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Process Engineers & Project Managers

On the use of energy per tonne of whole milk powder

Version 1.0

Executive Summary

The aim of this study was to investigate the validity of the statement in the Parson Brinckerhoff report titled “A review of inputs determining the Fonterra Base Milk Price” (14 August 2013):

- the energy use figures used in the Milk Price Model were not practically feasible for an efficient processor.

This study looks at data collected:

- during the energy and losses audit, conducted on the Darfield D1 plant in February 2014,
- data made available by Fonterra covering energy use and production at Darfield D1 for the year March 2013 – February 2014, and
- daily milk intake figures for the whole of Fonterra for the year June 2012 – May 2013.

Our conclusion is that we agree with Parson Brinckerhoff, in that the energy usage rates used in the Milk Price Model are not practically feasible for an efficient producer.

In our opinion the practically feasible energy use figures based on data studied for WMP would be:

- [ ] tonnes of steam per tonne of WMP, and
- [ ] kWh of electricity per tonne of WMP

By inference, the corresponding energy use figures for SMP would be:

- [ ] tonnes of steam per tonne of SMP, and
- [ ] kWh of electricity per tonne of SMP

When both the WMP and SMP changes are considered together, it is our opinion that the 2013 Milk Price would be reduced by 2.0 cents per kilogram of milk solids.

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Our opinion is that the currently proposed figures, to be used in the 2014 Milk Price Model, are also not practically feasible.

The methodology used in this study was:

1. Establishing raw energy use figures from Darfield D1 data, including a correction for unaccountable losses.
2. Deriving correction factors that were applied sequentially to the energy use data for the various factors where the operation of Darfield D1 varied from the requirements of the Notional Producer.
3. Applying these correction factors to obtain energy use figures that are practically feasible for an efficient processor.

The assumption within the Milk Price Model of 95% plant availability was not borne out by the Darfield data. We recommend further study to establish a representative overall availability figure and the consequent model changes.

We recommend that the issue of milk transportation within and between regions, particularly at peak milk, be further studied.

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Introduction

This study of energy used in the production of wholemilk powder was requested by the Commerce Commission. The aim was to clarify the validity of the conclusion that the energy usage rates were not practically feasible for an efficient processor, reached in the Parson Brinckerhoff report titled “A review of inputs determining the Fonterra Base Milk Price” (14 August 2013).

Fonterra carried out an “energy and losses audit” on the Darfield D1 plant in February 2014. We monitored this audit and found the data collection to be reliable.

However the 10-day duration of the audit was insufficient as far as average energy use was concerned. This led to our analysis of the historical energy and production data for the year from 1 March 2013 to 28 February 2014 (which included the audit period).

The analysis of this year-long data was complicated particularly by the completion, commissioning and operation of Darfield D2. However, these complications were generally able to be dealt with in an acceptable manner.

Acknowledging Fonterra’s Openness

We wish to acknowledge the openness and considerable assistance that we have had from Fonterra staff during this study. Particularly, and in no specific order: Peter Goss, Sri Pathmanathan, Roger Keedwell, Conrad Heron, and the operations staff at Darfield have gone out of their way to provide assistance and data whenever we requested it.

Access to the plant at Darfield was very openly provided in a professional and greatly appreciated manner.

Without this cooperation, the compiling of this report would have been much more difficult, if not impossible. We would like to say thank you to those who have provided this assistance.

Obtaining Production Data

Although we asked for one year of Fonterra’s finest-grained production data, the data that Fonterra felt was most appropriate to use was on approximately 10-day periods. The 10-day periods included Fonterra’s stock-balancing. We considered this to have been an acceptable compromise but feel that Fonterra should make efforts to improve the quality of their production data.

Initial checks on this data showed up possible flaws, most probably in the data collection process. The amount of production allocated to one short 3-day period was so great that hourly production would have been more than 40% above the dryer’s rated capacity. After discussion with Fonterra, a two-day period and a three-day period were amalgamated with their neighbouring periods.

Note that over the year, two periods were affected by daylight-saving. These periods were effectively 10.04 and 9.96 days longs (where one day is 24-hours).
The production data for one year (1 March 2013–28 February 2014), which includes the audit period (1–10 February 2014), is shown in Table 5 (page 21).
Note also, that some new data was provided by Fonterra in response to our submission of a draft of this report. This data, which is quite extensive and supersedes data that was used to compile this report, has not been analysed. However, upon brief inspection, it does not appear that the analysis of this data would change the conclusions of this report.

