National Dairy Project – opportunities for the genetic improvement program to evolve

NDP breed improvement subcomponent is ambitious given that organized genetic improvement programs commenced only relatively recently in the country. NDP Phase 1 (2012/13 to 2016/17) builds on breed improvement initiatives underway in the country and moves forward with a more scientific, organized and expanded approach to genetic evaluation and selection; putting in place policies, procedures and systems; supported by training and capacity building and a HRD strategy and plan. NDP Phase 1 moves forward with a genetic improvement program based on what is possible now; but given the long term nature of genetic improvement programs, a vision for the future is needed to further evolve the program and to position it to take advantage of new technologies such as genomics. This document offers a summary of where the breed improvement program is now and a vision for how it needs to evolve to make a more meaningful contribution through genetic improvement to productivity. The document highlights constraints, steps needed and impact on genetic improvement – the basic principles of which are well known[1]. This document also builds on earlier discussions with the Informal International Panel Experts on Breed Improvement and serves to brief participants in the upcoming workshop with the aim to ensure the NDP-I is on the best course possible for genetic improvement.

ref	Area	situation now	Where it needs to be/suggestions on how to move forward	Why important & impact on genetic progress
1.	HRD & partnership strategy	A HRD strategy & plan is under development	The HRD strategy and plan should have a long term (15 yr) time horizon and provide for additional development needs some of which are outlined in this document. The March workshop and international experiences will help to further elaborate the HRD strategy and extend to studies and partnerships advised.	Critical to guide NDP success – near - and particular longer-term.
2.	Awareness & extension on genetic improvement	Awareness & extension of importance of genetic improvement is focused on EIAs involved in for Progeny testing (PT) and Pedigree Selection (PS)program	Communications should be strong and a communication strategy is advised to guide the outreach program. .	Communications and outreach are critical for all stakeholders to have common understanding, what needs to be done and why
3.	Long term strategy & detailed	NDP program for producing bulls focuses on putting in place program & processes for PT and	Given the long term nature of genetic improvement the program needs to be optimized taking a long-term view, A study is needed. This is a desk study that could be	While NDP-I moves ahead to put in place programs and processes for Progeny testing (PT) and Pedigree Selection (PS) with the

[1] Process and pathways for genetic progress has been known since the 1960's and is presented in Annex 1 for the convenience of a broader audience reading this document.

	plan	PS. The program makes a good start given that it is early days for genetic evaluation programs in India.	done in a few weeks (about 4-6). An active R&D program is needed supporting NDP with a longer term view in mind which utilizes the data in INAPH[2] to guide breed improvement programs, the needs of which are likely to differ by breed, agro-ecological and production system.	ultimate view to produce high genetic merit bulls. NDP-I takes a pragmatic view of what is 'doable' within the nearer term. Given the long term nature of genetic improvement it is important to have a vision of what is optimal and move towards this, while at the same time aiming to have an adequate performance recorded population also to enable genomics. Estimates of genetic progress under different scenarios will help guide NDP and look for further opportunities to increase accuracy & intensity of selection, and reduce generation interval. I
4.	Selection objective	Bulls evaluated and selected for single trait – milk yield. NDP is moving forward to collect information (and ultimately include in selection index) on milk components, functional conformation such as mammary system & feet & legs; fertility, disease resistance. This will require new programs and significant training (eg type classification).	Parents selected based on composite selection index considering traits influencing productivity and profitability. Annex 3 provides examples of selection indices used in several other countries. Selection index approach is needed to select for traits that contribute to lifetime productivity & profitability. Traits must be identified and appropriated weighted. Different index will be likely needed for different breeds and different agro/production systems. Estimates for genetic progress need to be updated for multi-trait selection as they are based on single trait selection & use heritability estimates that are likely too high (but estimates for Indian situation are available for one or two breeds). INAPH[3] provides a database to capture key traits which will provide 'cradle to grave' analysis for different breeds and production systems to define productivity. Derivation of selection indices is complex requiring rigorous and time consuming	Focuses breed improvement on what is important Productivity and profitability is influenced by several traits thus a 'lifetime productivity index' approach is needed for India to achieve production targets sustainability; addressing consumer and market needs; farmer profitability; and need for dairy population to be more productive. Each additional group of functional trait included (for example conformation) would necessitate a program for data collection and evaluation. These can be large and complex programs on their own &

