TRAITS					
Survival rate, 1st parity	%-unit	**1.63**	0.87	2.16	1.84
Survival rate, later parities maternal	%-unit	**3.92**	2.55	4.93	4.28
Survival rate, later parities direct	%-unit	**2.55**	1.62	3.29	2.72
Calving ease, 1st parity	points	**5.79**	6.64	6.77	3.96
Calving ease, later parities maternal	points	**25.01**	29.58	33.42	12.02
Calving ease, later parities direct	points	**14.97**	17.86	19.80	7.25
FEMALE FERTILITY[2]					
IFL, heifers	day	**0.94**	0.65	1.06	1.11
ICF, cows	day	**0.64**	0.24	1.05	0.64
IFL, cows	day	**3.46**	2.87	3.76	3.73
UDDER HEALTH					
Udder health, 1st parity, 1st period	%-unit	**0.85**	0.79	0.86	0.92
Udder health, 1st parity, 2nd period	%-unit	**0.90**	0.86	0.88	0.95
Udder health, 2nd parity	%-unit	**1.22**	1.13	1.23	1.29
Udder health, 3rd parity	%-unit	**2.15**	2.08	2.08	2.29
GENERAL HEALTH					
Other metabolic, sum all lact	%-unit	**3.17**	3.04	3.90	2.57
Ketosis, sum all lact	%-unit	**1.49**	1.59	1.29	1.59
Feet & leg disorders, sum all lact	%-unit	**1.62**	1.80	1.45	1.61
Early repro disorders, sum all lact	%-unit	**2.09**	2.06	2.39	1.81
Late repro disorders, sum all lact	%-unit	**1.76**	1.62	2.02	1.64
LONGEVITY					
Average herd life[3]	day	**0.28**	0.22	0.27	0.36
CONFORMATION A.O.					
Frame	points	**0.0**	0.0	0.0	0.0
Udder	points	**29.07**	33.02	28.03	26.16
Feet & legs	points	**19.38**	22.01	18.69	17.44
Milkability	points	**19.38**	22.01	18.69	17.44
Temperement	points	**9.69**	11.01	9.34	8.72
CLAW HEALTH					
Sole ulcer, sum all lact	%-unit	**0.595**	0.785	0.523	0.476
Sole hemorrhage, sum all lact	%-unit	**0.097**	0.113	0.096	0.087
Heel horn erosion, sum all lact	%-unit	**0.154**	0.178	0.144	0.139
Digital dermatitis, sum all lact	%-unit	**0.154**	0.178	0.144	0.139
Cork screw claw, sum all lact	%-unit	**0.077**	0.089	0.074	0.069
Interdigital hyperplasia, sum all lact	%-unit	**0.296**	0.323	0.289	0.277
White line disease, sum all lact	%-unit	**0.096**	0.109	0.093	0.087
YOUNG STOCK SURVIVAL					
Survival heifers, 1-30 days	%-unit	**3.30**	1.31	4.75	3.83
Survival, heifers, 31-458 days	%-unit	**3.66**	1.90	4.98	4.10
Survival, bulls, 1-30 days	%-unit	**1.92**	1.40	2.72	1.63
Survival, bulls, 31-184 days	%-unit	**2.09**	1.50	2.96	1.83

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.9. Economic values (€) for HOL (mean of DNK, SWE and FIN) and within country-specific values for Organic scenario.

Trait	Unit	€ per unit, mean	Denmark	Sweden	Finland
MILK PRODUCTION					
Milk	kg	**-0.087**	-0.085	-0.094	-0.081
Fat	kg	**0.95**	1.50	1.35	-0.01
Protein	kg	**5.57**	4.97	5.09	6.65
Standard milk[1]	kg	**0.143**	0.147	0.136	0.145
GROWTH					
Net daily gain	g/day	**0.077**	0.090	0.226	-0.085
EUROP form score	score	**12.0**	7.5	13.8	14.7
CALVING TRAITS					
Survival rate, 1st parity	%-unit	**1.40**	0.76	2.15	1.27
Survival rate, later parities maternal	%-unit	**3.05**	2.17	4.33	2.65
Survival rate, later parities direct	%-unit	**2.01**	1.34	2.98	1.71
Calving ease, 1st parity	points	**5.85**	7.02	6.44	4.08
Calving ease, later parities maternal	points	**28.00**	32.16	35.94	15.91
Calving ease, later parities direct	points	**16.58**	19.11	21.33	9.28
FEMALE FERTILITY[2]					
IFL, heifers	day	**0.63**	0.53	0.69	0.67
ICF, cows	day	**0.16**	-0.21	0.60	0.11
IFL, cows	day	**3.87**	3.77	4.66	3.18
UDDER HEALTH					
Udder health, 1st parity, 1st period	%-unit	**1.56**	1.51	1.35	1.82
Udder health, 1st parity, 2nd period	%-unit	**1.67**	1.67	1.39	1.94
Udder health, 2nd parity	%-unit	**2.39**	2.33	1.97	2.85
Udder health, 3rd parity	%-unit	**4.12**	4.22	3.32	4.82
GENERAL HEALTH					
Other metabolic, sum all lact	%-unit	**4.06**	3.80	4.87	3.50
Ketosis, sum all lact	%-unit	**1.43**	1.49	1.21	1.59
Feet & leg disorders, sum all lact	%-unit	**2.78**	2.96	2.29	3.10
Early repro disorders, sum all lact	%-unit	**3.25**	3.29	3.25	3.21
Late repro disorders, sum all lact	%-unit	**2.50**	2.32	2.58	2.59
LONGEVITY					
Average herd life[3]	day	**0.29**	0.21	0.23	0.42
CONFORMATION A.O.					
Frame	points	**0.0**	0.0	0.0	0.0
Udder	points	**29.07**	33.02	28.03	26.16
Feet & legs	points	**19.38**	22.01	18.69	17.44
Milkability	points	**19.38**	22.01	18.69	17.44
Temperement	points	**9.69**	11.01	9.34	8.72
CLAW HEALTH					
Sole ulcer, sum all lact	point	**0.586**	0.771	0.514	0.472
Sole hemorrhage, sum all lact	point	**0.096**	0.111	0.091	0.086
Heel horn erosion, sum all lact	point	**0.148**	0.163	0.142	0.137
Digital dermatitis, sum all lact	point	**0.148**	0.163	0.142	0.137
Cork screw claw, sum all lact	point	**0.077**	0.089	0.073	0.069
Interdigital hyperplasia, sum all lact	point	**0.295**	0.326	0.284	0.275
White line disease, sum all lact	point	**0.096**	0.111	0.091	0.086
YOUNG STOCK SURVIVAL					
Survival heifers, 1-30 days	%-unit	**3.14**	1.75	4.71	2.97
Survival, heifers, 31-458 days	%-unit	**3.67**	2.58	5.08	3.34
Survival, bulls, 1-30 days	%-unit	**1.24**	0.54	2.20	0.97
Survival, bulls, 31-184 days	%-unit	**1.75**	0.89	3.09	1.26

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 5.10. Economic values (€) for RDC (mean of DNK, SWE and FIN) and country-specific values for Organic scenario (organic production system).

Trait	Unit	€ per unit, mean	Denmark	Sweden	Finland
		MILK PRODUCTION			
Milk	kg	**-0.086**	-0.084	-0.093	-0.080
Fat	kg	**0.94**	1.49	1.35	-0.02
Protein	kg	**5.50**	4.90	5.00	6.59
Standard milk[1]	kg	**0.141**	0.145	0.134	0.143
		GROWTH			
Net daily gain	kg/day	**0.092**	0.080	0.263	-0.066
EUROP form score	score	**12.6**	8.6	15.0	14.1
		CALVING TRAITS			
Survival rate, 1st parity	%-unit	**1.45**	0.86	2.14	1.34
Survival rate, later parities maternal	%-unit	**3.21**	1.95	4.84	2.84
Survival rate, later parities direct	%-unit	**2.09**	1.23	3.21	1.83
Calving ease, 1st parity	points	**6.00**	6.99	6.91	4.10
Calving ease, later parities maternal	points	**26.36**	31.67	34.84	12.55
Calving ease, later parities direct	points	**15.74**	19.19	20.53	7.64
		FEMALE FERTILITY[2]			
IFL, heifers	day	**0.77**	0.58	0.83	0.88
ICF, cows	day	**0.31**	0.03	0.80	0.11
IFL, cows	day	**3.13**	2.67	3.51	3.20
		UDDER HEALTH			
Udder health, 1st parity, 1st period	%-unit	**1.53**	1.45	1.37	1.75
Udder health, 1st parity, 2nd period	%-unit	**1.61**	1.62	1.40	1.82
Udder health, 2nd parity	%-unit	**2.23**	2.15	2.02	2.52
Udder health, 3rd parity	%-unit	**3.95**	3.96	3.42	4.48
		GENERAL HEALTH			
Other metabolic, sum	%-unit	**4.10**	4.13	4.83	3.34
Ketosis, sum all lact	%-unit	**1.43**	1.47	1.26	1.58
Feet & leg disorders, sum all lact	%-unit	**2.82**	3.20	2.28	3.00
Early repro disorders, sum all lact	%-unit	**3.17**	3.18	3.20	3.14
Late repro disorders, sum all lact	%-unit	**2.40**	2.28	2.35	2.56
		LONGEVITY			
Average herd life[3]	day	**0.26**	0.21	0.21	0.36
		CONFORMATION A.O.			
Frame	points	**0.0**	0.0	0.0	0.0
Udder	points	**29.07**	33.02	28.03	26.16
Feet & legs	points	**19.38**	22.01	18.69	17.44
Milkability	points	**19.38**	22.01	18.69	17.44
Temperement	points	**9.69**	11.01	9.34	8.72
		CLAW HEALTH			
Sole ulcer, sum all lact	%-unit	**0.595**	0.785	0.523	0.476
Sole hemorrhage, sum all lact	%-unit	**0.097**	0.113	0.093	0.087
Heel horn erosion, sum all lact	%-unit	**0.154**	0.178	0.144	0.139
Digital dermatitis, sum all lact	%-unit	**0.154**	0.178	0.144	0.139
Cork screw claw, sum all lact	%-unit	**0.077**	0.089	0.074	0.069
Interdigital hyperplasia, sum all lact	%-unit	**0.296**	0.323	0.289	0.277
White line disease, sum all lact	%-unit	**0.096**	0.109	0.093	0.087
		YOUNG STOCK SURVIVAL			
Survival heifers, 1-30 days	%-unit	**3.19**	1.92	4.83	2.83
Survival, heifers, 31-458 days	%-unit	**3.77**	2.77	5.26	3.28
Survival, bulls, 1-30 days	%-unit	**1.44**	0.68	2.63	1.00
Survival, bulls, 31-184 days	%-unit	**1.76**	0.85	2.97	1.46

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF: time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

5.2 Proposed index weights relative to yield index

The economic values presented in the previous part 5.1 cannot be compared directly across traits; thus, the values need to be converted from economic value per trait unit to economic value per index unit, i.e. the economic values need to be standardized to have the same SD of 10 index units for all the indices in NTM. NAV bulls born 2008-2011 were used to obtain the number of trait units per index unit for all traits. In principle, this is similar to the "Phenotypic value tool" for RDC, HOL, and JER used on the NAV website.

Finally, weight factors for the different sub-indices in NTM can be calculated. Traditionally, the weights are shown relative to the economic value of the yield index (Table 5.11). We also did this; however, values across breeds and scenarios cannot be compared because the value of the yield indices differs. The values can be made comparable if all weights are multiplied by the value of the yield index. In Table 5.12, 5.13, and 5.14 weight factors for each sub-trait in NTM are presented for the Conventional and Organic scenarios.

Table 5.11. Calculated values of one yield index unit (€) under conventional and organic assumptions. Original 2008-2012 shown for comparison.

Scenario	HOL	RDC	JER
Conventional	10.94	11.57	9.36
Organic	7.86	8.26	6.68
Original	7.61	8.33	6.79

Table 5.12. NTM weights for the individual sub-indices relative to the value of the yield index based on conventional and organic assumptions, respectively, for HOL. Original 2008-2012 weights shown for comparison.

	Scenario		
Sub-index	Original	Conventional	Organic
Yield	1.00	1.00	1.00
Growth	0.08	0.07	0.08
Fertility	0.41	0.38	0.47
Birth, direct	0.20	0.13	0.16
Calving, maternal	0.22	0.13	0.16
Udder health	0.46	0.30	0.72
General health	0.16	0.13	0.23
Frame	0.00	0.00	0.00
Feet & legs conformation	0.10	0.04	0.05
Udder conformation	0.12	0.05	0.07
Milkability	0.11	0.08	0.12
Temperament	0.04	0.04	0.05
Longevity	0.15	0.07	0.09
Claw health	0.05	0.09	0.14
Young stock survival	0.18	0.11	0.14

Table 5.13. NTM weights for the individual sub-indices relative to the value of the yield index based on conventional and organic assumptions, respectively, for RDC. Original 2008-2012 weights shown for comparison.

	Scenario		
Sub-index	Original	Conventional	Organic
Yield	1.00	1.00	1.00
Growth	0.11	0.08	0.08
Fertility	0.28	0.29	0.36
Birth, direct	0.15	0.08	0.10
Calving, maternal	0.13	0.08	0.11
Udder health	0.34	0.19	0.45
General health	0.13	0.09	0.17
Frame	0.00	0.00	0.00
Feet & legs conformation	0.07	0.05	0.07
Udder conformation	0.14	0.06	0.09
Milkability	0.07	0.09	0.12
Temperament	0.03	0.03	0.04
Longevity	0.09	0.06	0.07
Claw health	0.04	0.06	0.08
Young stock survival	0.24	0.15	0.19

Table 5.14. NTM weights for the individual sub-indices relative to the value of the yield index based on conventional and organic assumptions, respectively, for JER. Original 2008-2012 weights shown for comparison.

