Introduction
In the past five years, the wine sector has apparently been transformed from a high profile and successful industry, with a number of stock exchange listings, to one dogged by oversupply and bad news. In truth, the situation is nowhere near as bad, although the following is generally true:

• There is an oversupply of grapes;
• Producers have experienced a decline in return per litre of wine;
• There is a significant excess inventory;
• Grape prices are unsustainably low;
• Consolidation of retailers has empowered the sector’s major customers; and
• There is stronger international competition.

The oversupply of grapes is not due to a failure in sales, but rather a too rapid growth in supply. Sales continued to grow against a backdrop of substantial vineyard plantings in the late twentieth century. Producers have seen a decline in return, due mainly to adverse movements in the Australian dollar against our principal trading partners’ currency. This has resulted in virtually no movement in the price received for our product in the UK (in GB pound) and the USA (in US dollar) over the last decade. In other words, selling price has not declined. However, it must be noted that production costs (excluding grapes) have increased, entry tariffs to the UK have increased in line with the consumer price movements, and it is costing more to sell that product.

The inventory excess appears to be overstated. The AWBC is currently reviewing the data collection process to improve its accuracy, and the expected lower outcome will bring forward the expected recovery. The vagaries of the weather – frost and drought – may well lower the grape crops over the next two years, speeding the depletion of the excess and producing an earlier balance than forecast.

Grape prices and the plight of this essential part of the sector have seen plenty of publicity. It is clear that for many, the current prices are unsustainable. For some, the solution will be to exit the industry, but for many others a price-increase is needed to cover the cost of capital and provide a viable return.

Other New World wine producers now make appealing wines that are easy to drink, carry labels that are easy to understand, and sell at affordable prices. They are serious competitors. In addition, the EU Agriculture Commissioner, Mariann Fischer-Boel, is intent on driving agricultural reform in Europe. This includes a proposal to simplify labelling, remove crisis-distillation payments, and subsidise the grubbing of 400,000 ha (15%) of EU plantings. The result will significantly improve the competitive standing of the Old World wine producers.

Careful examination shows our situation is much better than portrayed. It is probable that the 2007 grape crop will be in balance with the demand for wine out of that vintage, with some potential for reduction in the excess inventory. In summing up our position:

I will use the quote that Jim Moulardellis borrowed from Winston Churchill’s comment after the Battle of Britain – some of the ‘darkest days’ of WW2 –

This is not the end. It is not even the beginning of the end. But it is perhaps the end of the beginning.

The quandary
The Australian industry has reached many of the targets contained in its 2025 vision. However, the ‘trade-scape’ is somewhat different to that envisaged. A short-term oversupply has to be managed, and a new set of challenges met as the supply comes into balance and grape prices recover.

Pressure from customers – retailer consolidation – conspires to ‘keep a lid’ on the selling price, yet the cost of goods will be inflated by grape-price growth, indexed tariffs/excise, labour, energy & other production costs. Unchecked this will lead to lower producer margins. The sector must find new ways to improve margins. This may be done through innovation in:

• Making wine…through process improvements, lower capital costs, increased recovery per unit input, greater product offering and wines with improved consumer appeal.
• Marketing wine…new product development (not just the liquid), but the package, closure, and even the channel to the market. As well, a greater understanding of consumer needs should drive back through the whole supply chain to the vineyard.

The intention of this paper is to concentrate on the winemaking opportunities.

The winemaking process
It could be argued that we do not understand the winemaking process well at all! Common assumptions made include that:

• We can overlook the impact of capital expenditure on costs.
• Wine losses are minimal.
• With fruit, we know what we are buying.
• Grapes are largely homogenous in nature within a variety and region combination each vintage.
• The majority of our processes for converting grapes into wine are well defined, state-of-the-art, and best-practice.
• The management of phenolics in white wines is well understood.
• Water ‘push-through’ of wine results in minimal loss and no water in the product.
• Clarification does not lead to wine loss.
• Electro dialysis is the cheapest cold-stabilisation option; and
• Heat stabilization is carried out effectively.