[2] Information Network on Animal Production and Health initiated in 2010 which provides the national database for dairy

[3] INAPH = Information network on animal production and health is the national dairy data base initiated by NDDB in 2010

			analysis by a team of experts. Derivation of selection index requires ongoing R&D potentially supported by national and international partnerships. HRD strategy and plan should provide for R&D needs.	considerable training & development will be needed. It is well known that single trait selection can undermine productivity eg by reducing fitness for traits like fertility & disease resistance. Traits have different inheritance and relationship to each other. This will influence not only the number of progeny needed for a given level of accuracy of selection, the weighting of traits and the amount of genetic progress that can be made. The ideal for a trait, such as ideal feet& legs that contributes to lifetime productivity is not known for India & needs to be developed. Further, for traits like mammary system needs to consider that there is still little mechanization (milking machines); although this may evolve in the longer future. The temperament of some indigenous breeds is likely not suitable for a mechanized farming system
5.	Progeny testing & pedigree selection	Bulls produced under NDP for widespread use in India are young bulls who are not progeny tested. It is their sires who are progeny tested.	Attempt should be made to make some bulls available for broad use in the cow population based on progeny test. This would require increased investment in bull housing (and biosecurity etc) during the 'wait period' until the progeny test is available. During the early stage of NDP the program builds systems and processes to eventually turnout High Genetic Merit bulls. But the young bulls produced initially cannot accurately be labeled as high genetic merit. A study is needed to quantify the genetic	Fundamental to genetic improvement is to be able to identify the genetic superior animals and then to use them widely as soon as possible. Accuracy of young bull evaluation is low (and comparable to a natural service bull being selected only on dam's yield). While selection of young bulls allows bulls to

			superiority these bulls represent compared to the relatively unselected population.	be used much earlier than waiting for progeny test evaluation, this is a good strategy in populations where high levels of genetic progress are being made. This is not yet the case in India and so there will be overlap in genetic quality of young bulls selected (at least in the early phase of NDP) and bulls occurring randomly in the population. A study is needed to quantify the genetic superiority. Genetic progress based on pre-NDP has not been measured, and low selection intensity and accuracy reported seems like little if any progress has been made. This highlights the need to incorporate genomics information.
6.		Number of organizations involved in the breed improvement programs Progeny Testing = 14 organizations; Pedigree selection = 7 organizations; AI semen stations = about 28	Ideally this would be greatly simplified as the large number of organizations each sampling relatively few bulls adds to the challenge of coordination and management of the program including assurance	This works out to be about 22 bulls per organization involved in the progeny testing program. Once genetic improvement is more broadly understood, and there is increased demand for semen from higher genetic merit bulls, this will entice bull stations to start sampling larger numbers of bulls, hopefully. Although, genomics may mean that fewer bulls need to be progeny tested.
7.		Number of bulls PT/ PS. Currently 160 bulls across 5 breeds/crosses & subprograms[4]	The numbers of bulls for PT are too low and NDP should aim for a minimum of 100 bulls per breed to be PT assuming 4-8 sires of sons selected from each batch. Even with 100 bulls this is still very low if ambitious genetic progress is sought.	The more bulls sampled the greater the selection intensity. There is a tradeoff due to

[4] Pre NDP [indicated in brackets are NDP planned number of programs and bulls to PT]: Murrah 48 bulls tested in 2 subprograms [120 = 6 programs @20 bulls each]; Mehsana 35 bulls tested in 2 subprograms[2 programs @20