	Scenario		
Sub-index	Original	Conventional	Organic
Yield	1.00	1.00	1.00
Growth	0.03	0.06	0.04
Fertility	0.23	0.25	0.27
Birth, direct	0.07	0.04	0.03
Calving, maternal	0.06	0.06	0.05
Udder health	0.51	0.33	0.77
General health	0.05	0.11	0.23
Frame	0.00	0.00	0.00
Feet & legs conformation	0.06	0.07	0.09
Udder conformation	0.15	0.13	0.18
Milkability	0.11	0.08	0.11
Temperament	0.03	0.02	0.03
Longevity	0.14	0.09	0.11
Claw health	0.04	0.04	0.05
Young stock survival	0.14	0.10	0.06

5.3 Expected genetic response using proposed relative NTM weights

The relative weights assigned to each sub-index in NTM described in chapter 5.2 does not directly reflect the genetic response for each individual sub-trait that can be obtained using the proposed weights. This is because they do not account for the genetic correlations between the sub-indices included in NTM. However, genetic correlations between NTM and the sub-indices can provide an estimate for the relative genetic response than can be achieved for the different traits in the breeding goal. The method used for the Original

NTM (see 2008 NTM report), use of correlations calculated from progeny tested bulls, illustrated the expected response well in the bull path of a breeding plan with progeny testing the key element. However, the response in the bull dam path was not considered.

Since the Original NTM calculations in 2008, genomic selection has been introduced in the NAV countries. This enables the use of pre-selected genotyped bull calves for estimating expected genetic response. The advantage of using pre-selected genotyped bull calves to predict response is that it resembles today's selection practice and reflects the relative genetic progress very well. Genomic selection of females will result in a similar response because the group of genotyped bull calves is a better representative of the entire population compared to progeny tested bulls. Also, the number of genotyped bull calves and bull sires is much larger than the number of progeny tested bulls and bull sires used in the old progeny testing scheme before the genomic era. This minimizes the risk of one "special" bull sire affecting the expected genetic response across the NTM sub-traits.

Correlations between NTM and the sub-indices were calculated using the proposed conventional and organic NTM index weights. Correlations based on the Original NTM were also calculated for comparison. Genotyped bulls born in either DNK, SWE or FIN (Nordic bulls) in 2015 and 2016 were used for the calculations. For JER genomic breeding values are not yet calculated for claw health (introduced February 2018) and young stock survival; thus, correlations between NTM and these two traits were based on progeny tested Nordic JER bulls born in 2009-2010 with traditional EBV. The results are presented in Table 5.15, 5.16, and 5.17 for HOL, RDC and JER, respectively. As an example, a correlation of 0.63 between the Conventional NTM and the yield sub-index indicates that selection based on NTM will result in a genetic response in yield of 63 % of the maximum genetic response achievable by selecting only for yield in the breeding goal.

Table 5.15. Correlations between sub-indices and Original, Conventional and Organic NTM, respectively for HOL. Correlations are based on December 2017 evaluation and data from 5,218 genotyped Nordic HOL bull calves born 2015-2016.

Trait	Original NTM	Conventional NTM	Organic NTM
Yield	0.48	0.63	0.41
Growth	0.07	0.11	0.08
Fertility	0.48	0.44	0.53
Birth, direct	0.30	0.26	0.28
Calving, maternal	0.38	0.32	0.33
Udder health	0.47	0.34	0.58
General health	0.39	0.34	0.45
Frame	-0.03	0.01	-0.07
Feet & legs conformation	0.24	0.17	0.19
Udder conformation	0.23	0.11	0.21
Milkability	0.03	0.04	-0.03
Temperament	0.08	0.09	0.04
Longevity	0.60	0.50	0.61
Claw health	0.24	0.24	0.30
Young stock survival	0.29	0.23	0.27

Table 5.16. Correlations between sub-indices and Original, Conventional and Organic NTM, respectively for RDC. Correlations are based on December 2017 evaluation and data from 4,368 genotyped Nordic RDC bull calves born 2015-2016.

Trait	Original NTM	Conventional NTM	Organic NTM
Yield	0.68	0.80	0.62
Growth	0.01	0.05	-0.02
Fertility	0.22	0.21	0.30
Birth, direct	0.23	0.14	0.19
Calving, maternal	0.19	0.16	0.20
Udder health	0.33	0.15	0.40
General health	0.22	0.17	0.28
Frame	0.00	0.02	-0.02
Feet & legs conformation	0.26	0.20	0.24
Udder conformation	0.16	0.04	0.14
Milkability	0.11	0.18	0.15
Temperament	0.04	0.09	0.05
Longevity	0.49	0.45	0.52
Claw health	0.15	0.14	0.20
Young stock survival	0.36	0.25	0.29

Table 5.17. Correlations between sub-indices and Original, Conventional and Organic NTM, respectively for JER. Correlations are based on December 2017 evaluation and data from 862 genotyped Nordic JER bull calves born 2015-2016.

Trait	Original NTM	Conventional NTM	Organic NTM
Yield	0.67	0.77	0.49
Growth	0.01	0.07	0.03
Fertility	0.23	0.25	0.31
Birth, direct	0.11	0.08	0.04
Calving, maternal	0.22	0.18	0.11
Udder health	0.53	0.38	0.70
General health	0.28	0.27	0.34
Frame	0.15	0.15	0.09
Feet & legs conformation	0.12	0.17	0.23
Udder conformation	0.27	0.15	0.37
Milkability	0.06	0.07	0.04
Temperament	0.02	-0.01	-0.04
Longevity	0.52	0.48	0.52
Claw health[1]	0.16	0.09	0.19
Young stock survival[1]	0.33	0.28	0.27

[1]Based on November 2017 evaluation and data from 97 progeny tested Nordic JER bulls born 2009-2010.

In general, use of the Conventional NTM weights will result in an increased genetic response for the production traits and less response for the functional traits. For the Organic NTM weights, the genetic response for the productions traits can be expected to be quite similar to the Original NTM. Response for the remaining traits are at the same level or larger than the Original NTM. It should be noted that the relative NTM weights and the subsequent expected genetic responses are quite sensitive to the value of the yield index driven by the assumed milk price. Thus, calculations using different milk prices are an important part of the sensitivity analyses for the NTM review (*Sensitivity analyses*).

The correlations between the Conventional and Organic NTM indices were 0.95, 0.95, and 0.92 for HOL, RDC and JER, respectively. The high correlations suggest that it may not be efficient to establish two separate breeding lines for conventional and organic production systems, respectively, using the current assumptions; although, some re-ranking of bulls can be expected. Also, correlations between the Original NTM and the Conventional NTM were high at 0.98, 0.96, and 0.97 for HOL, RDC and JER, respectively.

The reason for the lower correlation for JER can partly be explained by the lower profit for beef production in Organic JER compared to RDC and HOL. JER requires relatively more feed per produced slaughter animal because of slower growth rate. This affects some traits other than growth, i.e. fertility, calving traits, longevity, and young stock survival. Improvement of these traits all result in more slaughter animals, which does not increase profit as much for JER compared to RDC and HOL.

6 Economic value of saved feed costs

Feed costs comprise around 88 % of the total variable costs on a dairy farm (Andersen, 2017). Thus, it is of interest to the dairy sector to improve the conversion ratio of feed to product, i.e. milk and meat; i.e. to improve feed efficiency and save feed. It is also of interest for the society in general because improved feed efficiency, given unchanged output, may lower the emission of harmful greenhouse gases such as methane and minimize carbon foot print (Difford et al., 2018). Genetic variation for feed efficiency in dairy cattle has been confirmed (e.g. Li et al., 2017) and can therefore be improved through genetic selection.

Direct genetic selection for improved feed efficiency in dairy cattle involves several challenges. Feed intake measurements, i.e. dry matter intake (DMI), of single animals on a large scale are required before genetic selection for feed efficiency can be carried out effectively. Equipment for measuring feed intake in dairy cows is specialized and expensive. This means that currently records are only available from research farms. Pooling DMI data from research farms from several countries and the employment of genomic selection methods have already been attempted. However, accuracy of the genomic breeding values (GEBV) is still too low to be useful in practice. New cheaper methods for measuring DMI on a larger scale in commercial herds are emerging, so in the future large-scale recording of feed intake should be possible (Lassen et al., 2018).

Feed efficiency in dairy cattle has been improved; however, this is mainly an indirect effect of improved milk production which has improved the overall production efficiency. This effect is known as “dilution of maintenance” effect (VandeHaar et al., 2016), i.e. costs of maintenance are diluted with increasing output (milk or meat). This may not be the most effective way of selecting for improved feed efficiency because other sources of variation in feed efficiency may be missed when focus is on the” dilution of maintenance” effect only, and the disadvantage is antagonistic effects on functional traits such as fertility. In the following, we explore opportunities to use genetic selection for saved feed without relying on DMI records using an example based on HOL assumptions.

6.1 Trait definition

The overall aim of breeding for increased feed efficiency to save feed, which is equal to saving costs. EBV for saved feed can be divided into:

$$\text{EBV(saved feed)}_{\text{cow}} = v_1 \times \text{EBV(maintenance)} + v_2 \times \text{EBV(metabolic efficiency)} \quad (1)$$

where v_1 and v_2 are the economic weights for maintenance and metabolic efficiency, respectively. Energy requirements for maintenance depend on body weight and the physical activity of the animal; it is approximately 1 kg DM per 100 kg body weight or roughly 30 % of the daily energy intake for a lactating cow. Thus, smaller cows require less feed for maintenance and will receive a higher EBV for maintenance.

Metabolic efficiency is slightly more complicated and can be defined as the difference between observed and predicted energy requirement. The smaller the difference, the more efficient is the cow. This difference can also be referred to as *residual feed intake* (RFI; Koch et al., 1963):

$$\text{RFI} = \text{DMI}_{\text{actual}} - \text{DMI}_{\text{predicted}} \quad (2)$$

Besides records of feed consumption, the calculation of RFI requires repeated measurements of milk production and body weight and may be combined with indicator trait such as body condition score, stature, chest width or body depth. Measurements of milk production are already available from a number of herds including AMS herds participating in the dairy herd improvement scheme. Currently, weight data is only available from a handful of AMS herds.

6.2 Results

The economic value of saved feed, i.e. value of saving 1 kg dry matter (DM), is equal to the average value of 1 kg DM in the feed ration. We wanted, however, to explore different methods for calculation the economic value of saved feed or in this case RFI. The methods were based on simulated RFI data that was created using the simulation software SimHerd. This enabled possibilities for change of assumptions (e.g. prices, herd structure, trait definition etc.) Assumptions similar to the 2018 NTM assumptions (Biological assumptions and Economic assumptions) were used for the simulations.

The estimated economic value of improving RFI by 1 kg DM was €0.18/kg DM which is close to the average price of 1 kg DM in the feed ration used in the 2018 NTM calculations. Regarding the he economic value of maintenance, i.e. the value of decreasing metabolic body weight (MBW) by 1 kg in a lactation, annual energy requirements per kg MBW were calculated (Nielsen and Volden, 2011) and multiplied with the feed price (€0.18/ kg DM). Thus, the economic value of MBW was estimated to be €3.2 per kg MBW. An overview of the economic values of the saved feed traits and used standardization factors for calculating the economic value per index unit are shown in Table 6.1.

Table 6.1. Economic values of residual feed intake (RFI), metabolic live weight (MBW), and saved feed for HOL.

Trait	€ per trait unit	Standardization factor Trait units per index unit	€ per index unit
RFI, kg DM per lactation	0.18	17.1 kg DM[1]	3.06
MBW, kg	3.2	0.502 kg[2]	1.61
Saved Feed, kg DM	-	-	4.67

[1] σ_a adopted from Li et al., 2017 and modified

[2] σ_a adopted from Manzanilla-Pech et al., 2016 and modified; mean of Dutch and US records

We calculated the relative NTM weight of saved feed for comparison with the remaining NTM sub-traits. Standardization factors, i.e. conversion factor to get from economic value per trait unit to economic value per index unit, were adopted from Li et al. (2017) and Manzanilla-Pech et al. (2016) for RFI and MBW, respectively. For both traits SD was Both variables were adjusted to account for EBV with reliability less than one. Economic values per index unit were then calculated, for example for RFI: €0.18 per kg DM per lactation ×17.1 kg DIM per index unit = €3.06 per index unit. According to Manzanilla-Pech et al. (2016), 17.8 kg DM per year is required to maintain 1 kg MBW. Using the feed costs from RFI above in Table 6.1, we €3.2 per kg MBW annually.

The total amount of saved feed is the sum of improved RFI and reducing maintenance energy; thus, the economic value per index unit for saved feed is €3.06 + €1.61 = €4.67 per index unit. These values can all be converted to relative NTM weights by dividing with the economic value of a yield index unit. For HOL this is €10.94. Thus, the relative NTM weight for (total) saved feed in HOL is 0.43 which can be split into 0.15 for MBW and 0.28 for RFI.

6.3 Discussion

Estimating EBV for maintenance requires routinely recorded weight data from cows. These are currently only available from some AMS herds and correlated records using measuring tape from FIN and will require work before they can be incorporated in the routine evaluation for maintenance. Type traits such as stature, chest width and body depth are moderately genetically correlated to weight. These traits are recorded on many animals and may provide valuable indirect information for estimation of breeding values for maintenance.