Capital investment
One of the major key performance indicators reported in many businesses is return on capital through ratios such as ROCE. (Return on
Capital Employed). Capital may include items of equipment – storage tanks, refrigeration, bottling lines, etc., as well as working capital – stocks of wine. There are two means of improving this ratio:

- Increase the margin (higher sell price and/or lower manufacturing cost); and/or
- Decrease the capital investment (install lower cost equipment, outsource some aspects of production or grow production volumes faster than the investment).

High capital investment levels flow onto high depreciation charges and reduced margin.

Do we really need to spend this much on the process or is there a lower cost option?

Wine losses

Wine losses range up to 10% of the recoverable liquid in normal processing. This is frequently disguised by poor/un-gauged tanks, the incorporation of water with process aids and additives (offsetting the volume loss), and the complexity due to the sheer number of operations. Moreover, different processing stages and release ages tend to preclude a direct comparison of bottling recovery versus the primary (first) extraction rate.

If we consider a high protein white variety requiring 1.5 g/L of bentonite addition then, assuming 100,000 L wine, there is a need for 150 kg bentonite. Assuming a hydration rate of 5% v/w, the bentonite is made up to 3,000 L with water. If the wine is subsequently racked, to give (say) 98,000 L of protein stable wine allowing recovered (downgraded) lees, a 2,000 L wine loss is apparent but it is really 5,000 L. Wine losses coincident to processing represent a very substantial opportunity to reduce costs and our ‘environmental footprint’.

Understanding the raw material

The raw material that we buy is far from homogenous. The sample size, for a statistically valid pH measurement on a vineyard block, is different to that needed for colour or Brix. Statistics is a maligned subject, but to make good decisions it is essential to have good information. If the result is not statistically valid then the result may well be incorrect, pointing the user toward an incorrect decision.

The sector has undertaken two major steps to try to identify quality in the field – sugar (Baume or Brix) and more recently colour measurements. These simple measures have been extra-ordinarily useful in driving wine quality upwards. However, it is essential that improved quality measures, and even ‘style’ measures, be found to better identify value in the field. This will offer the sector many benefits, including:

- Transparency between grower and maker, reducing tensions through clear expectations and transparent assessments that avoid human bias and confer fair payments.
- The opportunity to match demand at a product level, say Jacob’s Creek Reserve Riesling, to actual parcels in the field. This cuts out wasteful ‘overmakes’.
- The ability to reliably stream production plans from the vineyard into the winery; reducing changeovers, allowing larger batches (eliminating costly small storage), improving quality (by excluding poorer fruit), and maximising the economies of scale from the start of the process.
- The ability to develop a broader range of styles within a variety, offering the consumer greater variety across brands and price points.
- The potential to predict harvest dates more accurately.

Grape varieties are largely homogenous within a region

Personal experience in one vintage, in one (warm) region and with Chardonnay found a four-fold range of grape solids for exactly the same process. This is a far greater variation than any likely from the treatment under evaluation.

Process definition state of evolution

The wine sector is relatively small and much of its equipment is either adapted from another industry or is an iteration of earlier designs. Is there an opportunity to ‘flick’ ideas from other industries? Maybe the mining industry or the pulp and paper industry, with their enormous capitalization, have solutions that may require adaptation (e.g. stainless steel, food-safe) before adoption. Grape pressing is really just a sector-specific euphemism for the dewatering of an organic mixture!

Phenolic management of white wines

The current knowledge of ‘phenolic extraction’ is directional rather than quantitative. We do not know what compounds are responsible for ‘phenolic taste’, let alone have an in-depth understanding of the impacts of temperature, time on skins, harvesting systems and processes on ‘phenolic taste’. Imagine the value that understanding the kinetics of extraction could bring to white processing. What if we found that there was a critical temperature below which reactions almost ceased, or that tank-presses release more ‘phenolic taste’ than some other forms of processing, or that the impact of induced turbulent flow (e.g. dimples) in a must-chiller generates more phenolics than ambient temperature processing? This knowledge is essential if we are to improve our processing systems, our decision-making and our management to maximize the value recovered from every tonne of grapes that is processed.

Water push-through

It is generally assumed that there is minimal wine loss and no water ingress to the product when water is used as a proving and cleaning medium in the semi-permanent (i.e. a permanent line and flexible hose combination) wine-line. Figure 1 shows an actual wine transfer at Orlando Wines through a 500 metre length of 76 mm stainless steel pipe, including several wine fittings and flexible hoses and a plate heat exchanger.