Obtaining Energy Use

We requested energy use data for the entire Darfield site (including both dryer one and dryer two). Fonterra provided extremely fine-grained data covering not just steam and electricity use, but also feed-water data for the boilers, as well as compressed air and chilled water usage. The data was provided on a 15-minute basis from 1 March 2013 to 28 February 2014.

We accumulated the energy use data such that it could be directly compared to the production data. For this process, it was assumed that production dates started and finished at 7am.

"DD1_Steam_Total_Flow" (meter tag A07FT3114) measured the use of steam by dryer one (including the steam use of the dryer's three evaporators) in tonnes of steam per hour. The values of the steam flow meter were averaged over the periods defined in the production data.

For the use of electricity, "DD1_Total_Electricity_Usage" provided the amount of energy used (in kWh) by dryer one. These figures were summed, again over the periods defined in the production data.

The steam and electricity usage per period can be seen in Table 6 (page 23).

During the energy and losses audit, the instruments collecting this data were observed and to the best of our knowledge were providing good data that was entirely acceptable for the purposes of this exercise. The steam meters had a manufacturers quoted accuracy of ±2% of actual reading, while the electricity use meters had a quoted accuracy of ±1%.

Obtaining an Energy Balance

Since the energy use meters measuring the actual energy consumed by various sections of the Darfield site are not the meters used for purchase of energy purposes, it is necessary to establish a relationship between the two sets of meters to ensure that the energy deemed "purchased" by the Milk Price Model includes "unaccounted for losses".

Electricity

The amount of electricity purchased by Fonterra is dictated by the tariff meters provided by [ ]. Fonterra's usage meter readings need to be adjusted to include the losses and unmetered usages between the tariff meters and the usage meters (for example "DD1_Total_Electricity_Usage").

The six tariff meters provided by [ ] can be allocated to the supply to dryer one, dryer two, and utilities. By summing all of the six meters, a site-wide total supply can be obtained.

The eight usage meters belonging to Fonterra can be allocated to the use of electricity on dryer one, dryer two, and utilities. By summing all of the eight meters, a site-wide total use can be obtained.

The sum of the two tariff meters supplying dryer one can be compared to the sum of dryer one's two usage meters. Similar comparisons can also be made for dryer two and utilities.

The proportion of supply when compared to the usage meters can be calculated. Due to the commissioning of dryer two during the year, the immediate comparison is invalid; for example, for the year, on average dryer two's electricity usage was just 61.6% of the supply.

Invalid data was removed by making the following checks:

- Was dryer one usage zero?
- Was dryer two usage zero where the tariff meters indicated supply?
- Was the total usage for utilities zero?
- Was the supply for dryer one less than the usage?

If the answer to any of these questions was "yes", the day's data was labelled invalid.

When only valid data is considered, the site-wide supply was 102.33% of use. When considering just valid data for dryer one, supply was 101.83% of use. While these figures are not unacceptable, they are, in our opinion, indicating unallocated losses that are higher than desirable.

Table 1 shows a summary of the electricity usages as a percentage of supply.

Table 1: Average electricity supply as percentage of use

	Without data validation	With data validation
Dryer one	100.81%	101.83%
Dryer two	110.41%	101.99%
Utilities	140.55%	104.07%
Site-wide	111.64%	102.33%

Steam

There are two boilers in the Darfield plant. Since these two boilers are usually directly connected on the steam side, we do not have sufficient data to separately assess the accuracy of dryer one's usage steam meter.

It is our understanding that the Milk Price Model assumes that the steam used for deaeration is accounted for within the steam price, thus the steam that is considered "purchased" by the Milk Price Model is the steam supplied by the boilers less the steam used by the deaerators; we label this "net steam supply".

The steam meters attached to each boiler were summed to produce the total boiler steam supply. The two deaerator steam meters were summed to produce a total for the steam consumed by the deaerators; this was deducted from the boiler steam supply to obtain the net steam supply.

The steam meters attached to each dryer were summed to produce the total steam consumed by the dryers. This was compared as a proportion of the net steam supply.

Due to commissioning issues similar to those seen with electricity metering, some data was clearly invalid. Invalid data was removed with the following checks:

- Was the steam used by the deaerators zero?
- Was only partial information available from dryer two?
- Was supply less than usage?
- Was net steam supply a negative figure?

If the answer to any of these questions was "yes", then the row of data was labelled invalid. Further, there were seven other rows (of the 35,420 original rows) that were manually deemed invalid for various other reasons.

Considering only the valid data, the site-wide steam net steam supply was 102.39% of usage. Table 2 summarises this data.

Table 2: Average steam use as percentage of net steam supply

	Without data validation	With data validation
Site-wide	15.55%	102.39%

In our opinion, this represents an acceptable result considering that line losses and soot blowing were not accounted for in any of the use figures.