Estimation of EBV for RFI is more complicated. This also requires records of cow weights but more importantly feed intake records collected on a large scale is key for a successful genetic selection program for RFI. This may first be a reality in several years. Also, more research is required to investigate how RFI change across the lactation. Typically, RFI models only account for overall changes in body weight under the assumption that the energy value of 1 kg loss in body weight is equal to the energy value of 1 kg gain in body weight. This is not the case as energy value of 1 kg loss is less than energy value of 1 kg gain. For example, body fat is mobilized until approximately 70 DIM whereas body protein is mobilized until 28 DIM. From approximately mid-lactation the cow begins to gain weight. Therefore, it is important to account for changes in body weight and type of body tissue to ensure that selection for RFI is not equal to an energy balance model See further discussion about this challenge in Li et al. (2017). Indicator traits such as body condition score may provide information about changes in different tissues.

7 Polledness in the breeding goal

In the future de-horning of cattle may not be accepted by the public due to concerns about animal welfare. Today, de-horning of cattle is a nuisance that would rather be avoided on any dairy farm. It is possible to select hetero- or homozygous carriers of the mutation responsible for polledness in dairy cattle. Polledness may be introduced in the NAV breeding goal as a new simple NTM sub-trait if it has an economic value. Currently, there are no indications that polledness affects the economic value of any current NTM sub-trait. In this chapter, the economic value of polledness will be calculated in a simple manner to give an estimate of the value of polledness compared to the current NTM sub-traits.

Costs related to dehorning calves are:

- Veterinary costs – local anesthesia and sedatives (mandatory)
- Dehorning costs – gas/electricity.
- Extra labor for the herd personnel (capture calves for vet + performing dehorning procedure).

Veterinary costs were established by investigating actual invoices sent by veterinarians to farms (DNK only). No vet fee is included because dehorning is usually performed when the veterinarian is visiting the herd anyway. We took a conservative approach and set the veterinary costs to €2.00 per calf (actual figures are less). The dehorning costs were set to €1.00 per calf. Finally, extra labor including catching the calf, holding the calf for veterinarian to perform injections, the dehorning procedure, and getting equipment ready was assumed to be around 6 minutes per calf – again a conservative approach was taken and the extra labor was increased to 10 minutes (or 0.2 hours) per calf. These assumptions were also applied to SWE and FIN.

It was assumed that only heifer calves (excl. heifer beef×dairy crossbreds) were dehorned in DNK whereas all calves were dehorned in SWE and FIN. The reason for this is that bull calves on average are slaughtered much earlier in DNK compared to SWE and FIN. This decreases the risk of bull calves hurting each other and staff; thus, dehorning is omitted. Calves that died before day 31 after birth were not dehorned. The results were based on the Conventional scenario including the use of both SS and BS for minimization of surplus heifers. Note: the choice of scenario will influence the number of calves that shall be dehorned annually.

7.1 Results and discussion

As mentioned the results are based on the conventional NTM 2018 scenario which is based on a model herd of 110 cows. The number of calves that survived the first 30 days after birth is shown in Table 7.1.

Table 7.1. Number of calves that survived day 30 after birth for each breed and country combination

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Heifers	37.3	38.4	36.9	37.2	37.7	36.5	38.8
Bulls incl. beef×dairy crossbreds	72.8	68.9	68.6	68.6	66.2	68.1	66.7
Total	110.1	107.3	105.5	105.8	103.9	104.6	105.5

Costs related to dehorning calves range from €2.73 to €7.30 per annual cow (Table 7.2). Costs related to dehorning depends on the total number of animals that must be de-horned. Therefore, the costs are much lower in DNK, where only purebred dairy heifer calves are dehorned, compared to SWE and FIN, where both heifers and bulls are de-horned, despite a higher hourly wage for DNK than for both SWE and FIN. Differences between the breeds in DNK can be explained by the mortality rate for heifers between 31 and 458 days of age – highest for JER and lowest for RDC. In SWE and FIN all calves are dehorned. The higher costs for SWE compared to FIN can be explained by a slightly higher (~7 %) hourly wage.

Table 7.2. Saved costs from dehorning in a herd with 100 % polled animals compared to a herd with 0% polled animals.

	RDC			HOL			JER
	DNK	SWE	FIN	DNK	SWE	FIN	DNK
Per calf, €	2.74	7.30	6.16	2.84	7.30	6.16	2.97
Per annual cow, €	2.74	7.02	5.92	2.73	6.90	5.86	2.85

Bulls carrying the mutation for polledness may be more expensive to use, given the same genetic level, than non-carrier bulls. The values in Table 7.2 illustrate how much more a semen dose from a carrier bull can costs to break even with semen from non-carrier bulls.

Compared to a recent American study our results seem a bit too low. Thompson et al. (2017) found that a semen dose from a homo- or heterozygous bull could cost between €5.08 and €10.17 more than a bull producing only horned offspring. However, they have included additional cost for using semen from polled bulls and accounted for whether a homo- or heterozygous bull is used.

Neither our study nor the American study considers the effect of introducing 100 % polledness from a genetic perspective. Polled bulls are likely to be from closely related families. This may decrease genetic variation and increase inbreeding in the population. Also, polled bulls may be genetically inferior to horned bulls. Thus, using only polled bulls will limit the genetic gain at population level. We do not have estimates on the economic consequences at the genetic level but they should not be underestimated.

Finally, legislation and consumer attitude towards dehorning of cattle from an animal welfare point of view is not taken into account either. The economic value of this is difficult to deduct but if dehorning of cattle, for example, became illegal, it may force the dairy cattle industry to focus even more on introducing polled genetics into the dairy population.

8 Sensitivity analyses

The economic values, shown so far, are based on a set of economic and biological or management assumptions outlined in Chapters 3 and 4. Many of the assumptions are associated with some uncertainty. The effect of these uncertainties on the economic values must be addressed, i.e. how sensitive are the economic values to changes in the assumptions. At the January 2018 NAV Workshop, recommendations for some additional analyses were made and additional recommendations were received from the HOL, RDC and JER breed organizations during Spring 2018.

In the following, results from these additional analyses are presented at two levels: (1) Those related to economic assumptions, and (2) those associated with biological/management assumptions. The results of the sensitivity analyses are calculated as averages across countries only and will be presented as deviations (both actual and percentage) from the economic values based on conventional assumptions if nothing else is mentioned. Deviations less than 3 % are considered minor and will not be discussed.

8.1 Change of economic assumptions

8.1.1 Milk price

Changes to economic values, if the price of milk, fat and protein is decreased by 10 %, are shown in Table 8.1, 8.2, and 8.3 for HOL, RDC, and JER, respectively. Increasing the milk price by 10 % will result in a similar change to the economic values but in the opposite direction. If the total income from milk is decreased by 10 %, whilst all costs are unchanged the profit from improving fat and protein yield decreases by 20 %. – for 1 kg of standard milk the economic value decreases 18.3 % for all breeds because feed costs are unchanged.

Improvement of ICF (interval from calving to first insemination) leads to more calvings and, therefore, higher annual milk production. With a lower milk price, the change in the economic value of ICF is -0.06 €/day in all breeds. However, because the economic value for JER, based on conventional assumptions, was 4-5 times lower than for HOL and RDC, the proportional decrease is much higher in JER. The actual change in the economic values for IFL_{cows} (interval from first to last insemination) is similar to the value of ICF.

Improving longevity leads to a higher proportion of older cows and therefore higher milk production, but because this extra milk is sold at a lower price, the economic value of longevity decreases by 0.04 €/day for all breeds.

Minor negative effects of a decreased milk price were seen for the economic value of the disease traits (4 % decrease for udder health) and calving ease because less milk is discarded when these traits are improved – more milk can be sold but at a lower price. Calving ease includes costs related to difficult calvings with veterinary assistance which may involve cesarean or dissection of calves. This requires antibiotic treatment and some milk must be discarded because of this.

8.1.2 Feed costs

The effects on the economic values, when feed costs were increased by 10 %, are shown in Table 8.1, 8.2, and 8.3 for HOL, RDC, and JER, respectively. The change to the economic values when feed costs are decreased by 10 % are similar but in opposite direction. Generally, changed feed costs only affect traits where improvement results in more milk or more animals for slaughter, i.e. milk, daily gain, survival rate, ICF and IFL_{cows} and young stock survival traits.

The largest proportional effect of increased feed costs was seen for ICF (18.5 % decrease) – the actual change is -0.12 €/day and was similar for IFL_{cows}. Improvement of ICF results in more annual calvings and, therefore, increased milk production. Also, more calves (beef×dairy crossbreds) can be sold for slaughter. However, the profit per kg milk or per kg meat is decreased because production costs have increased. The proportional impact of feed costs on milk and daily gain was less but still negative. Improvement of heifer survival means that fewer replacement heifers need to be born; instead more cows can be inseminated with beef semen resulting in more animals for slaughter. Finally, improvement of survival of bull calves results in more bulls and beef×dairy crossbreds for slaughter. Increased feed price result in a lower value for improving the heifer and bull survival – the negative impact was almost the same for the four young stock survival traits.

In JER, the effect of increased feed costs on traits for which improvements result in more animals for slaughter, was smaller compared to HOL and RDC. The reason for this is that JER grows slower than HOL and RDC and needs more feed per kg gain. Also, very few JER bull calves are slaughtered at 10 months of age – most are young bulls (>10 months) which have a lower slaughter price per kg. This creates a lower (on average) slaughter price per kg in JER and as a result a lower impact when the feed price is increased because the difference in profit between improving and not improving a trait is less than in HOL and RDC.

The economic values for the disease traits do not change when feed costs are changed. This is because the costs of producing the milk is the same whether the milk is sold or retained (discarded).

8.1.3 Meat price

Changes to economic values, when meat price is reduced by 10 %, were calculated. Increasing the meat price by 10 % will result in a similar change but in the opposite direction. The same traits as shown above (8.1.2) excluding milk are affected when the meat price is reduced. Again, changes to economic values for HOL and RDC were larger than for JER (see explanation above). The effect of improving daily gain was reduced by approx. 25 % when the meat price was reduced by 10 %. The effects on ICF and IFL_{cows} were similar but the proportional change was much larger for ICF because of the much lower economic value per day compared to IFL_{cows}. The impact on the young stock survival traits, when sales price for meatwas reduced by 10 %, were much larger (×2) than observed when feed costs were increased by 10 %.

8.1.4 Veterinary treatment costs

A veterinary treatment consists of a treatment fee (allowance for veterinarian and mileage) + costs related to materials and medicine. The veterinary treatment costs were increased by 10 % including treating costs (medicine and materials) for some claw health disorders. This resulted in increased economic values for traits including any veterinary treatment. The largest effect on the economic values were seen for the disease traits where the impact of health agreement schemes are smallest, i.e. metabolic and reproductive diseases (7-8% increase); whereas diseases with a higher degree of treatment by the herd manager were affected less, i.e. mastitis and feet & legs diseases (4-5 % increase). The effect of increased treatment costs on claw health disorders including treatment costs (sole ulcer, horn heel erosion, digital dermatitis, and interdigital hyperplasia) was modest ~4 %.

8.1.5 Labor costs

Labor costs were increased by 10 % and only include labor related to the herd personnel – claw trimmer labor costs were not increased. Calculation of marginal economic values for the conformation, milkability and temperament traits only includes extra labor; thus, the economic values for these traits increased by 10 % for all breeds when labor costs were increased by 10 %. The impact on the economic values of calving ease and claw health traits were less; these were increased by 4-6 %. Only minor increased economic values of mastitis and other diseases were observed when labor costs were increased.