A high-resolution flow meter was used to log temperature, specific gravity and flow rate. A cellarhand tasted the wine out at the tank and made the decision on when to divert the wine into target tank. The results showed:
• A wine/water interface of 261 metres, or 1,186 litres.
• 861 litres of this interface went into the target tank and 325 litres went to drain.
• The cellarhand ‘cut-out’ was near perfect; 189 litres of water entered the target tank and 179 litres of wine entered the wastewater system.

Using the best-case scenario portrayed above, an unintentional dilution has occurred. This was inconveniently disguised by an equivalent loss of wine into wastewater. Even more alarming is that there are two push-throughs (at the start and the end), the cellarhand may miss the cut-out, and there may be more than ten such transfer-based operations in the wine’s processing.

Clarification and wine loss
Clarification is far from benign when its impact on volume is considered.

Table 1 demonstrates the powerful influence of solids dryness; using a base solids level of 25% w/w:

- If the removed solids dryness is doubled, there is a 67% reduction in wine-loss.
- The economic value of this saved wine could be $2 per litre, or $800,000 in total.
- A 20% increase in the solids dryness generates a 23% reduction in wine-loss.
- A 20% reduction in the solids dryness leads to a 33% increase in product wastage.

In financial terms, there are two routes to loss: liquid (volume) and quality (monetary value). Many clarification systems provide a two-step process – removal of a moderate concentration of solids (say 25% w/w dry solids, or maybe 100% v/v wet solids), and then further processing to recover a lower quality (and value) product from that stream (Table 2). Clearly the choice of an optimum clarification system should include holistic operational impacts on the business. These include:

- Cost – the operational cost, plus the value of opportunity lost in entrained litres, plus the value loss for any downgraded material.
- The impact of the system on wastewater treatment & quality (this affects re-use options). RVD systems can have a substantial impact on wastewater.
- Capital costs – the depreciation component.

Table 1. A comparison of wine loss, through liquid entrainment with solids, for the clarification of 10 ML of wine containing 2% w/w solids (dry solids)2.

<table>
<thead>
<tr>
<th>Dryness of reject solids (% w/w)</th>
<th>Reject mass (tonne)</th>
<th>Reject volume (litre)</th>
<th>Entrained wine (litre)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>800</td>
<td>800,000</td>
<td>600,000</td>
<td>600 l of wine is rejected with the solids</td>
</tr>
<tr>
<td>30</td>
<td>667</td>
<td>667,000</td>
<td>467,000</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>500</td>
<td>500,000</td>
<td>300,000</td>
<td>300 l of wine is rejected with the solids</td>
</tr>
<tr>
<td>50</td>
<td>400</td>
<td>400,000</td>
<td>200,000</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>333</td>
<td>333,333</td>
<td>133,333</td>
<td>133.3 l of wine is rejected with the solids</td>
</tr>
</tbody>
</table>

RVD filters are a low capital cost option. However, there is a need to include the full suite of costs to understand what is the best outcome. There are high operating costs (filter-earth), high wastewater impacts, and the recovered quality may be poor leading to lost value.

If the industry could improve the recovery from, say, 20% dry solids to 40% dry solids, without any downgrade in unit value, for 80% of the crush, then the likely outcome would be:

- 2.0 million tonnes of fruit at (say) 750 litres per tonne primary extraction rate at 80% provides 1200 million litres of product.
- 1200 million litres at 2% dry solids, with reject solids at 20% dry solids, leads to 120 million litres of rejected product.
- 1200 million litres at 2% dry solids, with reject solids at 40% dry solids, leads to 60 million litres of rejected product.
- This would provide a gain in wine volume of 60 million litres.

If this has a value of $2 per litre, then the benefit is $120m per annum.

From an environmental perspective, if the industry were able to avoid the rejection of 60 million litres of wine, equivalent to (say) 84,000 tonnes of grapes1, we would save nearly 25,000 million litres of water. Extrapolating further, the industry could avoid the planting of 6,720 ha of vines2.