There remains an outstanding issue as far as the mass balance across the boilers is concerned. There appears to be more water (103%) leaving the boilers as steam than there is water entering the boilers! Further, this figure is a low estimate as boiler blow-down has not been accounted for. This subject needs further investigation by Fonterra but the good correlation between the steam meters indicates to us that the error is more than likely in the water meters.

Obtaining Raw Energy Use per Tonne of Product

To provide figures for the energy use per tonne of product, a raw result is obtained and then corrected for various factors such as tanker CIPs, buttermilk additions and partial loading of the dryers.

Electricity

To account for the difference between energy supplied and energy used, the electricity usage was increased by 102.33% (as per the site wide correction factor explained above).

This adjusted electricity total, now effectively including unaccountable losses, may be divided by the fit-for-purpose production for each period to obtain the kWh per tonne of product.

For the whole year, this amounted to an average electricity supply of [ ] per tonne of fit-for-purpose product. If we ignore the two periods where dryer one was cleaned before and after annual shutdown (i.e. the periods 9-10 August and 21-28 February) the standard deviation of the sample was 12.8 kWh/tonne over the 25 samples.

Table 3 shows the electricity supplied per tonne of product per period.

Steam

To account for the difference between energy supplied and energy used, the steam total flow was increased by 102.39% (as explained above).

This adjusted steam usage, now effectively including unaccountable losses, may be divided by the fit-for-purpose production for each period to obtain the tonnes of steam per tonne of product.

For the whole year, this amounted to an average steam supply [ ] of steam per tonne of fit-for-purpose product. If we ignore the two periods where dryer one was cleaned before and after annual shut-down, the standard deviation of the sample was 0.18 tonnes of steam per tonne of product over the 25 samples.

Table 3 shows the steam supplied per tonne of product per period.

Table 3: Energy supplied per tonne of fit-for-purpose product (including unaccountable losses)		
	Electricity (kWh)	Steam (tonnes)
[		
		]

Crosschecks on the Results

Dryer Capacity

We understand that Darfield D1 has a nameplate rating of 15.3 tonnes of whole milk powder per hour. We asked Fonterra for their estimate of the actual maximum sustained output and their response was "around [ ] tonnes per hour".

By aligning the dryer operating log with the production periods we obtained the number of on-product and off-product hours. By dividing the production per period by the total on-product hours, we calculated the dryer's output per on-product hour.

The average for the year was [ ] tonnes of product per on-product hour. This means D1 is consistently operating at an average [ ] above its nameplate rating, which is a very good achievement considering the short time since commissioning.

The standard deviation over the sample where annual cleaning was not executed was 0.66 tonnes of product per on-product hour over the 25 samples. This standard deviation is greater than expected. It is probably due to misalignment in the data between "production" and "time on product". It is our opinion that Fonterra needs to further investigate and correct this effect, such that future records more accurately depict actual run conditions. We have substantially reduced the effect of this variation by considering the full year's production data; however it should be noted that it would be inappropriate to draw any conclusions by analysing any specific 10-day period.

Table 4 shows the dryer's production per on-product hour for each period.

Dryer Availability

By dividing the number of on-product hours by the total number of hours available in each period, a measure of the dryer availability can be obtained.

If the winter shutdown (from 18 April 2013 – 8 August 2013) is excluded, then the dryer was on-product for [ ] of the time when milk was expected to be available to feed the dryer. From our experience this is relatively low, however the availability does not appear to be significantly correlated to the energy consumption (the R-squared factors were 0.26 for electricity and 0.25 for steam). Effectively, changes to availability will have only a small effect on energy consumption per tonne of product.

Table 4 shows the dryer's availability for each period. This is included simply to show the considerable variability of dryer availability over ten-day periods. To a large extent, this is caused by varying activities taking place inside some periods and not others. The only figure that is of much value is the average for the year.

In order to avoid many inconsistencies, this work continues to assume 95% plant availability, unless otherwise stated.

Our use of "availability" should not be directly compared with Fonterra's term "On Product Time", or OPT. Our understanding is that OPT is obtained by taking the total number of hours in a period, subtracting both the winter shutdown time and the standby time and dividing this into the number of on product hours. The important distinction between the two measures revolves around standby time. Thus, OPT will always be greater than availability. From data presented[1], OPT appears to be about five percentage points greater than availability.

[1] Historical OPT Peak and Full Season.xlsx, dated 18 June 2014.