Table 8.1. Results of sensitivity analyses of conventional economic assumptions for HOL. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT			ALTERNATIVE				
	Unit	Conv. average, €	Milk price -10 %	Feed price +10 %	Beef price -10 %	Vet. treat-ment costs +10 %	Labor costs +10%
				MILK PRODUCTION			
Standard milk[1]	kg	0.191	-0.035 (18)	-0.02 (8)	0.00	0.00	0.00
				GROWTH			
Daily gain	kg/day	0.213	0.00	-0.036 (17)	-0.055 (26)	0.00	0.00
EUROP form	score	11.1	0.00	0.00	0.00	0.00	0.00
				CALVING TRAITS			
Survival rate 1st	%-unit	1.61	0.00	-0.12 (8)	-0.25 (16)	0.00	0.00
Survival rate later, maternal	%-unit	3.92	0.00	-0.34 (9)	-0.67 (17)	0.00	0.00
Survival rate later, direct	%-unit	2.55	0.00	-0.22 (9)	0.00	0.00	0.00
Calving ease 1st	point	5.63	-0.01	0.00	0.00	0.19 (3)	0.36 (6)
Calving ease later, maternal	point	26.58	-0.09 (3)	0.00	0.00	1.15 (4)	1.43 (5)
Calving ease later, direct	point	15.67	-0.05 (3)	0.00	0.00	0.69 (4)	0.83 (5)
				FEMALE FERTILITY[2]			
IFL heifers	day	0.80	-0.00	0.01	0.01	0.00	0.02
ICF cows	day	0.54	-0.06 (12)	-0.12 (23)	-0.15 (27)	-0.01	-0.02 (4)
IFL cows	day	4.24	-0.06	-0.12 (3)	-0.15 (4)	-0.01	0.14
				UDDER HEALTH			
Udder health sum all lact	%-unit	4.34	-0.17 (4)	0.00	0.00	0.19 (4)	0.08
				GENERAL HEALTH			
Other metabolic, sum all lact	%-unit	3.16	-0.05	0.00	0.00	0.23 (7)	0.04
Ketosis, sum all lact	%-unit	1.45	0.00	0.00	0.00	0.11 (7)	0.03
Feet & legs, sum all lact	%-unit	1.61	-0.04	0.00	0.00	0.07 (4)	0.05
Early repro, sum all lact	%-unit	2.10	-0.06	0.00	0.00	0.11 (5)	0.04
Late repro, sum all lact	%-unit	1.81	-0.03	0.00	0.00	0.12 (7)	0.03
				LONGEVITY			
Average herd life[3]	day	0.31	-0.04 (13)	0.00	0.01	0.00	0.00
				CONFORMATION a.o.			
Frame	point	0.00	0.00	0.00	0.00	0.00	0.00
Udder	point	29.07	0.00	0.00	0.00	0.00	2.91 (10)
Feet & legs conf.	point	19.38	0.00	0.00	0.00	0.00	1.94 (10)
Milkability	point	19.38	0.00	0.00	0.00	0.00	1.94 (10)
Temperament	point	9.69	0.00	0.00	0.00	0.00	0.97 (10)
				CLAW HEALTH			
Sole ulcer, sum all lact	%-unit	0.586	0.00	0.00	0.00	0.022 (4)	0.031 (5)
Sole hemorrhage, sum all lact	%-unit	0.096	0.00	0.00	0.00	0.00	0.0057 (6)
Horn heel erosion, sum all lact	%-unit	0.148	0.00	0.00	0.00	0.0052 (4)	0.0058 (4)
Digital dermatitis, sum all lact	%-unit	0.148	0.00	0.00	0.00	0.0052 (4)	0.0058 (4)
Cork screw claw, sum all lact	%-unit	0.077	0.00	0.00	0.00	0.00	0.00
Interdigital hyperplasia, sum all lact	%-unit	0.295	0.00	0.00	0.00	0.010 (4)	0.012 (4)
White line disease, sum all lact	%-unit	0.96	0.00	0.00	0.00	0.00	0.0058 (6)
				YOUNG STOCK SURVIVAL			
Survival heifers 1-30 d,	%-unit	3.43	0.00	-0.24 (7)	-0.50 (14)	0.00	0.00
Survival heifers 31-458 d	%-unit	3.68	0.00	-0.16 (4)	-0.44 (12)	0.00	0.00
Survival bulls 1-30 d,	%-unit	1.72	0.00	-0.16 (9)	-0.32(18)	0.00	0.00
Survival bulls, 31-184 d	%-unit	2.29	0.00	-0.18 (8)	-0.39 (17)	0.00	0.00

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 8.2. Results of sensitivity analyses of conventional, economic assumptions for RDC. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT	Unit	Conv. average, €	ALTERNATIVE: Milk price -10 %	Feed price +10 %	Beef price -10 %	Vet. treat-ment costs +10 %	Labor costs +10%
MILK PRODUCTION							
Standard milk[1]	kg	0.189	-0.035 (18)	-0.02 (8)	0.00	0.00	0.00
GROWTH							
Daily gain	kg/day	0.230	0.00	-0.036 (16)	-0.056 (24)	0.00	0.00
EUROP form	score	11.3	0.00	0.00	0.00	0.00	0.00
CALVING TRAITS							
Survival rate 1st	%-unit	1.63	0.00	-0.12 (8)	-0.25 (15)	0.00	0.00
Survival rate later, maternal	%-unit	3.92	0.00	-0.33 (8)	-0.67 (17)	0.00	0.00
Survival rate later, direct	%-unit	2.55	0.00	-0.21 (8)	-0.43 (17)	0.00	
Calving ease 1st	point	5.79	-0.01	0.00	0.00	0.19 (3)	0.37 (7)
Calving ease later, maternal	point	25.01	-0.08 (3)	0.00	0.00	1.14 (5)	1.28 (5)
Calving ease later, direct	point	14.97	-0.04 (3)	0.00	0.00	0.69 (5)	0.76 (5)
FEMALE FERTILITY[2]							
IFL heifers	day	0.94	0.00	0.01	0.00	0.00	0.02 (3)
ICF cow	day	0.64	-0.06 (9)	-0.12 (19)	-0.16 (24)	-0.01	-0.02 (3)
IFL cows	day	3.46	-0.06	-0.12 (4)	-0.15 (4)	-0.01	0.14 (3)
UDDER HEALTH							
Udder health sum all lact	%-unit	4.22	-0.15 (4)	0.00	0.01	0.19 (5)	0.08
GENERAL HEALTH							
Other metabolic, sum all lact	%-unit	3.17	-0.05	0.00	0.00	0.23 (7)	0.04
Ketosis, sum all lact	%-unit	1.49	0.00	0.00	0.00	0.11 (7)	0.03
Feet & legs, sum all lact	%-unit	1.62	-0.04	0.00	0.00	0.07 (4)	0.05
Early repro, sum all lact	%-unit	2.09	-0.05	0.00	0.00	0.12 (7)	0.04
Late repro, sum all lact	%-unit	1.76	-0.03	0.00	0.00	0.12 (8)	0.03
LONGEVITY							
Average herd life[3]	day	0.28	-0.04 (13)	0.00	0.01	0.00	0.00
CONFORMATION a.o.							
Frame	point	0.00	0.00	0.00	0.00	0.00	0.00
Udder	point	29.07	0.00	0.00	0.00	0.00	2.91 (10)
Feet & legs conf.	point	19.38	0.00	0.00	0.00	0.00	1.94 (10)
Milkability	point	19.38	0.00	0.00	0.00	0.00	1.94 (10)
Temperement	point	9.69	0.00	0.00	0.00	0.00	0.97 (10)
CLAW HEALTH							
Sole ulcer, sum all lact	%-unit	0.595	0.00	0.00	0.00	0.022 (4)	0.032 (5)
Sole hemorrhage, sum all lact	%-unit	0.097	0.00	0.00	0.00	0.00	0.0058 (6)
Horn heel erosion, sum all lact	%-unit	0.154	0.00	0.00	0.00	0.0054 (4)	0.0060 (4)
Digital dermatitis, sum all lact	%-unit	0.154	0.00	0.00	0.00	0.0052 (4)	0.0058 (4)
Cork screw claw, sum all lact	%-unit	0.077	0.00	0.00	0.00	0.00	0.00
Interdigital hyperplasia, sum all lact	%-unit	0.296	0.00	0.00	0.00	0.010 (4)	0.012 (4)
White line disease, sum all lact	%-unit	0.096	0.00	0.00	0.00	0.00	0.0058 (6)
YOUNG STOCK SURVIVAL							
Survival heifers 1-30 d	%-unit	3.30	0.00	-0.23 (7)	-0.47 (14)	0.00	0.00
Survival heifers 31-458 d	%-unit	3.66	0.00	-0.16 (5)	-0.44 (12)	0.00	0.00
Survival bulls 1-30 d	%-unit	1.92	0.00	-0.16 (8)	-0.34 (18)	0.00	0.00
Survival bulls, 31-184 d	%-unit	2.09	0.00	-0.16 (8)	-0.35 (17)	0.00	0.00

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

Table 8.3. Results of sensitivity analyses of economic conventional assumptions for JER. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT	ALTERNATIVE						
	Unit	Conv. average, €	Milk price -10 %	Feed price +10 %	Beef price -10 %	Vet. treat-ment costs +10 %	Labor costs +10%
				MILK PRODUCTION			
Standard milk[1]	kg	0.191	-0.034 (18)	-0.02 (8)	0.00	0.00	0.00
				GROWTH			
Daily gain	kg/day	0.192	0.00	-0.022 (12)	-0.043 (22)	0.00	0.00
EUROP form	score	6.1	0.00	0.00	0.00	0.00	0.00
				CALVING TRAITS			
Survival rate 1st	%-unit	0.85	0.00	-0.09 (11)	-0.17 (19)	0.00	0.00
Survival rate later, maternal	%-unit	3.13	0.00	-0.36 (12)	-0.68 (22)	0.00	0.00
Survival rate later, direct	%-unit	1.87	0.00	-0.22 (12)	-0.40 (21)	0.00	0.00
Calving ease 1st	point	10.76	-0.03	0.00	0.00	0.56 (5)	0.48
Calving ease later, maternal	point	120.95	-0.39 (3)	0.00	0.00	5.94 (5)	5.77 (5)
Calving ease later, direct	point	64.72	-0.20 (3)	0.00	0.00	3.19 (5)	3.07 (5)
				FEMALE FERTILITY[2]			
IFL heifers	day	1.26	0.00	0.03	-0.01	0.00	0.03
ICF cows	day	0.18	-0.06 (36)	-0.10 (54)	-0.10 (55)	-0.01 (8)	-0.02
IFL cows	day	2.56	-0.06	-0.10 (4)	-0.10 (4)	-0.01	0.08
				UDDER HEALTH			
Udder health, sum all lact	%-unit	4.45	-0.18 (4)	0.00	0.01	0.17 (4)	0.10
				GENERAL HEALTH			
Other metabolic, sum all lact	%-unit	3.10	-0.05	0.00	0.00	0.22 (7)	0.04
Ketosis, sum all lact	%-unit	1.56	0.00	0.00	0.00	0.12 (8)	0.04
Feet & legs, sum all lact	%-unit	1.79	-0.04	0.00	0.00	0.07 (4)	0.06
Early repro, sum all lact	%-unit	2.03	-0.05	0.00	0.00	0.10 (5)	0.05
Late repro, sum all lact	%-unit	1.65	-0.03	0.00	0.00	0.11 (7)	0.03
				LONGEVITY			
Average herd life[3]	day	0.36	-0.04 (11)	0.00	0.00	0.00	0.00
				CONFORMATION a.o.			
Frame	point	0.00	0.00	0.00	0.00	0.00	0.00
Udder	point	33.02	0.00	0.00	0.00	0.00	3.30
Feet & legs conf.	point	22.01	0.00	0.00	0.00	0.00	2.20
Milkability	point	22.01	0.00	0.00	0.00	0.00	2.20
Temperament	point	11.01	0.00	0.00	0.00	0.00	1.10
				CLAW HEALTH			
Sole ulcer, sum all lact	%-unit	0.795	0.00	0.00	0.00	0.031 (4)	4.84
Sole hemorrhage, sum all lact	%-unit	0.114	0.00	0.00	0.00	0.00	1.14
Horn heel erosion, sum all lact	%-unit	0.1680	0.00	0.00	0.00	0.0054	1.14
Digital dermatitis, sum all lact	%-unit	0.168	0.00	0.00	0.00	0.0054	1.14
Cork screw claw, sum all lact	%-unit	0.091	0.00	0.00	0.00	0.00	0.91
Interdigital hyperplasia, sum all lact	%-unit	0.336	0.00	0.00	0.00	0.011	2.28
White line disease, sum all lact	%-unit	0.114	0.00	0.00	0.00	0.00	1.14
				YOUNG STOCK SURVIVAL			
Survival heifers 1-30 d	%-unit	1.56	0.00	-0.14 (9)	-0.28 (18)	0.00	0.00
Survival heifers 31-458 d	%-unit	2.05	0.00	-0.09 (4)	-0.27 (13)	0.00	0.00
Survival bulls 1-30 d	%-unit	0.75	0.00	-0.09 (12)	-0.17 (23)	0.00	0.00
Survival bulls, 31-184 d	%-unit	0.73	0.00	-0.07 (9)	-0.15 (20)	0.00	0.00

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

8.2 Change of biological or management assumptions

In the following a brief description of alternative scenarios, where biological or management assumptions are changed, is presented. Overviews of all the results are shown in Table 8.4, 8.5, and 8.6 for HOL, RDC, and JER, respectively.

8.2.1 Use of sexed semen

In the conventional scenario, the proportion of replacement heifers born from sexed semen (SS) was between 51.6 and 58.9 % (average around 52 %; see Table 3.13) depending on breed and country. It was investigated how increased or decreased use of SS affected the economic values. Table 8.4, 8.5, and 8.6 only include results from increasing the proportion of replacement heifers born from SS to approximately 62 %. In general, the effect of increasing the proportion of SS was minor. Decreasing the proportion to approx. 42 % resulted in a similar change to the economic values but in the opposite direction. Most noticeable changes were seen for the growth traits and young stock survival (bulls) because increasing or decreasing the use of SS changes the proportion of beef×dairy crossbreds for slaughter.

8.2.2 Replacement rate

In both the conventional and organic scenarios, a replacement rate of 32 % was used for all combinations of breed and country. However, at present some combinations of production system, breed and country are already well below this level. Thus, it is important to investigate how varying replacement rates will affect the economic values for each trait. Replacement rates of 27 and 37 % were investigated –mainly the former will be discussed here. Generally, a lower replacement rate, given the present assumptions, results in a changed herd structure towards more older cows. Fewer replacement heifers are needed; thus, more beef×dairy crossbreds can be bred, and fewer purebred dairy heifers and bulls are born.

Decreasing the replacement rate by 5 %-units had a major impact on several traits (Table 8.4, 8.5, and 8.6). A lower replacement rate will change the distribution between parities towards a greater proportion of older cows. This results in a higher annual milk yield but also increased frequency of diseases. A lower replacement rate results in a 15 % lower economic value of the calving traits in 1st parity, whereas the values in later parities is increased but only 4 and 8 % for survival rate and calving ease, respectively. For similar reasons, the economic values for $IFL_{heifers}$ decreases and IFL_{cows} increases when replacement rate is lowered. Improving ICF (and IFL) results in more calvings and more animals for slaughter. However, at a lower replacement rate the improvement of ICF with one day results in fewer extra animals for slaughter compared to a higher replacement rate; thus, we see a negative impact on the economic value. The effect is positive when replacement rate is increased but at a much lower level. Also, the values for young stock survival (heifers) decreases a slightly (~5 %) because fewer born heifers result in these traits being expressed fewer times.