In Figure 2, the solids level ranges from 55-60% dry solids above 25-30% dry solids below. Assuming a 2% w/w dry solids level in 100,000 litres of influent wine (i.e. 2,000 litres of dry solids in the wine), the level of product loss could range from …

- 8,000 litres of solids containing 6,000 litres of rejected wine, if 25% dry solids, to
- 3,333 litres of solids containing 1,333 litres of rejected wine, if 60% dry solids.

This represents a four-fold increment of wine loss between the two systems.

Table 2. Indicative solids levels of processes.

<table>
<thead>
<tr>
<th>Process</th>
<th>Dryness of reject solids (% w/w)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static settling</td>
<td>5-10%</td>
<td>High level of liquid, further settling to consolidate lesses improves recovery, but liquid may be tainted from by extended lees contact or by oxidation</td>
</tr>
<tr>
<td>Disk centrifuge</td>
<td>25-30%</td>
<td>Range can vary significantly depending upon the nature of the reject solids, the particle size and its charge</td>
</tr>
<tr>
<td>Rotary Vacuum Drum filter</td>
<td>40-45%</td>
<td>Need to correct for the inclusion of filter media in the discharge in order to truly calculate entrained liquid</td>
</tr>
<tr>
<td>Decanters (fixed bowl centrifuge)</td>
<td>50-55%</td>
<td>Variability as per disk centrifuge. If able to avoid RVD &amp; downgrade – very valuable</td>
</tr>
<tr>
<td>Filter presses</td>
<td>60-85%</td>
<td>High yielding and high capital cost</td>
</tr>
</tbody>
</table>

1Derived from an estimated 711 litres per tonne of grapes in nominal package volumes from personal discussions with ABS.
2Derived from the WFA Public Environment Report as follows: 2005 grape crush produced 1,433 ML of wine from 563,142 ML vineyard water. This calculates to 393 litres water to each litre of wine. It is estimated that 2.4 litres of water are used in manufacture of each litre of wine. Therefore a total of 395.4 litres is used for every litre of wine reported at 30 June. Private discussions with ABC support a nominal loss of 5% from the June stock to bottle. Therefore, 395.4/0.95 equals 416.2 l of water per litre of wine
3Derived from ABS 1329 02003 Australian Wine and Grape Industry. Total crush 1,925,000 tonnes from 153,204 bearing ha. Calculates to 12.56 t/ha. Therefore, 60 ML at 711 litres per tonne equates to 84,388 t. And, 84,388 t at 12.56 t/ha equates to 6,719 ha – using mean values.
Generally, the sector uses a two-step process that batches the solids-rich liquid from centrifugation, static settling and the like for further processing. The recovered material is generally of poor quality and is used in lower grade products. Potential reasons for downgrading include:

- Dilution with water in removal and transfer of the lees, or from the centrifugation process;
- Oxidation from handling numerous remnant parcels of solids-rich liquid without adequate inert gas protection;
- Prolonged contact with very high levels of solids, which may include yeast producing highly reductive conditions and sulphide characters;
- Extraction of material from the solids (e.g. lipids from grape juice pulp); and
- Use of high rates of filter earth under oxidative conditions, adding its own taint.

Cold stabilisation
This process has a substantial impact on the wine, including a reduction of mouth-feel (or extract) and an altered taste. It is an energy intensive process, resulting in significant wine loss, and it is dirty with respect to the waste-stream, generating high potassium and high BOD waste that is expensive to treat and limits water re-use options. Electro-dialysis has been touted as cheaper; but is it really when all costs are considered? It is worth revisiting this crucial process in a holistic manner, to evaluate:

- Blocking the precipitation;
- Ion exchange/dialysis;
- Encouraging precipitation through conventional chilling;
- Hybrid systems.

A better outcome may well arise if a significant portion of the potassium bitartrate is precipitated out, but the remainder blocked from precipitation. This approach may:

- Lend itself to continuous automated processing with good recovery of the tartrate and minimal wine loss;
- Reduce loss of mouth-feel, through retention of some tartrate; and
- Result in wines of more richness and better integration.