Table 4: Production and Availability		
	Production (tonnes/hour)	Availability
[		
		]
Std. dev	**0.66**	**12.8%**

Adjusting for Instant WMP

There were five periods during the year where instant whole milk powder was produced. Excluding those periods, the average energy consumptions were:

- [ ] kWh / tonne of WMP
- [ ] tonnes of steam / tonne of WMP

We are unaware of any theoretical reason why the figures should differ between WMP and IWMP, and indeed they are easily within one standard deviation of the figures including IWMP. We therefore see no reason to exclude the periods where IWMP was made.

Adjusting for Tanker CIP

Fonterra's assessment of the steam use for two days (7 and 8 December 2013) for the tanker wash and CIP was 9.2 tonnes of steam. During those two days 97 tankers were washed, giving an average of 0.095 tonnes of steam per tanker wash.

During the whole year (1 March 2013 – 28 February 2014) there were 9,076 truck washes. Therefore our best estimate of the total steam usage for the year for tanker washing is 860.8 tonnes of steam, which amounts to 0.2% of the total net steam supply. As this is well inside the order of accuracy of this work, we have elected to neglect this effect.

We believe a similar argument applies for the use of electricity in tanker washing.

Adjusting for the Milk Treatment Effect

The milk treatment for dryer two is within dryer one's energy measurement. It is necessary to estimate the extra energy measured as part of dryer one's energy that should be allocated to dryer two. To do this we considered only data collected after dryer two was commissioned (established by data availability from dryer two instrumentation) and assessed:

- The average energy assigned to dryer one when dryer one was operating and dryer two was not operating, and
- The average energy assigned to dryer one when dryer one and dryer two were both operating

This was done by thresholding the steam use on dryer one and dryer two:

- Dryer one was considered to be operating when using more than 23 tonnes of steam per hour
- Dryer two was considered to be operating when using more than 47 tonnes of steam per hour
- Dryer two was considered to be not-operating when the value for its steam use was below 1 tonne of steam per hour

Electricity

For electricity, we again considered data only when dryer two was commissioned:

- The average electricity use rate assigned to dryer one when dryer one was operating and dryer two not operating was [ ] kW.
- The average electricity use rate assigned to dryer one when both dryer one and dryer two were operating was [ ] kW.

During the year, dryer two was operating (as defined above) for 3619 hours. Thus, the estimated extra electricity measured as being consumed by dryer one but really consumed by dryer two was ([ ] – [ ]) × 3619h = 568,000 kWh.

The correction factor was applied to each period's "electricity including unaccountables" by multiplying that number by 96.63%.

Steam

For steam:

- The average steam rate assigned to dryer one when dryer one was operating and dryer two not operating was [ ] tonnes of steam per hour.
- The average steam rate assigned to dryer one when dryer one and dryer two were operating was [ ] tonnes of steam per hour.

The amount of steam *decreased* when dryer two was operating; this is not a likely scenario! Further, given that the difference was only minor, it was decided to consider this effect negligible and to ignore it.

[

]

[ ]

[

]

[

]

Adjusting for the Partial Loading Effect

The production data from Darfield One indicated that enough milk was intended to be supplied to the dryer for 252 days of the year, in other words, the plant was square-curved at its maximum capacity for that time. The Milk Price Model must assume a standard season milk curve for available milk.

Fonterra provided milk supply data on a daily basis from 1 June 2012 to 31 May 2013 for each of only five regions: upper, central and lower North Island, lower South Island, and a combination of upper and central South Island. These were abbreviated as UNI, CNI, LNI, U/CSI, and LSI.

The implicit assumption in combining the upper and central south island regions is that milk will be transported between those two regions. We found no allowance for this milk transportation in the model. We recommend further study of this issue, particularly at peak milk.

We assumed that each of the five regions (UNI, CNI, LNI, U/CSI, and LSI) were independent in that no milk was transported between regions. This required the shifting of two dryers from CNI to LNI, or otherwise additional transportation costs would have had to be accounted for.

Each drying plant (WMP or SMP) was assumed to be able to swallow 1.9 million litres of wholemilk supply per day (that is, as per the model, 95% of maximum capacity of 2,000,000 litres per day). Note that this is at odds with the [ ]% availability observed over the year for Darfield D1 (see Table 4 on page 11).

In our opinion, the availability figure [ ] is too low to use as a long-term average, however equally the figure of 95% assumed in the model is unrealistically high. We recommend that this is studied further in order to establish an overall availability figure.

To give an idea of the size of this difference in assumptions, if we were to assume an availability of say 87%, we estimate that this would require Fonterra to model an additional six drying plants in the notional capital costs for the Milk Price Model. Further, there are other knock-on costs, such as staff, repairs and maintenance, and energy use.