The greatest impact of a lower replacement rate was seen for the economic values for longevity which decreased by 28 % in all breeds. However, an increase in replacement rate of 5 %-points results in a 33 % increase of the economic values. This indicates that the relationship between replacement rate and economic values is not linear. This was investigated further to understand the relationship between replacement rate and longevity. Improvement of longevity in the NTM program is done by decreasing the replacement rate by one %-unit. In Table 5.2 some key figures were presented for two situations: (1) changing the replacement rate from 27 to 26 % and (2) changing the replacement rate from 37 to 36 %. The economic value of longevity is given as profit per cow per day. This is calculated as the difference in total profit divided by the difference in the number of herd longevity days. The difference in total profit is only approx. 3 % higher in situation (1) using the low replacement rate whereas the difference in longevity days is approx. 90 % higher. The result of the latter is a 46 % lower economic value for longevity in situation (1). However, when showing the economic value as profit per cow per %-unit change in replacement rate the values are almost similar in the two situations.

8.2.3 Participation in health agreement schemes

Since the 2008 NTM calculations health agreement schemes have been implemented in DNK and are running on a trial basis in SWE and FIN. Participation in these schemes enables the herd personnel to initiate treatment for certain diseases or perform follow-up treatments after the initial treatment has been performed by a veterinarian. Three main schemes are used:

4. Basis agreement – all treatments are done by the herd veterinarian (in SWE the herd personnel can always perform re-treatments).
5. Basis agreement + add-on module 1 – all diagnoses and first treatments are done by the herd veterinarian. The herd personnel can perform follow-up treatments for certain diseases and initiate treatments in young stock.
6. Basic agreement + add-on module 2 – the herd personnel can initiate treatment of certain diseases for a limited or unlimited time period. Further instructions and authorization also allow the herd personnel to initiate treatment of milk fever and/or retained placenta.

For the current calculations, the 2017 DNK participation numbers in the different health agreement options shown above were used, and it was assumed that SWE and FIN in the future will participate at a similar level. It is important to investigate possible impacts on the economic values if, for example, participation in SWE and FIN turns out to be less than expected. The proportion of herds for option 1was assumed to be 10 % in the Conventional scenario. Increasing this proportion will increase treatment costs for certain diseases because more treatments must be performed by a veterinarian and decreasing the proportion will have the opposite effect.

Two scenarios were investigated for sensitivity analyses: (1) no herds participate in option 1 (Basis0%), and (2) 20 % of all herds participate in option 1 (Basis20%). Only results for Basis0% are shown but results for Basis20% were similar but in the opposite direction. The effects of changing participation proportion were minor or non-existing for most traits (Table 8.4, 8.5, and 8.6). The greatest effects were seen for diseases where owner treatment is possible, i.e. udder health and feet & legs. However, the effects were still limited to ~5 % change of the economic values.

Table 8.4. Results of sensitivity analyses of conventional biological and management assumptions for HOL. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT			ALTERNATIVE		
	Unit	Conv. average, €	Sexed semen 62 %	Replacement rate = 27 %	Basis 0%[4]
			MILK PRODUCTION		
Standard milk[1]	Kg	0.191	0.00	0.003	0.00
			GROWTH		
Daily gain	kg/day	0.213	-5.6	5.2	0.00
EUROP form	score	11.1	-0.54 (5)	-0.02	0.00
			CALVING TRAITS		
Survival rate 1st	%-unit	1.61	-0.01	-0.24 (15)	0.00
Survival rate later, maternal,	%-unit	3.92	-0.04	0.16 (4)	0.00
Survival rate later, direct	%-unit	2.55	-0.14 (6)	-0.02	0.00
Calving ease 1st	point	5.63	0.00	-0.86 (15)	-0.01
Calving ease later, maternal	point	26.58	0.87	2.10 (8)	-0.06
Calving ease later, direct	point	15.67	0.05	0.66 (4)	-0.03
			FEMALE FERTILITY[2]		
IFL heifers	day	0.80	0.01	-0.12 (14)	0.00
ICF cows	day	0.54	0.00	-0.04 (7)	0.01
IFL cows	day	4.24	-0.01	0.10	0.01
			UDDER HEALTH		
Udder health, sum all lact	%-unit	4.34	0.00	-0.01	-0.20 (5)
			GENERAL HEALTH		
Other metabolic, sum all lact	%-unit	3.16	0.00	-0.06	-0.02
Ketosis sum, sum all lact	%-unit	1.45	0.00	-0.03	0.00
Feet & legs sum, sum all lact	%-unit	1.61	0.00	-0.02	-0.08 (5)
Early repro sum, sum all lact	%-unit	2.10	0.00	-0.04	-0.06
Late repro sum, sum all lact	%-unit	1.81	0.00	-0.03	-0.02
			LONGEVITY		
Average herd life[3]	day	0.31	0.00	-0.09 (28)	0.00
			CONFORMATION a.o.		
Frame	point	0.00	0.00	0.00	0.00
Udder	point	29.07	0.00	0.00	0.00
Feet & legs conf.	point	19.38	0.00	0.00	0.00
Milkability	point	19.38	0.00	0.00	0.00
Temperament	point	9.69	0.00	0.00	0.00
			CLAW HEALTH		
Sole ulcer, sum all lact	%-unit	0.586	0.00	-1.26	0.00
Sole hemorrhage, sum all lact	%-unit	0.096	0.00	-0.21	0.00
Horn heel erosion, sum all lact	%-unit	0.148	0.00	-0.32	0.00
Digital dermatitis, sum all lact	%-unit	0.148	0.00	-0.32	0.00
Cork screw claw, sum all lact	%-unit	0.077	0.00	-0.17	0.00
Interdigital hyperplasia, sum all lact	%-unit	0.295	0.00	-0.64	0.00
White line disease, sum all lact	%-unit	0.096	0.00	-0.21	0.00
			YOUNG STOCK SURVIVAL		
Survival heifers 1-30 d	%-unit	3.43	0.01	-0.21 (6)	0.00
Survival heifers 31-458 d	%-unit	3.68	0.01	-0.38 (10)	0.00
Survival bulls 1-30 d	%-unit	1.72	-0.12 (7)	-0.04	0.00
Survival bulls, 31-184 d	%-unit	2.29	-0.09 (4)	0.03	0.00

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

[4]See explanation in chapter 1.2.3. Participation in health agreement schemes

Table 8.5. Results of sensitivity analyses of conventional biological and management assumptions for RDC. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT			ALTERNATIVE		
	Unit	Conv. average, €	Sexed semen 62 %	Replacement rate = 27 %	Basis 0%[4]
			MILK PRODUCTION		
Standard milk[1]	kg	0.189	0.00	0.004	0.00
			GROWTH		
Daily gain	kg/day	0.230	-5.3	4.2	0.00
EUROP form	score	11.3	--0.48 (4)	-0.03	0.00
			CALVING TRAITS		
Survival rate 1st	%-unit	1.63	-0.02	-0.23 (14)	0.00
Survival rate later, maternal	%-unit	3.92	-0.02	0.14 (4)	0.00
Survival rate later, direct	%-unit	2.55	-0.,11 (4)	-0.03 (4)	0.00
Calving ease 1st	point	5.79	0.00	-0.88 (15)	-0.01
Calving ease later, maternal	point	25.01	0.50	1.67 (7)	-0.05
Calving ease later, direct	point	14.97	-0.09	0.4	-0.00
			FEMALE FERTILITY[2]		
IFL heifers	day	0.94	0.00	--0.14 (15)	0.00
ICF cows	day	0.64	0.00	-0.02 (4)	0.01
IFL cows	day	3.46	0.00	0.08	0.01
			UDDER HEALTH		
Udder health, sum all lact	%-unit	4.22	0.00	-0.01	-0.19 (5)
			GENERAL HEALTH		
Other metabolic, sum all lact	%-unit	3.17	0.00	-0.06	-0.02
Ketosis, sum all lact	%-unit	1.49	0.00	-0.03	0.00
Feet & legs, sum all lact	%-unit	1.62	0.00	-0.03	-0.08 (5)
Early repro, sum all lact	%-unit	2.09	0.00	-0.04	-0.06
Late repro, sum all lact	%-unit	1.76	0.00	-0.03	-0.02
			LONGEVITY		
Average herd life[3]	day	0.28	0.00	-0.08 (28)	0.00
			CONFORMATION a.o.		
Frame	point	0.00	0.00	0.00	0.00
Udder	point	29.07	0.00	0.00	0.00
Feet & legs conf.	point	19.38	0.00	0.00	0.00
Milkability	point	19.38	0.00	0.00	0.00
Temperement	point	9.69	0.00	0.00	0.00
			CLAW HEALTH		
Sole ulcer, sum all lact	%-point	0.595	0.00	-1.24	0.00
Sole hemorrhage, sum all lact	%-point	0.097	0.00	-0.20	0.00
Horn heel erosion, sum all lact	%-point	0.154	0.00	-0.26	0.00
Digital dermatitis, sum all lact	%-point	0.154	0.00	-0.31	0.00
Cork screw claw, sum all lact	%-point	0.077	0.00	-0.16	0.00
Interdigital hyperplasia, sum all lact	%-point	0.296	0.00	-0.59	0.00
White line disease sum, sum all lact	%-point	0.096	0.00	-0.19	0.00
			YOUNG STOCK SURVIVAL		
Survival heifers 1-30 d	%-point	3.30	0.06	-0.22 (7)	0.00
Survival heifers 31-458 d	%-point	3.66	0.03	-0.32 (9)	0.00
Survival bulls 1-30 d	%-point	1.92	-0.10 (5)	-0.03	0.00
Survival bulls, 31-184 d	%-point	2.09	-0.10 (5)	-0.03	0.00

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

[4]See explanation in chapter 1.2.3. Participation in health agreement schemes

Table 8.6. Results of sensitivity analyses of conventional biological and management assumptions for JER. Actual differences in € are presented. Change in % (absolute value) is shown in ( ) if larger than 3 %.

TRAIT		ALTERNATIVE				
	Unit	Conv. average, €	Sexed semen 62 %	Replacement rate = 27 %	Basis 0%[4]	Purebred bulls killed
				MILK PRODUCTION		
Standard milk[1]	kg	0.191	0.00	0.004	0.00	0.00
				GROWTH		
Daily gain	kg/day	0.192	-2.6	3.4	0.00	-64.1 (33)
EUROP form	score	6.1	-0.12	0.01	0.00	-2.3 (38)
				CALVING TRAITS		
Survival rate 1st	%-unit	0.85	0.00	-0.14 (16)	0.00	-0.06 (7)
Survival rate later, maternal	%-unit	3.13	0.04	0.23 (7)	0.00	-1.09 (35)
Survival rate later, direct	%-unit	1.87	0.00	0.05 (3)	0,00	-0.62 (33)
Calving ease 1st	point	10.76	0.00	-1.66 (15)	-0.05	0.00
Calving ease later, maternal	point	120.95	2.85	14.36 (12)	-0.57	0.00
Calving ease later, direct	point	64.72	1.16	6.39 (10)	-0.3	0.00
				FEMALE FERTILITY[2]		
IFL heifers		1.26	0.00	-0.19 (15)	0.00	0.15 (12)
ICF cows	day	0.18	0.00	-0.05 (26)	0.01 (5)	0.02 (12)
IFL cows	day	2.56	0.00	0.04	0.01	0.02
				UDDER HEALTH		
Udder health, sum all lact	%-unit	4.45	0.00	0.01	-0.29 (7)	0.00
				GENERAL HEALTH		
Other metabolic, sum all lact	%-unit	3.10	0.00	-0.06	-0.01	0.00
Ketosis, sum all lact	%-unit	1.56	0.00	-0.04	0.00	0.00
Feet & legs, sum all lact	%-unit	1.79	0.00	-0.04	-0.12 (7)	0.00
Early repro, sum all lact	%-unit	2.03	0.00	-0.04	-0.07 (4)	0.00
Late repro, sum all lact	%-unit	1.65	0.00	-0.03	-0.05	0.00
				LONGEVITY		
Average herd life[3]	day	0.36	0.00	-0.10 (28)	0.00	0.03 (7)
				CONFORMATION a.o.		
Frame	point	0.00	0.00	0.00	0.00	0.00
Udder	point	33.02	0.00	0.00	0.00	0.00
Feet & legs conf.	point	22.01	0.00	0.00	0.00	0.00
Milkability	point	22.01	0.00	0.00	0.00	0.00
Temperament	point	11.01	0.00	0.00	0.00	0.00
				CLAW HEALTH		
Sole ulcer, sum all lact	%-point	0.795	0.00	-1.63	0.00	0.00
Sole hemorrhage, sum all lact	%-point	0.114	0.00	-0.23	0.00	0.00
Horn heel erosion, sum all lact	%-point	0.168	0.00	-0.34	0.00	0.00
Digital dermatitis, sum all lact	%-point	0.168	0.00	-0.34	0.00	0.00
Cork screw claw, sum all lact	%-point	0.091	0.00	-0.19	0.00	0.00
Interdigital hyperplasia, sum all lact t	%-point	0.336	0.00	-0.69	0.00	0.00
White line disease, sum all lact	%-point	0.114	0.00	-0.23	0.00	0.00
				YOUNG STOCK SURVIVAL		
Survival heifers 1-30 d	%-point	1.56	0.01	-0.15 (10)	0.00	0.52 (33)
Survival heifers 31-458 d	%-point	2.05	0.02	-0.23 (11)	0.00	0.54 (26)
Survival bulls 1-30 d	%-point	0.75	-0.03 (4	-0.03 (4)	0.00	-0.37 (50)
Survival bulls, 31-184 d	%-point	0.73	-0.03 (5)	-0.05 (7)	0.00	-0.43 (58)

[1]4.20 % fat and 3.40 % protein

[2]IFL, time between first and last insemination; ICF, time from calving to 1st insemination

[3]Average economic value of herd life in 1st, 2nd and 3rd parity

[4]See explanation in chapter 1.2.3. Participation in health agreement schemes

8.2.4 Culling of all purebred JER bull calves

It is a well-known challenge in JER herds to raise and sell purebred JER bulls without an economic loss. Instead, most purebred JER bull calves are killed at birth, except in organic herds. In the conventional scenario, it was assumed that purebred JER bulls were all slaughtered. However, it is often not possible to sell the purebred JER calves so we needed to create a scenario to account for this challenge, i.e. setting stillbirth rate for purebred JER bulls to 100 %. The traits that were negatively affected were traits where genetic improvement results in more bull calves being born (Table 8.6. Results of sensitivity analyses of conventional biological and management assumptions for JER. Actual differences in € are presented.). For the growth traits, the economic values decreased by 33-38 % because the traits are expressed in fewer animals. The impact of survival rate in 1st parity was limited (7 %) because the proportion of bulls is already low compared to the proportion of heifers due to the use of SS. For later parities, the impact is much larger, ~35 %, because the proportion of heifers and bulls is more equal; removing a proportion of the calves means that the trait is expressed fewer times.