		(Murrah, Mehsana, HF cross, Jersey Cross, Sunandini are progeny tested[5] & a further 30 for 2 breeds (Rathi & Kankreij are selected on pedigree. The PT and PS programs have undergone 1 generation of selection. These already very small programs were operated separated this no connections & selection intensity therefore was further compromised. NDP plans to PT 310 bulls across 6 breeds & PS 180 bulls across 9 breeds[4] [see footnote previous page) Disconnected PT programs within breed will have greater impact by creating contemporaries across PT programs this past oversight is addressed by NDP.	The number of bulls is limited by test population; but there are opportunities to evaluate more bulls based on partial records with marginal reduction in accuracy of selection. Sampling in larger herds also increases efficiency of selection. Optimization study is needed to give insights into potential to increase bulls evaluated for the given performance tested population available.	inbreeding such that similar levels of selection intensity cannot be achieved with smaller number of bulls sampled. Inbreeding can compromise productivity and reduce the variation in the population
8.		NDP plans to dramatically expand from the current limited number of breed improvement programs from Progeny testing: 5 breeds & 7	NDP should simplify the program to focus on fewer priority breeds. NDP needs to prioritize the breeds that are most important to be included in the project. This is particularly important for the indigenous breeds which might be best included in a conservation program. Also planned is a progeny testing program for	While the country has yet to implement a strong breed improvement moving ahead with 15 breed improvement is a very daunting challenge. This not only introduces much complexity, but the genetic

each] ; 27 HF crossbreeds [3 programs @20 each] , 25 Jersey crossbreeds [2 programs @20 each] and 25 Sunandini [1 program of 30].
In the case of the PS program : only 2 programs underway for Rathi and Kankreij, 15 bulls each breed sampled [plan is to increase this to 30 bulls per program and introduce programs for a further 7 breeds : Tharapkar, Gir, Sahiwal, Hariana, Pandharpuri, Nili Ravi, and Jaffrabadi

		subprograms to an additional 1 breed (HF) & additional 7 subprograms see Annex 1. For Pedigree selection will increase from 2 PS programs to include an additional 7 breeds	purebred Holstein due to concern for GxE (bulls rank differently in N America versus India). While, there has been decades of importation of exotics (Holstein and Jersey) no studies have been undertaken until a recent initiative to measure GxE organized by NDDB which started with use of semen in 2009. Results will not be available for at least another year. Imported germplasm should be selected for functional traits (eg especially traits like calving ease) and average bulls for yield traits. A customized selection index for imported germplasm for India's situation is possible given that some 40 traits are evaluated in many countries.	progress that can be achieved in small programs, especially with pedigree selection is questionable. Furthermore, breeds like Hariana planned for NDP are not widely recognized as a priority dairy breed in the country.
9.		Importations of germplasm (semen, embryos) is limited in the case of Holstein and Jersey and non-existent in the case of Indian breeds from Brazil and Italy.	In the absence of live bull imports of Holstein & Jersey expansion of semen imports. Increase possibility for expanding embryo imports of Holstein and Jersey by moving ahead with practical performance requirements Increase knowledge on Indian breeds that have benefited from genetic improvement programs in Italy and Brazil with the hypothesis that selection of best animals and years of genetic selection will have evolved these populations to provide opportunity for genetic improvement for india in particular for Jaffrabadi and Gir for which no breed improvement programs have thus far existed in India. India may also benefit from importing Kankreij semen from Brazil and Murrah from Italy. Building awareness of GoI committee responsible for setting importation standards/regulations on breed improvement opportunities through imports and appropriate health and performance requirements.	About 30% of the program relies on exotics mostly for crossbreeding so import of semen would all NDP to quickly move ahead (in the absence of live bull imports of Holstein and Jersey). Further, imports from Holstein in particular will create more links and increase the potential to use genomics . Semen or embryo imports from Indian germplasm of higher genetic merit through evaluation and selection programs of Murrah in Italy and Kankreij, Jaffrabadi, and Gir in Brazil would kick start these programs.
10.		Crossbred bulls are a key feature of the NDP and account for 130 out of 310 bulls proposed for progeny testing. . 3 cross-bred/inter se mating programs have been underway since early 90s: Sanundini (Kerala),	Studies are needed on the generations of crossbreeding results. Moving forward this is an imperative to guide the development of a strategy and plan focused on the crossbreeding/inter se programs. Genetic evaluation models require modification (informed by R&D) to support this program. The above will benefit from a R&D program requiring appropriate HRD and partnerships which have yet to be elaborated.	Crossbreding/intersee programs are extremely challenging to manage and achieve success. While it is widely accepted that crossbreds under certain environments offer higher production while being better adapted; maintaining the optimal level of exotic & indigenous genes with successive generations of