The above assumptions neglect a potential constraint in that the model assumes that each region will produce a defined split between WMP and SMP through dedicated dryers, which are not interchangeable. This is almost certain to produce more partial loading than we have estimated here and, according to our analysis, either further substantially increases the number of drying plants required in the Milk Price Model, or results in considerably more milk transportation between regions. We recommend further study of this issue.

The daily milk collection figures were analysed such that the dryer requirements in each region were categorised as either:

- full plants, or
- partially full plants and on water during their un-loaded time, or
- partially full in a stop/start operating mode

If insufficient milk was available to fill a dryer completely, dryers were assumed to run on water for the time when they were not producing product, provided the time on product exceeded 90% of the available time.

If insufficient milk was available to fill a dryer to 90% of its capacity, then it was assumed that the dryer would start and stop to consume the available milk.

The expected energy consumptions for a WMP dryer operating at 40% capacity (the average of the year's data) would be, in our opinion, about [ ] tonnes of steam per tonne of product, or 144% of a full dryer. This same factor was applied to electricity usage. These figures were based on the numbers quoted by GEA in 2013—the same figures as used by Aurecon in their letter of 30 August 2013, titled "Milk Price Model – Energy Consumption Clarification"—but adjusted for the assumptions above including some of our own estimates. Table 7 shows the derivation of the steam usage during partial loading. The calculation is based on a two-day cycle, where the dryer is on-product for 40% of the time.

By applying the above to the daily data supplied by Fonterra we calculated a correction factor of 103.7% for the effect of partial loading. Note that this figure is not very sensitive to changes in the percentage at which dryers move from starting and stopping to continuous running (as can be seen in Figure 1).

This analysis is rather theoretical and does not cover all the issues that would be experienced by the Notional Producer. For example, as stated above, there is no consideration as to how the split of milk between WMP and SMP will be handled to achieve the monthly powder production figures in the model.

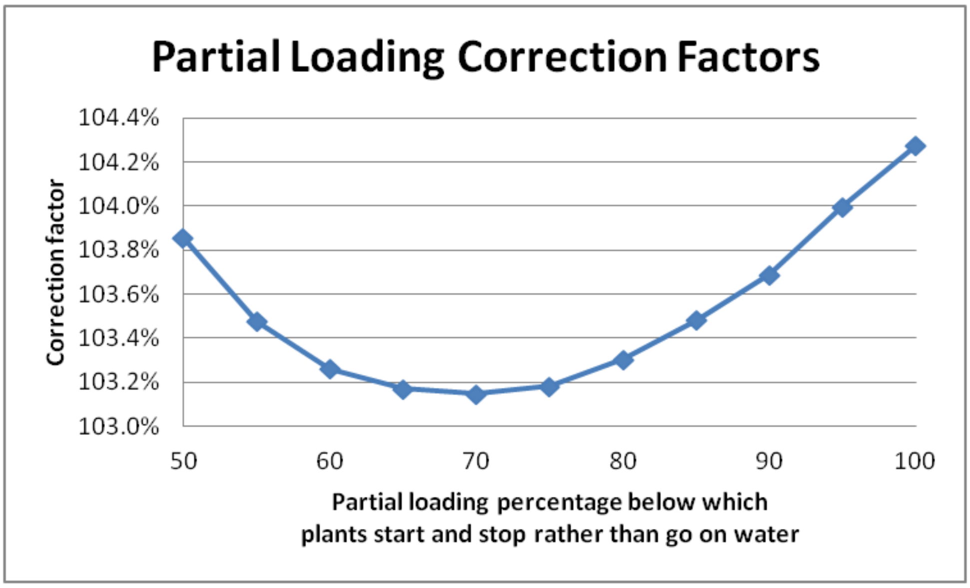

Figure 1: Partial loading correction factors for varying stop/start thresholds

Adjusting for the Dryer Hibernation Effect

Again, by analysing the daily milk data, it is possible to estimate the number of dryer days when there is insufficient milk to require the starting of some of the region's dryers. During that time dryers and their surrounds need to be kept in a "hibernating" state, such that a dryer can be activated to produce fit-for purpose product on reasonably short notice. For hygiene reasons it is necessary to keep the plant clean and tidy, for example with air-conditioning running. Winter maintenance is assumed to be done under hygienic conditions.

To assess the energy requirements of plants in this hibernating condition, the energy use for Darfield D1, during the time when it was not producing powder, was analysed to establish an energy consumption per day.