Heat stabilisation
There are a number of potential problems with the current use of bentonite to adsorb heat labile proteins; these include:

- The heat-test may lead to over-fining of wines by up to 100% (double the rate);
- Bentonite leads to a substantial amount, up to 5-6%, of lees, which require further processing, are lower in quality than the parent-wine, and are generally difficult to handle with respect to separation, collection and reprocessing;
- This difficulty in handling leads increased losses to wastewater, with adverse yield and environmental implications;
- The sheer amount of benonite – a montmorillonite-clay – added can be substantial. Rates up to 3 g/L may be encountered in high protein varieties; and
- The preparation of a bentonite suspension typically requires a 4-5% hydration rate, or 19-24 litres of water per kg of bentonite.

The ideal would be to replace bentonite addition with some other process that is more environmentally and wine-friendly. However, in the interim there are a number of opportunities including:

1. To improve the heat test. If the rate of bentonite addition can be halved, savings are substantial without any process change.
2. To optimise the bentonite-addition process. For instance:
   - Review competitive preparations for their addition rate-effectiveness;
   - Identify settling characteristics, both volume and nature, in an endeavour to avoid carry-over through the centrifuge;
   - Identify what opportunities there may be to improve these characteristics, through co-fining or even the natural synergies between bentonite and yeast/grape solids; and
   - In-line dose all bentonite prior to a centrifuge – ideally in conjunction with an existing operation.

The overall benefit of such an outcome (refer Table 3) can be seen to be substantial:

- A large winery, making 20 million litres of varietal white wines per annum, could save $1.75 m.
- The current process can be substantially simplified, eliminating a racking and lees consolidation and RVD recovery, through ‘piggy-backing’ the operation with a planned centrifuge-operation.
- In an environment of potential shortage, the additional 1.06 million litres of first-rate varietal white wine has potential to further add to the balance sheet by an amount equivalent to the gross margin of that particular product (maybe several millions of dollars more).
- In a small winery, the lower addition rates also benefit, with lower lees losses.
OPPORTUNITIES TO CAPTURE MORE VALUE IN THE WINEMAKING PROCESS

It is noteworthy that the cost of bentonite is miniscule when compared with that of wine-loss, and also that labour is not substantial (even with the inflated figures used here). It can also be seen that there is significant room, if necessary, to buy a substantially more expensive bentonite in order to realise wine-volume savings.

Strategies for improvement

In developing a strategy to better manage the production process it is essential to look at:

1. The customer
2. The raw materials: can we improve purchase efficiency?
3. The process: can we improve it?
4. The product itself: what are the costs of its variability and of defective product?

The customer

What is the customer’s perception of value and does it match ours? Do we need to use expensive oak barrels, expensive processing (e.g. bottle-fermentation with sparkling wines) or mature the wine in bottle for two years prior to sale? We may think that we are adding value, but do our customers? Mercedes Benz used to believe that they were adding value through their very thorough engineering process, but the customer’s perception was that they were over-engineering rather than adding value.

As winemakers we may believe that we are adding value by the maturation of our beloved Shiraz in (say) 50% new and 50% one-year old French oak barrels. This may have a rough cost of:

- $1350 for a 300-litre barrel.
- A depreciation rate of 40% in year 1, 30% in year 2, 20% in year 3, 10% in year 4 during the life of the barrel. Assuming one-year of barrel age, depreciation at 35% of $1350 equates to $473 per barrel, or $493 per 300 litres, that is $1.58 per litre.
- An estimated wine loss of 14 litres per annum and 15 litres uptake by the oak for the first-fill, leads to a total, for 12 months, of 21.5 litres at $4 per litre = $86/300 litres = $0.29 per litre.

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- An estimated wine loss of 14 litres per annum and 15 litres uptake by the oak for the first-fill, leads to a total, for 12 months, of 21.5 litres at $4 per litre = $86/300 litres = $0.29 per litre.