		Friewal (ICAR) and HF-crossbreed (SAG). Clarity needed on genetic progress achieved in these programs.	Semen processing with crossbreds is problematic and will require a strong R&D program to address.	selection is challenging. There are very few successful inter se mating genetic improvement programs operating anywhere in the tropics globally. NDP needs to move cautiously. A further challenge is that of semen quality/processing with crossbreds is problematic The above have implications for several factors influencing genetic progress: accuracy, intensity and genetic variation
11.		One sire is sampled per month with blanket coverage in one village. In genetic evaluations, villages will be treated as herds and thus contemporaries will be compared within village-year-season. Progeny testing relies on small herds	Multiple sires need to be sampled concurrently within a village/ herd. Progeny testing should aim to make use of larger herds. Although 80% of herds are 3 cows or less, 7% or some 5 M herds are 10 cows or larger. Currently only about 10,000 cows are performance tested across all 5 breeds; whereas some experts feel that a minimum of about 200,000 are needed for 1 breed not only for PT but to enable genomics selection.	Accuracy of genetic evaluation relies on contemporaries being compared under the same environmental/management condition. There are seasonal effects in much of the country; and because there has been no data available the variation between management practices in herds is not known. Further Dr. Garg indicates there is considerable seasonal variation due to feed availability/quality Increasing use of larger herds would increase not only the efficiency of progeny testing but also reduce the time to sample a young sire – currently taking nearly 1.5 years thus adding nearly a year to generation interval. More efficient use of herds available would allow more

				testing of bulls & increase selection intensity.
12.		It takes atleast 15 months for a young sire to be sampled	This needs to be reduced dramatically. Focusing sampling larger villages and larger herds would reduce the time to carryout sampling	The longer it takes to sample a bull to carryout test matings to get sufficient number of daughters, increases the generation interval and decreases genetic progress. Focusing on larger herds and villages would enable the more sires to be sampled concurrently and
13.		Only daughters of young bulls being progeny tested are performance recorded	All cows in the herd/village should be recorded.	Accuracy of evaluation is influenced by knowing the influence of genetics on any variation for production recorded in the herd/village. Unless all cows in the herd/village are recorded, it is not possible to accurately adjust for the non-genetic component of variation. Recording other animals like half sisters, dams etc enables incorporation of relationship matrix in the genetic evaluation which, also increases accuracy of selection as this contributes to better knowledge on the genetics of the bulls family. Conversely, for the same level of accuracy fewer daughters are needed as information on relatives contribute information. This means that for the same population available for sampling bulls more bulls can be sampled.
14.		Only the first lactation performance is recorded. Entire lactation record is used.	Later lactation records are needed. The number of records will need to be informed by analysis Although data has not been available, studies should be undertaken to evaluate the potential to utilize partial lactation records eventually.	Analysis elsewhere shows that correlation between 1st and later lactation is <.7 thus different genes are involved to determine how a cow will produce in the first lactation versus later.