We estimate that, approximately, after correction for unallocated losses, that for each dryer in hibernation:

- the daily steam use will be 12 tonnes
- the daily electricity will be 3,854 kWh

There is a fixed energy use per dryer to enter and leave the hibernation state. We estimate that, approximately:

- the fixed steam use will be 607 tonnes
- the fixed electricity use will be 70,400 kWh

The once-a-year shutdown and restarting CIP, required for entering and leaving hibernation, was subtracted from the average production calculations and transferred to the hibernating energy use figures.

By combining the above figures for the 26 WMP dryers, the increase in the energy use per tonne of product was established. This was:

- 0.04 tonnes of steam per tonne of product, and
- 10.02 kWh per tonne of product

Adjusted Energy Use per Tonne of Product

When all the above was taken into account, the result is to arrive at two figures for the energy used:

- [ ] tonnes of steam per tonne of WMP, and
- [ ] kWh of electricity per tonne of WMP

This is effectively an increase of:

- 17% in steam use per tonne of product, and
- 1.7% in electricity use per tonne of product

To summarise, this was obtained:
For electricity (per tonne of product):

- Including unaccountables: [ ] kWh (after 102.33% correction)
- Milk treatment correction: [ ] kWh (after 96.63% correction)
- [ ]kWh (after 98.07% correction)
- Partial loading correction: [ ] kWh (after 103.69% correction)

- Production-only: [ ] kWh
- Hibernation loading correction: [ ] kWh (after adding 10.02 kWh)

For steam (per tonne of product):

- Including unaccountables: [ ] tonnes (after 102.39% correction)
- [ ] tonnes (after 98.07% correction)
- Partial loading correction: [ ] tonnes (after 103.69% correction)
- Production-only: [ ] tonnes
- Hibernation loading correction: [ ] tonnes (after adding 0.04 tonnes)

The Overall Impact on the Milk Price

Since we do not have sufficient data to run the Milk Price Model ourselves, we have reverse-engineered the calculations in an attempt to establish the effect on the 2013 Milk Price.

WMP

When the above adjusted energy use figures are applied to the 2013 Milk Price, the price per kilogram of milk solids moves from $5.364 to $5.350, or a change of 1.4 cents.

SMP

Because the steam and energy consumptions used in the model for SMP are derived from the same source, it is entirely reasonable to believe that the discussion above would apply equally. In fact, the partial load effect would likely be greater.

Thus, in our opinion, the energy figures that should be used are:

- [ ] tonnes of steam per tonne of SMP, and
- [ ] kWh of electricity per tonne of SMP

When these two numbers are applied to the 2013 Milk Price, the price per kilogram of milk solids moves from $5.364 to $5.358, or a change of 0.6 cents.

Combined

When both the WMP and SMP changes are considered together, it is our opinion that the 2013 Milk Price would be reduced by 2.0 cents per kilogram of milk solids.

2014 Model

This analysis was based on the 2012/13 (F13) Milk Price Model. In a note to the Milk Price Group[2] it was stated "there have been no changes to the way Fonterra budget energy calculation since the last review". On this basis, our conclusions are equally applicable to the 2013/14 (F14) Milk Price.

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[2] A note to the Milk Price Group (MPG) from Warwick Paine and Marcus Dixon, dated 30 January 2014, titled "140130 F14 Energy review.pdf".

Further, we note that, in the above mentioned document, the estimated variable cost of steam has risen by 12% (year-on-year) and that of electricity by 8%. These cost increases will obviously increase the 2.0 cents per kilogram of milk solids quoted above.

We also note, contrary to the statement to the Milk Price Group, that the F14 Milk Price Model shows a change in the way unaccountable energy losses are treated[3]. This change seems to be a partial implementation of our recommendation regarding unaccountable losses (see page 7). It remains our considered opinion that the currently proposed figures, to be used in the 2014 Milk Price Model, are also not practically feasible.

Comments on the Model

BMP

While investigating the energy uses in the Milk Price Model, we noted that there seems to be a major discrepancy in the electrical use for BMP production. Although this more than doubles the electrical use, the final outcome on the Milk Price is insignificant (a change of $0.0008).

The electrical use of 134 kWh per tonne of product appears to be a figure assuming a thermal vapour recompression evaporator, while the steam use of 2.97 tonnes per tonne of product is a figure assuming a mechanical vapour recompression evaporator. We believe that the electrical use may be nearer 300 kWh per tonne of product, on the basis of a mechanical vapour recompression evaporator.

[3] The F14 Make Allowance Model, titled "F14 May 14 IMP Make Allowance Model VCR v1.xlsm" (see tab "ProdVarCosts", cells F310:V315)

Conclusion

Our conclusion is that we agree with Parson Brinckerhoff: the energy usage rates used in the Milk Price Model were not practically feasible for an efficient processor.