Table 3. A worked example of bentonite handling, based upon a nominal 100,000 litre volume requiring a 1.0 g/L addition. Plausible improvements to a current processing scheme (A) are shown, through in-line dosing and centrifugal removal, either without (B) or with (C) a reduction of dosing rate to 0.5 g/L.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Current</th>
<th>Improved (A)</th>
<th>Improved (B)</th>
<th>Improved (C)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wine volume (L)</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentonite volume (L)</td>
<td>2,000</td>
<td>2,000</td>
<td>1,000</td>
<td></td>
<td>Assuming a 5% hydration rate</td>
</tr>
<tr>
<td>Start volume (L)</td>
<td>102,000</td>
<td>102,000</td>
<td>101,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lees volume (L)</td>
<td>5,000</td>
<td>500</td>
<td>250</td>
<td></td>
<td>Assume 5% lees in (A), and centrifugation to 20% DS in (B) and (C)</td>
</tr>
<tr>
<td>Estimated loss (L)</td>
<td>1,000</td>
<td>200</td>
<td>200</td>
<td></td>
<td>Loss associated with racking and consolidation; typical transfer loss deemed to be 0.2%</td>
</tr>
<tr>
<td>Target wine volume (L)</td>
<td>96,000</td>
<td>101,300</td>
<td>100,550</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovered lees volume (L)</td>
<td>2,000</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target wine value ($)</td>
<td>168,000</td>
<td>177,275</td>
<td>175,962</td>
<td></td>
<td>Assume $1.75/L</td>
</tr>
<tr>
<td>Value of recovered wine ($)</td>
<td>1,500</td>
<td>0</td>
<td>0</td>
<td></td>
<td>Assume $0.75/L</td>
</tr>
<tr>
<td>Value (cost) of RVD ($)</td>
<td>(1,000)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>Assume $0.20/L, in labour, WW treatment etc</td>
</tr>
<tr>
<td>Total value ($)</td>
<td>168,500</td>
<td>177,275</td>
<td>175,962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net benefit ($)</td>
<td>0</td>
<td>8,775</td>
<td>7,462</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentonite cost ($)</td>
<td>70</td>
<td>70</td>
<td>35</td>
<td></td>
<td>Assume $0.70/kg</td>
</tr>
<tr>
<td>Labour cost ($)</td>
<td>200</td>
<td>25</td>
<td>25</td>
<td></td>
<td>Assume 8 hours at $25 for a tank addition, racking &amp; lees removal, &amp; 1 hour for hydration of the bentonite.</td>
</tr>
</tbody>
</table>

Clear and reliable identification of fruit quality in the field could offer substantial savings in the purchase of the most important raw material, the grapes; it could also offer savings in depreciation charges, could quite possibly improve quality, and could allow the adjustment of purchasing during vintage to best meet surpluses or deficits.

In addition there may be substantial opportunities to improve...
the purchase of non-commodity dry goods, such as enzymes, fining agents and tartaric acid. Commodity dry goods can be specified, and once those specifications are identified and met, the only criterion is price. It is suspected that there may be significant opportunities for a more thorough evaluation of such materials, including their fitness-for-purpose, downtime avoidance, defect elimination, and utility per unit cost. For instance, a more holistic view for enzymes may include:

- Cost per tonne of grapes processed. A high unit cost may be offset by high activity per unit.
- Impact of reaction time on the process. A fast reaction time may lead to substantial processing benefits.
- Subsidiary benefits. Maybe the solids are more compact, reducing RVD processing.
- Improved awareness of value. It may be that doubling the enzyme expenditure (to $3 per tonne) may halve the RVD cost (to $7.60 per tonne). The enzyme increment of $1.50 may have averted $7.60 in processing cost.

Process

1. Measurement
One of the most important elements of any process improvement programme is good measurement. Good volume measurement is a great start. Losses in winemaking may well equate to 10% of the start volume. This is partly disguised by the amount of water used in the process (possibly up to 7% in some whites) and by inadequate measurement systems.

Whilst the elements of the winemaking process are simple, the sheer number of operations, the number of entities involved, and the different process stages and release dates make it complex. The coordination and management of a complex and (possibly) data-rich environment make it very difficult to achieve optimal outcomes. In some cases it may be desirable to use statistics to assess the validity of the conclusion. If the conclusion is not statistically significant, the answer may well be incorrect. If the answer is not correct, it will not be possible to make a good decision. In other cases it is worth using statistics to design trials. A 20% improvement may well be lost amongst the natural variability in the raw material (refer the variability in solids level). This may well result in losing a substantial opportunity for improvement or, worse, by chance the result may suggest an improvement has occurred when the ‘noise’ or variability has disguised a decline in effectiveness/efficiency.

2. Understand costs
Capital costs are frequently ignored, but the delight of a $1 m facility must be spread over (say) 10 years, or $100,000 per annum. If the production volume is 1,000,000 litres, then a total depreciation charge of $0.20 per litre is accrued. If a winemaker draws a salary of $80,000 plus car using an additional cost factor of 1.25, then the cost for that production volume is about $125,000 or $0.25 per litre.