			NDP is planning to use test day animal model for estimating breeding values. In that case partial records can be used (further informed by the R&D needed)	Productivity (& ultimately profitability) is based on multiple lactations ; ideally bulls are selected based on their transmitting ability for this trait. Some traits are only fully expressed later lactations eg functional type, mastitis incidence Partial records can reduce the sampling time & reduce generation interval. The above influences selection accuracy, intensity and has the potential to reduce generation interval
15.		Herds/villages for progeny testing may not be on the ration balancing program	Strong coordination is needed between Breeding and Feeding project components. Herds used for progeny testing should be on ration balancing program.	Variation in production is expressed under situations where cows are better managed. The care and feeding of the young bulls dam will contribute to the health of the young bull and reduce risk of losses due to disease. This affects accuracy and intensity of selection and contributes to expression of genetic variation
16.		An estimated 10,000 cows are performance recorded in the country. NDP will increase this to about 100 daughters for every progeny tested bull Program is based on progeny and pedigree selection but hopes to use genomics	The recorded population should be much larger and include at least 100 first and second lactation daughters on at least 100 bulls per breed. India needs to be in a position to make use of genomics in addition to progeny testing.	Although the NDP initiates programs and builds systems it should have a vision for a much larger progeny testing program to support higher levels of genetic progress moving forward with a selection index approach for productivity. Genomics will only contribute to increasing genetic improvement possible if a large reference population is available to interpret genotype based

				on phenotypic information (eg performance of daughters for productivity related characteristics) Compared to N America/Europe India will require a larger reference population for same level of accuracy due to lack of pedigree performance information, lower levels of heritability Accuracy intensity
17.		PT programs are not necessarily part of bull station – only 5[6] of 50 AI Bull stations operate a PT or PS sampling program. The genetic quality of the bulls available does not impact the semen sold although there may be a price differential for PT bulls.	PT programs should be a fundamental 'R&D' underpinning the business success of bulls stations.	Awareness of genetic improvement and demand by farmers for higher genetic quality , selected bulls will determine the future of bull stations and their self interest to operate PT programs. This should increase the expansion of these programs – more bulls selected, and also underpin the sustainability of these programs past NDP as it will determine the business success of the bull stations. This supports long term sustainability of programs and the business of the bulls station Be
18.	Semen production	Semen production is not optimized in terms of sperm per dose Importation requirements also require more sperm per dose which does not increase fertility but does significantly increase the cost of semen purchase.	While optimization of semen production per bull is a priority for NDP it is important that there is strong integration between all activities of the Breed improvement program. Semen importation regulations need to be modified for optimal sperm per dose for fertility. Standards and standard setting bodies need better information to guide performance guidelines for importation. This will require ongoing awareness and capacity building. Support for this needs also be part of the HRD strategy.	Suboptimal semen processing will impact genetic progress as the best bulls will not be able to be used optimally in the national herd. Further, suboptimal semen processing (in particular the current practice of putting nearly double the sperm per dose required) will mean that more bulls are

[6] BAIF, SAG, Mehsana Cooperative, KMF (Bangalore), TN

				needed Current semen importation requirements limit genetic progress opportunity through semen import. Costs are escalated not only due to product wastage (sperm per dose) but also because exporters need modify their standard processing procedures to fill orders for India. intensity
19.	Genetic evaluation	NDP needs advice and assistance on genetic evaluation program. Data management supported through INAPH The current plan is for NDDB to also be responsible for genetic evaluation	Specialized models and software may be eventually needed beyond what is available 'packaged inflexible software like SAS NDP needs to move forward an independent organization for genetic evaluation.	There has been considerable R&D elsewhere on model development to optimize genetic evaluation and there are potentially much better models than SAS. Given all the other challenges of the NDP it is vital that best model is used for sire evaluation. l focus on Longer term this may affect transparency and acceptance of the genetic evaluation, especially as genetic evaluation programs impact business success, competition and profitability.
20.	Data management for genetic evaluation	Simplistic strategy for data management Only EIAs provide data to INAPH	Expanded strategy for data management is needed which also considers the current and planned organizations contributing to genetic improvement in India. Data capture should extend to entire country – for example, global organizations that are selling semen in India; large initiatives underway like Nestle, Delaval etc.	Critical is data and information monitoring to limit loss which can be extremely high Strategy needs to provide for current and longer term needs which include such developments as moving towards genomics; multi-trait selection. And also enable data capture from other organizations. Accuracy intensity