In our opinion, assuming 95% plant availability, the practical energy use figures would be:

- [ ] tonnes of steam per tonne of WMP, and
- [ ] kWh of electricity per tonne of WMP

By inference, again assuming 95% plant availability, the energy use figures for SMP would be:

- [ ] tonnes of steam per tonne of SMP, and
- [ ] kWh of electricity per tonne of SMP

When both the WMP and SMP changes are considered together, it is our opinion that the 2013 Milk Price would be reduced by 2.0 cents per kilogram of milk solids.

The assumption within the Milk Price Model of 95% plant availability was not borne out by the Darfield data. We recommend further study to establish a representative overall availability figure and the consequent model changes.

We recommend that the issue of milk transportation within and between regions, particularly at peak milk, be further studied.

Appendix

Table 5: Darfield D1 Production Data for March 2013 – Feb 2014

Date range (as per Fonterra)	1st-10th Mar	11th-20th Mar	21st-31st Mar	1st-10th Apr	11th-17th Apr	18th-30th Apr	Winter shutdown	9th-10th Aug	11th-20th Aug	21st-31st Aug*	1st-10th Sep	11th-20th Sep	21st-30th Sep
Start timestamp (inclusive)	1/03/2013	11/03/2013	21/03/2013	1/04/2013	11/04/2013	18/04/2013	1/05/2013	9/08/2013	11/08/2013	21/08/2013	1/09/2013	11/09/2013	21/09/2013
End timestamp (exclusive)	11/03/2013	21/03/2013	1/04/2013	11/04/2013	18/04/2013	1/05/2013	9/08/2013	11/08/2013	21/08/2013	1/09/2013	11/09/2013	21/09/2013	1/10/2013
Days in span	10	10	11	10.04	7	13	100	2	10	11	10	10	9.96
* Periods corrected as per Fonterra's agreement													
D1 tonnes of WMP	[												]
D1 tonnes of IWMP	[												]
Cream sent out by D1-tonnes	[												]
Skim sent out by D1-tonnes	[												]
D1 tonnes of WMP stock food(not included above)	[												]
Fit-for-purpose output (tonnes)	**[**												**]**
Fit-for-purpose output per day (tonnes/hour)	**[**												**]**
Whole milk used - tonnes	[												]
Difference in silo level for the period(tonnes) = start level - end level	[												]
Whole milk used by D1- tonnes	[												]
18% Total solids- Permeate used by D1- tonnes	[												]
Lactose used by D1- tonnes	[												]
[ ]	[												]
[ ]	[												]
Tonnes of lecithin by D1 used	[												]
Tonnes of rework used by D1	[												]
DD2 standardised milk tonnes used to apportion milk , permeate, cream, [			]								[		]
DD1 standardised milk tonnes used to apportion milk , permeate, cream, [			]								[		]

Table 5: Darfield D1 Production Data for March 2013 – Feb 2014 (continued)

1st-10th	11th-20th	21st-31st	1st-10th	11th-20th	21st-30th	1st-10th	11th-20th	21st-31st	1st-10th	11th-20th	21st-31st	1st- 6th	7th-10th	11th-20th	21st-28th
Oct	Oct	Oct	Nov	Nov	Nov	Dec	Dec	Dec	Jan	Jan	Jan*	Feb	Feb	Feb	Feb
1/10/2013	11/10/2013	21/10/2013	1/11/2013	11/11/2013	21/11/2013	1/12/2013	11/12/2013	21/12/2013	1/01/2014	11/01/2014	21/01/2014	1/02/2014	7/02/2014	11/02/2014	21/02/2014
11/10/2013	21/10/2013	1/11/2013	11/11/2013	21/11/2013	1/12/2013	11/12/2013	21/12/2013	1/01/2014	11/01/2014	21/01/2014	1/02/2014	7/02/2014	11/02/2014	21/02/2014	1/03/2014
10	10	11	10	10	10	10	10	11	10	10	11	6	4	10	8
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Table 6: Darfield D1 Energy Use Data for March 2013 – Feb 2014													
Date range (as per Fonterra)	1st-10th Mar	11th-20th Mar	21st-31st Mar	1st-10th Apr	11th-17th Apr	18th-30th Apr	Winter shutdown	9th-10th Aug	11th-20th Aug	21st-31st Aug*	1st-10th Sep	11th-20th Sep	21st-30th Sep
Start timestamp (inclusive)	1/03/2013	11/03/2013	21/03/2013	1/04/2013	11/04/2013	18/04/2013	1/05/2013	9/08/2013	11/08/2013	21/08/2013	1/09/2013	11/09/2013	21/09/2013
End timestamp (exclusive)	11/03/2013	21/03/2013	1/04/2013	11/04/2013	18/04/2013	1/05/2013	9/08/2013	11/08/2013	21/08/2013	1/09/2013	11/09/2013	21/09/2013	1/10/2013
* Periods corrected as per Fonterra's agreement													
Steam flow (D1 average tonnes/hr)	[												]
Total flow (tonnes of steam)	[												]
Total flow including unaccountables (tonnes of steam)	[												]
Total steam including unaccountables and less [ ] (tonnes of steam)	[												]
Total steam including unaccountables, less [ ] (tonnes of steam), and increased for partial loading	[												]
Tonnes of steam/tonne of product	**[**												**]**
Electricity (kWh for the period)	[												]
Electricity including unaccountables (kWh for the period)	[												]
Electricity including unaccountables and less extra milk treatment (kWh)	[												]
Electricity including unaccountables and less extra milk treatment and less [ ] (kWh)	[												]
Electricity including unaccountables and less extra milk treatment, [ ], and increased for partial loading (kWh)	[												]
kWh/tonne of product (including unaccountables and less extra milk treatment, [ ], and increased for partial loading)	**[**												**]**