The effect of improving $IFL_{heifers}$ and ICF in this scenario results in slightly increased economic values. Improving $IFL_{heifers}$ results in more pregnant heifers; thus, the need for replacement heifers decreases. This results in more later parity cows that can be inseminated with beef semen which results in more slaughter animals. At the same time fewer purebred JER bulls are born which also increases economic values. The explanation for the increased economic values for ICF and longevity is similar. Improvement of these traits both result in the need for fewer replacement heifers and therefore more beef crosses can be produced.

Because all purebred JER bull calves are killed, improvement of young stock survival for bulls will have no impact on the purebred JER calves. In the beef×dairy crossbreds 50 % of the dairy genes are expressed, which results in a substantial drop in economic values: 50-58 %. The effect on young stock survival for heifers is slightly more complicated. Improvement of heifer survival reduces the need for replacement heifers – and fewer cows therefore need to be inseminated with purebred JER semen. This also decreases the number of purebred JER bull calves. In the conventional scenario, the contribution from purebred bull calves is negative when young stock survival is improved because sales price of the meat cannot cover the feed costs in purebred JER bulls. If all purebred JER bull calves are killed at birth this negative contribution will disappear; thus, the economic value of improving heifer survival will increase (26-33 %) compared to the conventional scenario.

8.3 Relative weighting and expected genetic response

Based on the results from the sensitivity analyses, relative weights and expected genetic response were calculated for selected scenarios used in the sensitivity analyses. The NTM weights below are shown relative to the yield index. The expected genetic response was calculated as the correlations between the NTM index and the sub-indices. Genotyped bulls born in either DNK, SWE or FIN (Nordic bulls) in 2015 and 2016 were used for the calculations.

Results are shown for the following scenarios:

- MILKM10: conventional assumptions using a 10 % lower milk price
- FEEDP10: conventional assumptions using a 10 % higher feed costs
- BEEFM10: conventional assumptions using a 10 % lower price for beef
- LABORP10: conventional assumptions using 10 % higher labor costs
- VETCOSTP10: conventional assumptions using 10 % higher veterinary costs
- RPL27: conventional assumptions using a replacement rate of 27 %

Table 8.7, 8.9, and 8.11 show the relative weighting for MILKM10 and FEEDP10 for HOL, RDC and JER, respectively, and the proposed conventional NTM weights are shown for comparison. The associated expected genetic responses are showed in Table 8.8, 8.10, and 8.12 for HOL, RDC and JER, respectively. A lower milk price results in a lower economic value per yield index unit. Thus, the relative weighting of most of the remaining sub-indices increases. The effect on the expected economic response is a lower response for yield and a higher response for the remaining trait groups. The economic value of the yield index was also reduced in the FEEDP10 scenario but not as much as in the MILKM10 scenario. Compared to the proposed conventional scenario, relative weights were increased for fertility, general health, udder conformation, milkability and claw health for HOL. For RDC relative weights were increased for fertility, calving, udder health, general health, udder conformation and claw health. For JER the situation was slightly different; here the value of the yield index dropped relatively more compared to HOL and RDC. JER produce more fat which requires relatively more energy; thus, JER is punished relatively more when feed costs increase. Because of this, the relative weights of most sub-indices increased compared to the proposed conventional NTM weights. Only the relative weight of the birth index decreased slightly whereas the weights for claw health and young stock survival were unchanged.

Table 8.13, 8.15, and 8.17 show the relative weighting for BEEFM10 and LABORP10 for HOL, RDC and JER, respectively. The expected genetic responses are shown in Table 8.14, 8.16, and 8.17 for HOL, RDC and JER, respectively. When the payment for beef is decreased only traits, for which improvement results in more animals for slaughter, are affected negatively. Thus, for HOL relative weights were decreased slightly for growth, fertility, birth, calving and young stock survival. The same was observed for RDC except that changes in economic values of birth and calving were too small to affect the relative NTM weights for these two traits. For JER only relative weights for fertility, calving and young stock survival were affected negatively. For example, the relative weight of growth was not affected in JER because the negative impact on the economic value of JER growth was too small.

Compared to the proposed conventional NTM weights, minor changes were observed when labor costs were increased. Relative weights for fertility, udder health, feet & legs, and udder conformation were increased slightly for HOL. The remaining traits were not affected. The same was observed for RDC, except that the relative weights for udder health and feet & legs were unchanged. Note: economic values of udder health and feet & legs were increased when labor costs were increased but the increase was not big enough to cause changes to the relative NTM weights for these to traits. For JER only the relative weights for udder and milkability increased slightly. Given the relatively small changes to the relative weighting, only small changes in expected genetic response for the LABORP10 NTM compared to the proposed conventional NTM were observed.

Table 8.19, 8.21, and 8.23 show the relative weighting for VETCOSTP10 and RPL27 for HOL, RDC and JER, respectively. The expected genetic responses are shown in Table 8.20, 8.22, and 8.24 for HOL, RDC and JER, respectively. Increasing veterinary costs only increased the relative NTM weights for udder health and general health for HOL. For RDC general health was affected, and for JER only udder health was affected. The impact on the expected genetic response was minor; for HOL the genetic response for yield was reduced slightly whereas the response was increased for udder health, general health and longevity. The genetic response for RDC was limited to a minor increase for fertility and general health. For JER a minor decrease in expected genetic response was observed for fertility, calving and longevity, whereas the response for udder conformation increased slightly.

Reducing the replacement rate to 27 % had a relatively large impact on the expected genetic response – not so much on the relative NTM weights. However, because the herd structure is changed towards more older cows which means a higher annual milk production the economic value of the yield index increases (~2 %). This reduces the weights of most NTM sub-indices in all three breeds. Compared with the proposed conventional NTM, the expected genetic response for yield is increased when replacement rate is lowered, the response for growth is also increased for HOL and RDC. For the remaining sub-indices expected genetic response is mostly decreased (unchanged for a few traits). Especially, the expected genetic response for longevity is affected negatively for all three breeds.

Table 8.7. Weighting of NTM sub-indices relative to the yield for Conventional NTM, Conventional NTM MILKM10 and Conventional NTM FEEDP10, respectively for HOL.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	1.00	1.00	1.00
Growth	0.07	0.09	0.07
Fertility	0.38	0.45	0.40
Birth, direct	0.13	0.16	0.13
Calving, maternal	0.13	0.16	0.13
Udder health	0.30	0.33	0.33
General health	0.13	0.15	0.14
Frame	0.00	0.00	0.00
Feet & legs conformation	0.04	0.05	0.04
Udder conformation	0.05	0.06	0.06
Milkability	0.08	0.10	0.09
Temperament	0.04	0.04	0.04
Longevity	0.07	0.07	0.07
Claw health	0.09	0.11	0.10
Young stock survival	0.11	0.14	0.11

Table 8.8. Correlations between sub-indices and Conventional NTM, Conventional NTM MILKM10, and Conventional NTM FEEDP10, respectively for HOL. Correlations are based the December 2017 evaluation and data from 5,218 genotyped Nordic HOL bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	0.63	0.55	0.60
Growth	0.13	0.11	0.11
Fertility	0.44	0.50	0.46
Birth, direct	0.26	0.29	0.26
Calving, maternal	0.32	0.35	0.33
Udder health	0.34	0.38	0.36
General health	0.34	0.38	0.36
Frame	0.01	-0.02	0.00
Feet & legs conformation	0.17	0.19	0.18
Udder conformation	0.11	0.13	0.13
Milkability	0.04	0.05	0.04
Temperament	0.09	0.08	0.08
Longevity	0.50	0.53	0.52
Claw health	0.24	0.27	0.25
Young stock survival	0.23	0.26	0.24

Table 8.9. Weighting of NTM sub-indices relative to the yield for Conventional NTM, Conventional NTM MILKM10 and Conventional NTM FEEDP10, respectively for RDC.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	1.00	1.00	1.00
Growth	0.08	0.10	0.08
Fertility	0.29	0.35	0.31
Birth, direct	0.08	0.11	0.09
Calving, maternal	0.08	0.10	0.09
Udder health	0.19	0.23	0.21
General health	0.09	0.11	0.10
Frame	0.00	0.00	0.00
Feet & legs conformation	0.05	0.06	0.05
Udder conformation	0.06	0.08	0.07
Milkability	0.09	0.11	0.09
Temperament	0.03	0.03	0.03
Longevity	0.06	0.06	0.06
Claw health	0.06	0.07	0.06
Young stock survival	0.15	0.19	0.15

Table 8.10. Correlations between sub-indices and Conventional NTM, Conventional NTM MILKM10, and Conventional NTM FEEDP10, respectively for RDC. Correlations are based on the December 2017 evaluation and data from 4,368 genotyped Nordic RDC bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	0.80	0.73	0.78
Growth	0.05	0.04	0.04
Fertility	0.21	0.27	0.23
Birth, direct	0.14	0.19	0.15
Calving, maternal	0.16	0.18	0.17
Udder health	0.15	0.20	0.18
General health	0.17	0.19	0.17
Frame	0.02	-0.01	0.01
Feet & legs conformation	0.20	0.23	0.20
Udder conformation	0.04	0.07	0.06
Milkability	0.18	0.19	0.17
Temperament	0.09	0.07	0.08
Longevity	0.45	0.47	0.46
Claw health	0.14	0.17	0.15
Young stock survival	0.25	0.30	0.26

Table 8.11. Weighting of NTM sub-indices relative to the yield for Conventional NTM, Conventional NTM MILKM10 and Conventional NTM FEEDP10, respectively for JER.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	1.00	1.00	1.00
Growth	0.06	0.08	0.07
Fertility	0.25	0.30	0.28
Birth, direct	0.04	0.05	0.04
Calving, maternal	0.06	0.08	0.06
Udder health	0.33	0.39	0.37
General health	0.11	0.13	0.12
Frame	0.00	0.00	0.00
Feet & legs conformation	0.07	0.08	0.09
Udder conformation	0.13	0.16	0.15
Milkability	0.08	0.10	0.09
Temperament	0.02	0.03	0.02
Longevity	0.09	0.11	0.13
Claw health	0.04	0.05	0.04
Young stock survival	0.10	0.13	0.10

Table 8.12. Correlations between sub-indices and Conventional NTM, Conventional NTM MILKM10, and Conventional NTM FEEDP10, respectively for JER. Correlations are based on the December 2017 evaluation and data from 862 genotyped Nordic JER bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM MILKM10	Conventional NTM FEEDP10
Yield	0.77	0.70	0.71
Growth	0.07	0.08	0.08
Fertility	0.25	0.30	0.30
Birth, direct	0.08	0.08	0.07
Calving, maternal	0.18	0.18	0.17
Udder health	0.38	0.45	0.44
General health	0.27	0.29	0.29
Frame	0.15	0.14	0.14
Feet & legs conformation	0.17	0.19	0.21
Udder conformation	0.15	0.22	0.20
Milkability	0.07	0.08	0.07
Temperament	-0.01	-0.01	-0.02
Longevity	0.48	0.52	0.53
Claw health[1]	0.09	0.12	0.11
Young stock survival[1]	0.28	0.33	0.29

[1]Based on November 2017 evaluation and data from 97 progeny tested Nordic JER bulls born 2009-2010.