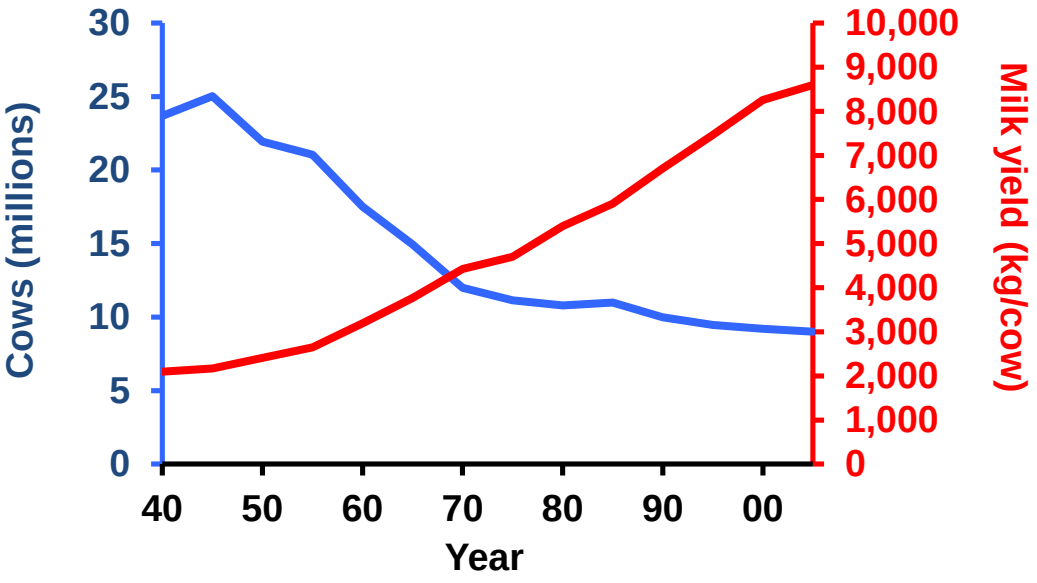
Annex 1 – Status and plans for Progeny Testing and Pedigree Selection Programs

	Before NDP bulls	With NDP
	Bulls sampled every 15-18 mths	**Bulls sampled every 15 mths**
Progeny selection program	**5 breed programs & 7 subprograms. Total of 160 bulls sampled** Murrah – 48 bulls [2 program – 20 + 28] Mehsana – 35 bulls [2 program – 20+15] HF cross-27 bulls 1 program Jersey crossbred – 25 bulls in 1 program Sanundini* – 25 bulls in 1 program HF – bull rearing program for 20 bulls resulting from planned matings with imported semen. No progeny testing	**6 breed programs & 15 subprograms. Total of 310** Murrah – 120 bulls [6 sub program @ 20 bulls each] Mehsana – 40 bulls [2 program@20] HF crossbred – 60 bulls [3 programs @20 bulls each] Jersey crossbred – 40 bulls [2 programs @20 each] Sanundini– 30 bulls in 1 program HF purebred – 20 bulls 1 program
Pedigree selection	**2 programs & 30 bulls** **Rathi , Kankreij – 15 bulls each**	**9 programs & 270 bulls** Rathi & Kankreij programs expanded to 30 each 30 bulls for each of additional breeds: Tharapkar, Gir, Sahiwal, Hariana, Pandharpuri, Nili Ravi, and Jaffrabadi

* Sanundini is a synthetic breed

Annex 2 – Progress in breed improvement & genetic evaluation advances in N America

Figure 1 – Evolution of US dairy population due to genetic improvement



Source: Wiggins, G. 2009. US Department of Agriculture

Table 1 – Genetic evaluation advances & impact on genetic progress

Year	Advance	% Gain
1862	**USDA established**	
1895	**USDA begins collecting dairy records**	
1926	**Daughter-dam comparison**	**100**
1962	**Herdmate comparison**	**50**
1973	**Records in progress**	**10**
1974	**Modified cont. comparison**	**5**
1977	**Protein evaluated**	**4**
1989	**Animal model**	**4**
1994	**Net merit, PL, and SCS**	**50**
2008	**Genomic selection**	**>50**