Table 6: Darfield D1 Energy Use Data for March 2013 – Feb 2014 (continued)

1st-10th	11th-20th	21st-31st	1st-10th	11th-20th	21st-30th	1st-10th	11th-20th	21st-31st	1st-10th	11th-20th	21st-31st	1st- 6th	7th-10th	11th-20th	21st-28th
Oct	Oct	Oct	Nov	Nov	Nov	Dec	Dec	Dec	Jan	Jan	Jan*	Feb	Feb	Feb	Feb
1/10/2013	11/10/2013	21/10/2013	1/11/2013	11/11/2013	21/11/2013	1/12/2013	11/12/2013	21/12/2013	1/01/2014	11/01/2014	21/01/2014	1/02/2014	7/02/2014	11/02/2014	21/02/2014
11/10/2013	21/10/2013	1/11/2013	11/11/2013	21/11/2013	1/12/2013	11/12/2013	21/12/2013	1/01/2014	11/01/2014	21/01/2014	1/02/2014	7/02/2014	11/02/2014	21/02/2014	1/03/2014
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Table 7: Energy Used During Partial Production	
Production over two days	
Total time (hours)	48
Time in production	40%
Availability	95%
Dryer capacity (t prod/h)	13
Production over two days (t prod)	**237**
Energy used in production over two days	
Energy used per tonne of product (t steam/t prod)	[ ]
Total energy in production (t steam)	**[ ]**
Energy used during non-production over two days	
Number of hours over two days in non-production time	28.8
Energy used for an evaporator clean (as per GEA, t steam)	[ ]
Number of evaporator cleans required	1
Energy required for evaporator cleans	[ ]
Other CIPs e.g. milk treatment, concentrate system, high pressure pumps (estimate, tonnes of steam)	[ ]
Daily fixed steam on dryer (as per GEA, t steam/day)	[ ]
Hourly fixed steam on dryer (t steam/h)	[ ]
Fixed steam used during non-production time (t steam)	60
Average steam use per on-product hour (t steam)	[ ]
Estimated unaccountable losses during production	2.39%
Losses per hour (t steam/h)	[ ]
Losses during non-production time (t steam)	18.5
Startup and shut down steam (as per GEA)	[ ]
Number of actions (one start up, one shutdown)	2
Steam used for startup and shutdown	[ ]
Estimated maximum steam output of boiler (t steam/h)	30
Maximum likely turn down ratio	less than 12:1
Minimum likely boiler output (t steam/h)	2.5
Losses in steam supply system	0.64
Deaerator use at low load (t steam/h)	0.5
Steam required to be vented a low load (t steam/h)	1.36
Steam vented during non-production	39.1
Average steam use per on-product hour (t steam)	[ ]
Estimated time for boiler to reduce steam output to minimum flow from production (hours)	0.25
Estimated time for boiler to increase steam output to maximum flow from off-production (hours)	0.5
Proportion of on-product steam use during boiler output change	50%
Steam occasionally vented due to rapid load change (t steam)	10.1
Total steam use during non-production time	**[ ]**
Energy used per tonne of production produced during partial loading	
Energy used in production (t steam)	[ ]
Energy used during non-production (t steam)	[ ]
Total energy used over two days (t steam)	[ ]
Production over two days (t prod)	[ ]
Energy used per tonne of product (t steam/t prod)	**[ ]**
Partial Stop/Start Factor	**144%**