Table 8.13. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM BEEFM10 and Conventional NTM LABORP10, respectively for HOL.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	1.00	1.00	1.00
Growth	0.07	0.06	0.07
Fertility	0.38	0.36	0.39
Birth, direct	0.13	0.11	0.13
Calving, maternal	0.13	0.11	0.13
Udder health	0.30	0.30	0.31
General health	0.13	0.13	0.13
Frame	0.00	0.00	0.00
Feet & legs conformation	0.04	0.04	0.04
Udder conformation	0.05	0.05	0.06
Milkability	0.08	0.08	0.09
Temperament	0.04	0.04	0.04
Longevity	0.07	0.07	0.07
Claw health	0.09	0.09	0.09
Young stock survival	0.11	0.10	0.11

Table 8.14. Correlations between sub-indices and Conventional NTM, Conventional NTM BEEFM10, and Conventional NTM LABORP10, respectively for HOL. Correlations are based on December 2017 evaluation and data from 5,218 genotyped Nordic HOL bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	0.63	0.65	0.61
Growth	0.13	0.11	0.11
Fertility	0.44	0.41	0.45
Birth, direct	0.26	0.24	0.26
Calving, maternal	0.32	0.30	0.32
Udder health	0.34	0.34	0.35
General health	0.34	0.33	0.35
Frame	0.01	0.02	0.01
Feet & legs conformation	0.17	0.17	0.18
Udder conformation	0.11	0.12	0.13
Milkability	0.04	0.04	0.05
Temperament	0.09	0.09	0.09
Longevity	0.50	0.50	0.51
Claw health	0.24	0.24	0.24
Young stock survival	0.23	0.22	0.23

Table 8.15. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM BEEFM10 and Conventional NTM LABORP10, respectively for RDC.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	1.00	1.00	1.00
Growth	0.08	0.07	0.08
Fertility	0.29	0.28	0.30
Birth, direct	0.08	0.07	0.09
Calving, maternal	0.08	0.07	0.08
Udder health	0.19	0.20	0.20
General health	0.09	0.09	0.09
Frame	0.00	0.00	0.00
Feet & legs conformation	0.05	0.05	0.05
Udder conformation	0.06	0.06	0.07
Milkability	0.09	0.09	0.09
Temperament	0.03	0.03	0.03
Longevity	0.06	0.06	0.06
Claw health	0.06	0.06	0.06
Young stock survival	0.15	0.14	0.15

Table 8.16. Correlations between sub-indices and Conventional NTM, Conventional NTM BEEFM10, and Conventional NTM LABORP10, respectively for RDC. Correlations are based on December 2017 evaluation and data from 4,368 genotyped Nordic RDC bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	0.80	0.81	0.79
Growth	0.05	0.05	0.05
Fertility	0.21	0.19	0.22
Birth, direct	0.14	0.13	0.15
Calving, maternal	0.16	0.15	0.16
Udder health	0.15	0.16	0.16
General health	0.17	0.15	0.15
Frame	0.02	0.03	0.02
Feet & legs conformation	0.20	0.19	0.20
Udder conformation	0.04	0.05	0.05
Milkability	0.18	0.18	0.18
Temperament	0.09	0.09	0.08
Longevity	0.45	0.45	0.45
Claw health	0.14	0.14	0.14
Young stock survival	0.25	0.24	0.26

Table 8.17. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM BEEFM10 and Conventional NTM LABORP10, respectively for JER.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	1.00	1.00	1.00
Growth	0.06	0.06	0.06
Fertility	0.25	0.24	0.25
Birth, direct	0.04	0.04	0.04
Calving, maternal	0.06	0.05	0.06
Udder health	0.33	0.33	0.33
General health	0.11	0.11	0.11
Frame	0.00	0.00	0.00
Feet & legs conformation	0.07	0.07	0.07
Udder conformation	0.13	0.13	0.14
Milkability	0.08	0.08	0.09
Temperament	0.02	0.02	0.02
Longevity	0.09	0.09	0.09
Claw health	0.04	0.04	0.04
Young stock survival	0.10	0.08	0.10

Table 8.18. Correlations between sub-indices and Conventional NTM, Conventional NTM BEEFM10, and Conventional NTM LABORP10, respectively for JER. Correlations are based on December 2017 evaluation and data from 862 genotyped Nordic JER bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM BEEFM10	Conventional NTM LABORP10
Yield	0.77	0.77	0.76
Growth	0.07	0.08	0.07
Fertility	0.25	0.24	0.25
Birth, direct	0.08	0.08	0.08
Calving, maternal	0.18	0.18	0.18
Udder health	0.38	0.38	0.39
General health	0.27	0.27	0.27
Frame	0.15	0.15	0.15
Feet & legs conformation	0.17	0.17	0.17
Udder conformation	0.15	0.15	0.16
Milkability	0.07	0.07	0.08
Temperament	-0.01	0.00	-0.01
Longevity	0.48	0.48	0.49
Claw health	0.09	0.10	0.10
Young stock survival	0.28	0.26	0.28

[1]Based on November 2017 evaluation and data from 97 progeny tested Nordic JER bulls born 2009-2010.

Table 8.19. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM VETCOSTP10 and Conventional NTM RPL27, respectively for HOL.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	1.00	1.00	1.00
Growth	0.07	0.07	0.07
Fertility	0.38	0.38	0.37
Birth, direct	0.13	0.13	0.12
Calving, maternal	0.13	0.13	0.12
Udder health	0.30	0.31	0.28
General health	0.13	0.14	0.12
Frame	0.00	0.00	0.00
Feet & legs conformation	0.04	0.04	0.04
Udder conformation	0.05	0.05	0.05
Milkability	0.08	0.08	0.08
Temperament	0.04	0.04	0.03
Longevity	0.07	0.07	0.05
Claw health	0.09	0.09	0.08
Young stock survival	0.11	0.11	0.11

Table 8.20. Correlations between sub-indices and Conventional NTM, Conventional NTM VETCOSTP10, and Conventional NTM RPL27, respectively for HOL. Correlations are based on December 2017 evaluation and data from 5,218 genotyped Nordic HOL bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	0.63	0.62	0.65
Growth	0.13	0.11	0.12
Fertility	0.44	0.44	0.42
Birth, direct	0.26	0.26	0.25
Calving, maternal	0.32	0.32	0.31
Udder health	0.34	0.35	0.32
General health	0.34	0.35	0.32
Frame	0.01	0.00	0.02
Feet & legs conformation	0.17	0.17	0.17
Udder conformation	0.11	0.12	0.10
Milkability	0.04	0.04	0.05
Temperament	0.09	0.09	0.08
Longevity	0.50	0.51	0.48
Claw health	0.24	0.24	0.23
Young stock survival	0.23	0.23	0.22

Table 8.21. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM VETCOSTP10 and Conventional NTM RPL27, respectively for RDC.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	1.00	1.00	1.00
Growth	0.08	0.08	0.08
Fertility	0.29	0.29	0.28
Birth, direct	0.08	0.09	0.08
Calving, maternal	0.08	0.08	0.08
Udder health	0.19	0.20	0.18
General health	0.09	0.10	0.09
Frame	0.00	0.00	0.00
Feet & legs conformation	0.05	0.05	0.04
Udder conformation	0.06	0.06	0.06
Milkability	0.09	0.09	0.08
Temperament	0.03	0.03	0.02
Longevity	0.06	0.06	0.04
Claw health	0.06	0.06	0.05
Young stock survival	0.15	0.15	0.14

Table 8.22. Correlations between sub-indices and Conventional NTM, Conventional NTM VETCOSTP10, and Conventional NTM RPLP10, respectively for RDC. Correlations are based on December 2017 evaluation and data from 4,368 genotyped Nordic RDC bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	0.80	0.80	0.83
Growth	0.05	0.05	0.07
Fertility	0.21	0.21	0.19
Birth, direct	0.14	0.14	0.13
Calving, maternal	0.16	0.15	0.15
Udder health	0.15	0.16	0.14
General health	0.17	0.16	0.14
Frame	0.02	0.01	0.04
Feet & legs conformation	0.20	0.20	0.18
Udder conformation	0.04	0.04	0.04
Milkability	0.18	0.18	0.17
Temperament	0.09	0.09	0.08
Longevity	0.45	0.45	0.41
Claw health	0.14	0.14	0.12
Young stock survival	0.25	0.26	0.24

Table 8.23. Weighting of NTM sub-indices relative to the yield index for Conventional NTM, Conventional NTM VETCOSTP10 and Conventional NTM RPL27, respectively for JER.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	1.00	1.00	1.00
Growth	0.06	0.06	0.06
Fertility	0.25	0.25	0.23
Birth, direct	0.04	0.04	0.04
Calving, maternal	0.06	0.06	0.06
Udder health	0.33	0.34	0.31
General health	0.11	0.11	0.10
Frame	0.00	0.00	0.00
Feet & legs conformation	0.07	0.07	0.06
Udder conformation	0.13	0.13	0.12
Milkability	0.08	0.08	0.08
Temperament	0.02	0.02	0.02
Longevity	0.09	0.09	0.07
Claw health	0.04	0.04	0.04
Young stock survival	0.10	0.10	0.09

Table 8.24. Correlations between sub-indices and Conventional NTM, Conventional NTM VETCOSTP10, and Conventional NTM RPLP10, respectively for JER. Correlations are based on December 2017 evaluation and data from 862 genotyped Nordic JER bull calves born 2015-2016.

Trait	Conventional NTM	Conventional NTM VETCOSTP10	Conventional NTM RPL27
Yield	0.77	0.76	0.80
Growth	0.07	0.07	0.08
Fertility	0.25	0.25	0.22
Birth, direct	0.08	0.08	0.09
Calving, maternal	0.18	0.18	0.19
Udder health	0.38	0.39	0.35
General health	0.27	0.27	0.25
Frame	0.15	0.15	0.16
Feet & legs conformation	0.17	0.17	0.14
Udder conformation	0.15	0.16	0.12
Milkability	0.07	0.07	0.08
Temperament	-0.01	-0.01	0.01
Longevity	0.48	0.49	0.46
Claw health	0.09	0.09	0.09
Young stock survival	0.28	0.28	0.26

[1]Based on November 2017 evaluation and data from 97 progeny tested Nordic JER bulls born 2009-2010.

9 Economic value of an index unit

In the section *Proposed index weights* proposed relative NTM weights for conventional and organic production circumstances were presented. These are show in Table 9.1. Results of the sensitivity analyses were presented at the May 2018 NAV Workshop. Subsequently, the breed organizations have made final proposals for the NTM weighting which was then approved by the NAV Board in August 2018.

Compared to the economically proposed NTM weights, the breed organizations have proposed the following changes:

HOL

- Originally assumed milk price reduced by 10 %
- NTM based on 100 % conventional production circumstances
- Reduced NTM weight for fertility
- Increased NTM weight for udder conformation

RDC

- Originally assumed milk price reduced by 10 %
- NTM based on 100 % conventional production circumstances
- Increased NTM weight for udder conformation
- Increased NTM weight for udder health

JER

- Originally assumed milk price reduced by 10 %
- NTM based on 70 % conventional and 30 % organic assumptions (weighting of economic values from each scenario)
- No weight on growth

The final relative NTM weights are shown in Table 9.1.

Table 9.1. Relative final NTM weights for each NTM sub-index for HOL, RDC and.

NTM sub-index	HOL	RDC	JER
Yield	1.00	1.00	1.00
Growth	0.09	0.10	0.00
Fertility	0.40	0.35	0.31
Birth, direct	0.16	0.11	0.05
Calving, maternal	0.16	0.10	0.08
Udder health	0.33	0.25	0.53
General health	0.15	0.11	0.17
Frame	0.00	0.00	0.00
Feet & legs conformation	0.05	0.06	0.09
Udder conformation	0.20	0.25	0.18
Milkability	0.10	0.11	0.11
Temperament	0.04	0.03	0.03
Longevity	0.07	0.06	0.11
Claw health	0.11	0.07	0.05
Young stock survival	0.14	0.19	0.12

The expected genetic responses based on the final NTM weights are shown in Table 9.2. Here, the new weighting of milk, fat and protein yield in the yield index is included also (Appendix A).

Table 9.2. Expected genetic response based on final NTM weights for HOL, RDC and JER, respectively. Expected response based on the current or old NTM weighting is shown for comparison. Calculations based on December 2017 evaluation and data from 5,218, 4,368 and 867 genotyped bulls born in 2015-2016 for HOL, RDC and JER, respectively.

	HOL NTM		RDC NTM		JER NTM	
	Old	New	Old	New	Old	New
Yield	0.41	**0.58**	0.65	**0.69**	0.59	**0.63**
Growth	0.03	**0.08**	-0.10	**0.02**	-0.02	**0.02**
Fertility	0.48	**0.45**	0.16	**0.25**	0.23	**0.31**
Birth, direct	0.27	**0.25**	0.18	**0.16**	0.09	**0.09**
Calving, maternal	0.37	**0.33**	0.19	**0.18**	0.19	**0.16**
Udder health	0.51	**0.39**	0.35	**0.29**	0.58	**0.57**
General health	0.36	**0.35**	0.17	**0.19**	0.28	**0.33**
Frame	0.01	**0.02**	0.04	**0.04**	0.17	**0.11**
Feet & legs conformation	0.30	**0.19**	0.28	**0.23**	0.15	**0.20**
Udder conformation	0.42	**0.28**	0.37	**0.27**	0.42	**0.30**
Milkability	0.05	**0.08**	0.14	**0.20**	0.09	**0.08**
Temperament	0.09	**0.09**	0.05	**0.07**	0.00	**-0.01**
Longevity	0.63	**0.52**	0.45	**0.45**	0.49	**0.52**
Claw health	0.26	**0.24**	0.16	**0.15**	0.16	**0.16**[1]
Young stock survival[1]	0.26	**0.23**	0.32	**0.28**	0.32[1]	**0.33**[1]

[1]Based on November 2017 evaluation and data from 97 progeny tested Nordic JER bulls born 2009-2010.

9.1 The value of one NTM index unit

The economic value of each NTM sub-index unit is shown in Table 9.3. These are the value of one yield index unit multiplied by the relative NTM weight for each sub-index. The value per yield index unit was presented in *Chapter 5.2*. However, because the final proposals by the breed organizations resulted in the use of the originally assumed milk price being reduced by 10 %, the economic values per yield index unit have changed slightly. Furthermore, for JER, the relative NTM weights were based on 70 % conventional and 30 % organic assumptions by weighting the economic values from each scenario. The final economic values per yield index unit are:

- HOL: **€8.90**
- RDC: **€9.38**
- JER: **€6.61**

The economic value of one NTM unit depends on the standardization, i.e. the factor used to achieve a standard deviation of 10 for NTM. Calculations of the standardization factors were based on NAV bulls born in 1997-1998. The value of a NTM unit can be calculated as: (1) the sum of the economic values for the sub-indices divided by the sum of the standardized relative NTM index weights or (2) divide the economic value of a unit of the yield index by the factor used for standardization of the NTM index.