3. Losses
As outlined earlier, losses represent a substantial opportunity within the process, and can be broken into liquid loss and value loss – where the volume or part thereof is recovered but at a downgraded quality.

4. Do we need to do the operation at all?
This may sound overly simple. However, it is likely that some processing steps may be avoided altogether, or where a physical transfer is involved ‘coupled’ with another operation. One example would be the in-line dosing of bentonite prior to a centrifuge: add and remove the bentonite as a part of a scheduled centrifugation operation. This is the ‘coupling’ of two or more operations into one:

- It avoids visiting the tank for the addition (a 1 g/L addition to a 1.5 million litre vessel is a 1.5 tonne addition, or 30,000 litres), possibly de-topping, to make room for the addition, and re-topping afterwards.
- It avoids the racking of the wine and separate removal & aggregation of the lees.
- It avoids the RVD filtration and recovery of the lees.
- With only one line set-up, there is a reduction of wine loss, pumping energy, exposure to dissolved oxygen, and risk to the wine quality, as the wine was already going to the centrifuge.

5. In-process control
The continuing development of in-process measurement systems appears to expand the opportunity to couple two or more processes together, eliminate downtime, and ensure product integrity. Examples of such opportunities include:

- Filtration-warming-dissolved oxygen adjustment can be controlled by turbidity, temperature and dissolved oxygen measurement in the one process.
- Alcohol, carbon dioxide and dissolved oxygen levels can be monitored in-line to the bottling filler eliminating downtime (to verify integrity) and out-of-specification production.
- Target solids levels can be assured through bypass and/or recirculation options with filters/centrifugal clarifiers. This may be of value for management of white fermentations or the provision of nuclei for sparkling wine gas evolution.

This type of approach can also be applied to ensure that bottles are filled to the correct height (check-weighers), labels are correctly applied to the right number of bottles for the destination market (vision systems) and glass/other inclusions are detected prior to the wine reaching the market place. The cost of production failure includes downtime, reworks (invariably much higher than thought), and losses – to waste, to bottle (overfills), and to sales (missed shipment, product withdrawals). The customer expects good quality, and delivering it is a pre-requisite to his loyalty; non-delivery means a substitute is found for your product amongst the 14,000 other labels available for sale in Australia.

The elimination of reworks (such as reprocessing of wine), claims against the company for defective product, failure to deliver on time or loss of customers to competitor’s product are frequently underestimated. Once a customer has switched to one of the other 14,000 or so labels available they may never come back to your product. These costs can be hard to identify but may well be some of the greatest opportunities for gain in our business.

6. Technology transfer
The old adage ‘nothing is new under the sun’ is useful to remember and should guide us to other industries and processes for inspiration. Pressing of grapes is simply called dewatering in another industry.

The cavitated air flotation system (Figure 3) injects air with a flocculent to ‘float’ out wastewater solids in a skimmer-box system. It should be possible to use this principle to rapidly separate skins and seeds from freshly crushed white must prior to pressing. The potential advantages include the following:
• Low capital cost.
• Low operating cost.
• Reduced skin contact time.
• No maceration – softer free-run juice.
• Low solids – in free-run fraction.
• Reduced press tank number – shorter press time, high fill-volumes.
• Safe, easy to clean, and low maintenance.
• Faster processing may well eliminate the need for must chilling!

7. Other opportunities
These could include the following:

• Hybrid centrifugation/filtration solutions.
• Modelling to assist in decision making.
• Measured Container Bottles to reduce overfills.
• Alternative approaches to red fermentation – could we get more value out of a tonne of grapes, faster, at a lower cost, or could we optimise fermentation to dial-up different wine-styles to better meet our customer’s needs?

Conclusion
The industry is on the verge of change. Grape price increases may well drive production costs faster than the selling price can be increased. Innovation within the process offers an enormous range of possibilities that have the potential to improve our competitive position through lower costs, higher quality, and a more targeted delivery of appealing wines to the consumer. We know a lot about winemaking, but we need to build on and integrate this knowledge into better processing systems to extract the true value potential on offer.

Literature cited