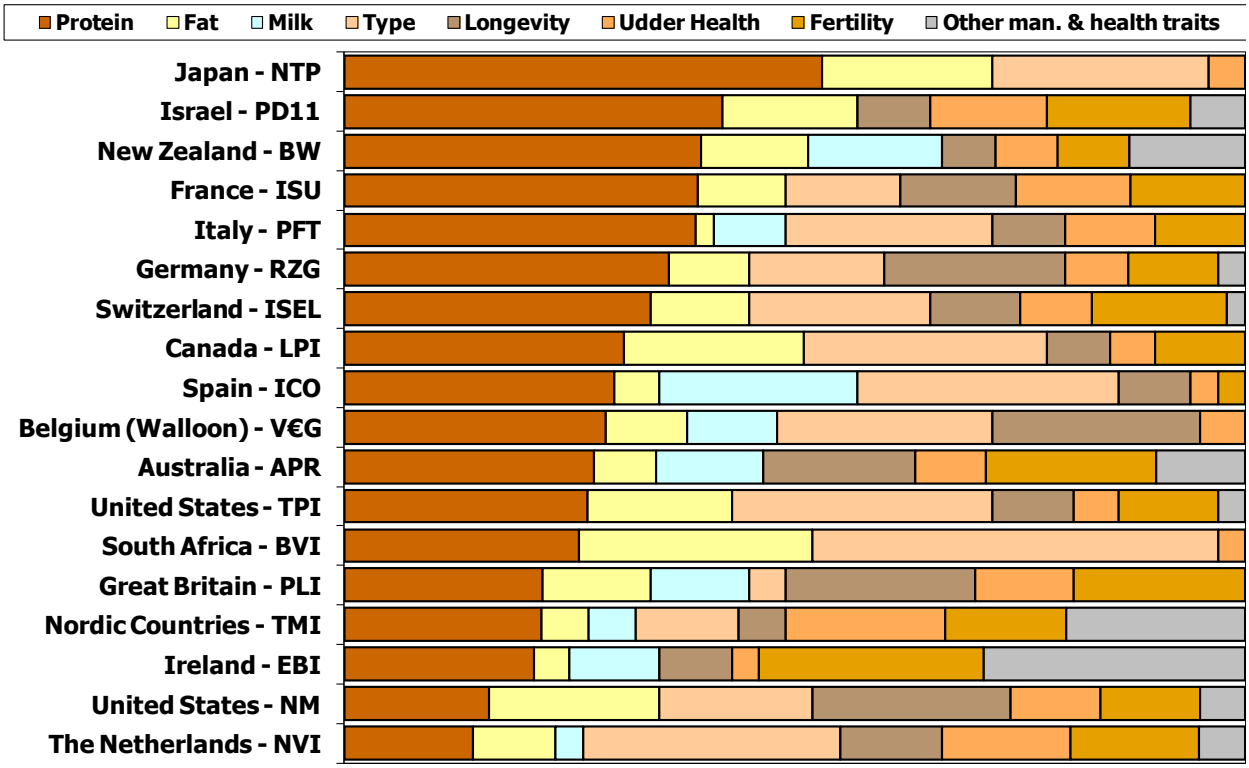
Source: Wiggins, G. 2009. US Department of Agriculture

Table 2 – Increase in accuracy with genomics in Canadian genetic improvement programs.

	Accuracy of genetic evaluation		
	traditional	genomics	gain
Young bulls	39	70	31
Young heifers	37	67	30
Cows with first or second record	55	74	19
Progeny tested bulls based on first evaluation	86	90	4

Source : Miglior, F. 2012. Canadian Dairy Network

Annex 3 – Selection indices in other countries, traits included and relative emphasis



Source: Miglior, F. 2012. Canadian Dairy Network