Table 9.3. Final relative weights for each sub-index in NTM after standardization using NAV bulls born in 1997-1998 and the economic value per unit of each sub-index.

	Standardized relative NTM weights			Economic value of an index unit, €		
	HOL	**RDC**	**JER**	HOL	RDC	JER
Yield	**0.90**	**1.02**	**0.83**	8.90	9.38	6.61
Growth	**0.08**	**0.10**	**0.00**	0.79	0.92	0.00
Fertility	**0.36**	**0.36**	**0.26**	3.56	3.31	2.07
Birth, direct	**0.14**	**0.11**	**0.04**	1.38	1.01	0.32
Calving, maternal	**0.14**	**0.10**	**0.07**	1.38	0.92	0.56
Udder health	**0.30**	**0.26**	**0.44**	2.97	2.39	3.50
General health	**0.14**	**0.11**	**0.14**	1.38	1.01	1.11
Frame	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00
Feet & legs conformation	**0.05**	**0.06**	**0.07**	0.49	0.55	0.56
Udder conformation	**0.18**	**0.26**	**0.15**	1.78	2.39	1.19
Milkability	**0.09**	**0.11**	**0.09**	0.89	1.01	0.72
Temperament	**0.04**	**0.03**	**0.03**	0.40	0.28	0.24
Longevity	**0.06**	**0.06**	**0.09**	0.59	0.55	0.72
Claw health	**0.10**	**0.07**	**0.04**	0.99	0.64	0.32
Young stock survival	**0.13**	**0.19**	**0.10**	1.29	1.75	0.80
2018 NTM	**-**	**-**	**-**	**9.89**	**9.20**	**7.96**

The economic values presented in Table 9.3 for NTM 2018 are defined as the economic value per NTM unit per annual cow. These values should be used if we want to express the total economic value of an average progeny. If we want to calculate the value of an index unit of the sire the value should be divided by 2.

Based on the assumptions used for the NTM calculations the average number of lactations for a Nordic cow is 2.8 lactations for HOL and RDC and 2.9 lactations for JER. Using this information, it is possible to approximate the total economic potential per NTM unit for an average female.

It is important to note that the economic potential of an animal depends on the specific point in time in an animal's life because the total economic potential will decrease as traits which contribute to the NTM value are expressed. Thus, the full economic potential of a heifer will be just before it is born. At the time of first calving, a heifer will have lost some of its economic potential due to expression of for example young stock survival. Also, it must be taken into account that the male growth traits are not expressed in females, i.e. the economic value of the growth index is zero. At the time of calving, a HOL heifer, for example, still has 2.8 lactation ahead of her. Thus, the average economic value of one NTM unit for a heifer at calving is equal to:

```
(Value of 1 NTM unit per annual cow – economic value for growth – economic value
of young stock survival) × 2.8 lactation
```

The breed specific average economic value of one NTM unit for a heifer at calving is then equal to:

- HOL: **€25.54**
- RDC: **€23.12**
- JER: **€22.11**

The values shown above are for an average female. Some females will have a lower genetic potential per NTM unit because they for example die at birth or as a heifer. This unutilized economic potential will have to be transferred to the remaining animals to maintain the assumption about economic potential of an average animal. This makes determination of the economic potential for a specific animal quite complicated and should be avoided.

The economic value per NTM unit can be used to compare females, if for example the difference in NTM units between two RDC heifers is 10 – the economic difference from a genetic point of view is 10 NTM units × €23.12 per unit = €231.20.

If the economic value per daughter group is desired a HOL bull with +10 NTM units over another will produce offspring which on average are +5 NTM units better because only half the value of a bull is transferred to the offspring. Thus, the economic merit of the average daughter is 5 × €25.54 = €127.70

10 General discussion

Since the Original NTM index was created in 2008 the Nordic dairy sector have seen some major changes. The proportion and amount of milk produced under organic circumstances has increased. Sexed semen has been introduced and is now widely used, usually in combination with beef semen. This minimizes the number of surplus heifers, and the number of animals for slaughter is maximized. Treatment of certain diseases such as mastitis without the herd veterinarian being present is now possible in Denmark and will most likely also be possible in both Sweden and Finland in the near future. Consumer focus on animal welfare has increased and the looming threat of climate changes has increased the focus on improving feed efficiency. All these factors have been considered during the 2018 NTM review.

From the initial results (chapter 5) it became clear to the NTM stakeholders that the weighting of the different trait groups in the NTM index is quite sensitive to the used milk price. If the assumed milk price is too high too much weight is put on the production traits and too little weight on the functional traits and *vice versa* if the assumed milk price is too low. Thus, it was agreed to use a 10 % lower milk price that was Originally suggested for calculation of the final NTM weights.

Accounting for the use of health agreement schemes in the calculations meant lower treatment costs for some diseases. This especially lowered the NTM weighting of udder health. The RDC and HOL breeding associations, therefore, agreed that the weight on udder health should be increased slightly compared to the economically optimal weight. In JER this was achieved by constructing a weighted NTM, 70 % conventional and 30 % organic at the level of economic values. Overall, we present a revised NTM which is focused slightly more towards production (increase income) than the old NTM, but still focus very much on improvement of animal health and fertility (save costs).

The NTM calculations only focus on calculation of the relative weight for each sub-index in NTM. In parallel with this job weighting of milk, fat and protein yield in the yield index has been reviewed and updated. A summary of this work is presented in Appendix A. Details can be found on NAVs website. The yield index and many other NTM sub-traits are based on data from 1^{st}, 2^{nd} and 3^{rd}+ lactations. Breeding values are calculated for each lactation and the weighted form the final breeding value for e.g. protein yield. The weighting of each lactation should reflect the distribution of lactation 8-10 years into the future. So, the lactation weights were also reviewed and updated. This work is presented in Appendix B and details can be found on NAVs website.

The initial analyses of saved feed for the NTM review showed a high economic value of saved feed compared to the current NTM sub-traits. A sufficient amount of data on feed efficiency is not yet available to make efficient selection for efficient animals, but we expect this will happen within the next few years. Until then it may be an option to focus on reducing the maintenance costs, i.e. selecting for smaller cows and more efficient cows. However, this requires data on cow weight and possibly the use of correlated data. This has to be studied further before a possible implementation into NTM. Thus, the number of trait groups in the NTM index is unchanged.

10.1 Model challenges – future development

The definition of an economic value of a trait was in our case defined as the effect of a marginal change in the genetic level of the trait keeping all other traits in the breeding goal constant (Chapter 2.1). The latter may be difficult to fulfill for some traits because structural relationships exist among the traits, for example between fertility, culling rate (longevity) and milk yield (Kargo et al., 2014). Wolfova and Wolf (2013) suggest that relationships among traits should be accounted for when they are structural and caused by changes to age structure of the herd but not when they are caused by genetic correlations between traits. A good example of this is when the economic values for longevity are calculated. Longevity is affected by improvements of other functional traits (e.g. fertility and health traits), i.e. involuntary culling is decreased. The current NTM model does not take such structural relationships into account. The result is that the economic value of longevity is overestimated and the economic values of other functional traits are underestimated. The *ad hoc* solution for this is described in Chapter 5.1.

Structural relationships between traits can be taken into account using mechanistic, dynamic and stochastic models such as the SimHerd model. However, correlated genetic responses are also included in these types of models; thus, keeping all other traits constant when one trait is changed is still not possible. This must be accounted for subsequently using multiple regressing to avoid double counting (Østergaard et al., 2016).

Software like SimHerd may be useful for the estimation of economic values of traits in the NAV breeding goal. However, the NAV breeding goal contains ~100 traits – the current SimHerd version cannot handle such number of trait and will have to be modified and extended.

A feed efficiency trait will also have to be added to the NTM model in the near future. The definition of suitable traits is well under way and will most likely include an index consisting of a breeding value for maintenance and a breeding value for metabolic efficiency, i.e. RFI. It should be possible to modify the current Excel based model to include calculation of economic values for these traits. A proposal for economic value of RFI is included within this report.

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Appendix A: Weights for milk, fat and protein yield in the yield index

During the NTM 2018 review focus has been on determining the economic value of the yield index relative to the remaining NTM sub-traits. No proposals were given regarding the relative weighting of fat, protein, and milk yield within the yield index. The relative weighting of the three yield traits depends on the used price model. For example, the current weighting of the milk, fat, and protein yield in the yield index is the result of reduced payment for protein and increased payment for fat in 2012. This trend is expected to continue and, therefore, the yield index weights should be updated.

A detailed report on this work can be found on NAVs website. Several scenarios were investigated but it is important to note that the final weights for milk, fat and protein yield should reflect the expected payment scheme 5-7 years ahead. The expectation is a higher payment for fat relative to protein and more focus on milk solids instead of milk yield. The final weights proposed by the NAV breed organizations are shown in Table A1. Common for all breeds is a changed protein-fat ratio towards more weight on fat yield; for JER equal weights are put on fat and protein yield. For HOL and RDC an increased negative weight is put on milk yield indicating more emphasis on increased amounts of milk solids rather than milk yield.

Table A1. Final relative weights for M, F, and P yield in the yield index for HOL, RDC and JER. Old weights are shown for comparison.

	Relative weight in yield index			
	M-index	F-index	P-index	F:P
Holstein, new	-0.25	0.55	0.70	1.3
Holstein, old	-0.20	0.40	0.80	2.0
RDC, new	-0.25	0.55	0.70	1.3
RDC, old	-0.20	0.40	0.80	2.0
Jersey, new	-0.30	0.65	0.65	1.0
Jersey, old	-0.30	0.50	0.80	1.6

Correlations between new and old GEBV for the yield index were 0.98 for HOL and RDC and 0.99 for JER – based on December 2017 evaluation and genotyped Nordic bulls born in 2015-2016. This indicates minimal re-ranking of the bulls. Larger changes were seen for the indices for milk, fat and protein yield. In Table A2 expected genetic progress for milk, fat and protein yield using the old and new weights are shown as correlations between milk, fat and protein yield and the yield index. Also, expected genetic progress is shown for fat and protein percentages.

The changes in expected genetic progress reflect the changed weights. For all breeds, genetic progress is expected to decrease for milk yield and protein yield and increase for fat yield. Because of the decreased weight on milk yield, genetic progress for fat and protein percentage is expected to increase compared to the old yield index.

Table A2. Expected genetic progress for milk, fat and protein yield and fat and protein percentages shown as correlations between EBV for the sub-traits and the yield index. The values are based on December 2017 evaluation and genotyped Nordic bulls born in 2015-2016.

		Milk	**Fat**	**Protein**	**Fat %**	**Protein %**
Holstein 5,218 bulls	New yield index	0.28	0.92	0.75	0.39	0.33
	Old yield index	0.44	0.83	0.87	0.20	0.22
RDC 4,368 bulls	New yield index	0.47	0.91	0.86	0.24	0.19
	Old yield index	0.57	0.85	0.93	0.09	0.11
Jersey 867 bulls	New yield index	0.41	0.95	0.80	0.06	0.12
	Old yield index	0.50	0.92	0.87	-0.05	0.04

Appendix B: Weights on lactations

Breeding values for several NTM sub-traits are based on records from multiple lactations. These traits are yield, fertility, udder health, general health, claw health, and conformation traits (frame, feet & legs, udder). The previous lactation weights reflect the average distribution of lactations in the NAV dairy populations approximately 10 years ago and were 0.5, 0.3 and 0.2 for 1st, 2nd, and 3rd lactation, respectively. The relative high weight on 1st lactation considered that 1st lactation is expressed early in a progeny testing scheme resulting in higher reliabilities of the combined breeding value for e.g. yield at an early stage. However, genomic selection schemes have now completely replaced progeny testing; thus, a large weight on 1st lactation is no longer necessary because genomic breeding values have more equal reliabilities across lactations.

The new lactation must reflect the distribution of lactations in a future production system with a lower replacement rate than is currently observed. For calculation of economic values for the NTM traits, it was assumed that the replacement rate would be around 32 % when the breeding goal is realized 7-10 years into the future for all NAV breeds across countries. Using results from the NTM model a new distribution of 1st, 2nd, and 3rd+ lactations was **0.30:0.25:0.45**. This set of weights reflects the future distribution of lactations and signals that older cows (3rd lactation and older) also are important in a breeding goal. For comparison, the distribution of lactations in 2016 for Danish Holstein was 0.38:0.28:0.34 indicating a slightly higher replacement rate than 32 %.

Table B1 illustrates the effect of changing lactation weights from the current of 0.5:0.30:0.20 to the new of 0.30:0.25:0:45. The yield traits and selected claw health traits are used as examples, but the results also apply to the remaining NTM sub-traits. The correlations for all the investigated traits were ~0.99, indicating minimal effect of a relative large change and a very limited effect on re-ranking of animals. This is because the genetic correlation between lactations are high, for example the genetic correlation between protein yield in different lactation is ~0.90 across the NAV breeds.

Table B1. Correlations between breeding values based on old and new lactation weights based on the 2018 NTM model for selected traits in HOL, RDC and Jersey. Based on NAV AI sires born 2008-2010 with reliability above 0.50.

Breed	Holstein	RDC	Jersey
Number of sires	914	678	164
M-index	0.992	0.991	0.997
F-index	0.992	0.989	0.994
P-index	0.997	0.988	0.995
Number of sires	905	669	162
Digital dermatitis	0.997	0.998	0.998
Sole ulcer	0.995	0.995	0.996