BIOSOLIDS STRATEGIC PLANNING: AN AUSTRALIAN PERSPECTIVE

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ABSTRACT

Water utilities in Australia have embarked on another round of business transformation as energy and environmental pressures are driven upward by the biggest resources led economic boom that Australia has witnessed. These utilities face escalating operating costs, tighter constraints on business practices and growing interest from far ranging stakeholder groups that present fundamental risks to their business viability. One of the most significant areas of operational risk and opportunity for these utilities is the appropriate release of biosolids back into society – through beneficial reuse and disposal routes. The way in which water utilities approach this issue has changed. Biosolids are now clearly seen as a product or resource, and rightly or wrongly there is growing corporate pressure to find a market for cost recovery from this product.

This paper presents the findings of a number of long ranging strategic planning studies for Australian water utilities into the current and future opportunities for this resource. It presents knowledge on market opportunities, technology innovations, business risks and financial triggers that provide a direction for water utilities into the future. It incorporates these drivers into a vision for future wastewater treatment infrastructure.

KEYWORDS

Biosolids, Wastewater, Treatment, Planning, Strategy, Disposal, Nutrients, BMS

1 INTRODUCTION

The generation of Biosolids in wastewater treatment is typically underestimated in importance and treated as a secondary decision in the development of business planning within public utilities. Many Australian water utilities are reconsidering their total water management options with respect to treatment and subsequently a new round of Biosolids Master Planning projects have commenced.

The pressures on biosolids disposal in Australia presents many significant differences from those in New Zealand. The current trend is to ban through legislation or financially penalise the disposal of biosolids to landfill and encourage “beneficial” reuse frequently resulting in agricultural reuse (“Restricted Use 2” as defined under the Environmental Guidelines for the Use and Disposal of Biosolids Products, NSW EPA). By comparison, biosolids disposal to land in New Zealand is strongly discouraged by private industry (and as recognised in the Guidelines for the Safe Application of Biosolids to Land in New Zealand, 2003) resulting in land-filling being frequently the method of choice for disposal of biosolids.

Despite these significant differences in the end point for biosolids, there are still considerable similarities in the situations confronted by the industry in Australia and in New Zealand. These similarities include;

- End market dependence
- High costs for transport and disposal
- Nutrient recovery
- Emphasis on greenhouse gas emissions

- Increased pressure for energy from biosolids and renewable energy credits
- Odour, health and safety related issues during the transport and disposal of biosolids.

In a number of recent biosolids strategy projects within Australia these issues have been raised with varying priorities and have had to been addressed based on current and emerging technologies and the particular situation for the client or for a specific plant. In some cases, external factors have resulted in adoption of solutions other than the least cost solutions. Some of the issues and solutions can be translated to the New Zealand context to provide insight to potential pathways for the medium and long term management of biosolids.

2 METHODOLOGY

In any Biosolids Management Strategy (BMS), it is essential to compare all options on an equal footing and generate essential comparisons for both financial and non-financial considerations. The ability to rapidly develop cost capital and operating estimates in a more complete manner without any preconceived biases is a situation faced in many wastewater option comparisons. To address this issue, use was made of in-house models to size and cost all options considered.

The Technomic™ (Technical + Economic) Model is a tool developed by CH2M HILL in North America to generate mass and heat balances, process sizing and cost estimates for various biosolids treatment configurations. For strategy development, the model was calibrated for typical Australian sludge characteristics and an Australian cost basis. The input of the Technomic Model provides a set of different biosolids treatment technology options which are grouped under thickening, pre treatment, digestion, dewatering, and product generation (e.g. thermal processes, alkaline stabilization, composting etc). The selected process is fundamental to the mass balance calculation underlying the model.

Additional cost and operating cost data was provided by the use of a further in-house model, CPES™, that is used in the rapid design and cost estimation for sewage treatment plants in general. This provides further cost data for thickening, digestion and dewatering.

The elimination of any bias and the provision of more complete costing data provides an increased degree of confidence in ensuring that the most appropriate solution has been selected, without any personal bias. Although the tools used are high level, the cost estimates developed are well suited for comparative purposes. The cost data base is regularly updated based on actual plant costs and operating parameters such as power or fuel consumption.

3 BIOSOLIDS MANAGEMENT STRATEGIES

3.1 STRATEGY 1

3.1.1 BACKGROUND

A major regional authority required development of a biosolids strategy with the key objective of reducing costs in the short and long term and, if possible, to generate revenue. The authority operates eighteen sewage treatment plants ranging in size from approximately 400 EP to 150,000 EP. The total population served is nearly 700,000 EP with growth expected to take this to nearly 1.3 million people in the next 15 years.

3.1.2 BMS DRIVERS

There were multiple objectives for the development of a BMS:

- Uncertainty in the current biosolids strategy was a major driver for the development and implementation of a management strategy. A number of existing treatment facilities required upgrades in the near future and these required a clear direction for biosolids management to permit a more consistent approach with the overall delivery of the upgrades;

- Efficiency based outcomes including cost reduction from current biosolids practices to achieve the overall objectives of efficient, cost effective services for their consumers.

- Robust and flexible strategy providing for a 15 year planning horizon. If market factors significantly change or legislation precludes a market then the strategy needed to be able to recommend the alternate pathway(s) to address these needs;

- Provides diversification to make multiple market outlets available;

- Promotes innovative solutions for future emergent markets and technologies;

- Social and community impacts including the reduction of odours and truck movements in built up environments;

- Environmental concerns including sustainable solutions to biosolids management, greenhouse gas emission reductions and reductions in overall carbon footprint.

3.1.3 END MARKET DRIVERS

It is the aim or desire of many wastewater authorities to turn a waste cost into a revenue stream. The ultimate intention is to make the authority profitable in its own right without depending on income from the rate payer. The sale of biosolids as a value added product is thought to be a key component in the achievement of this. In order to achieve an income from biosolids there must be a market for the product produced and the product must be produced in a format suitable for that end market. During the development of the this biosolids management strategy, the reliance on only two markets; mine site rehabilitation and agricultural reuse, was seen as a major risk to security of operation. Closure of either or both of these markets would seriously jeopardise the ongoing operation of the sewage treatment. In fact, during the course of the project, the local regulator (the then Department of Environment and Resource Management) strongly intimated that the major mine site rehabilitation facility in the region would no longer be considered as "beneficial reuse" and that alternative pathways should be employed. As some of the biosolids were not sufficiently stabilised for agricultural reuse without severe regulatory requirements, this potentially placed the disposal of biosolids in a potentially precarious situation.

Similarly, during the course of the project, a media release suggested that infections experienced by a number of people in Sydney may be associated with the use of compost material incorporating biosolids. Although this claim was subsequently substantially disproved to a large degree and none of the clients biosolids were currently used for composting , the experience in Sydney demonstrated that a major end path for biosolids to cease to exist within a very short time frame.

Market diversification was therefore seen as a critical issue in security of operation and a major issue in the effective risk management of business operations. Other potential markets were therefore evaluated and constraints identified.

The potential biosolids markets reviewed included both existing and potential markets with further diversification in existing markets seen as a potential risk mitigation measure. The markets identified and reviewed included;

- Beneficial Agricultural Reuse (more local reuse or additional markets)

- Mine site rehabilitation (more local reuse or additional markets)

- Forestry (local reuse)

- Composting

- Public space landscaping
- Landfill top cover
- Building industry
- Energy generation
- Solids reduction (although not so much a market, this was seen as an adjunct to improving security of disposal).

Many of these markets had been investigated previously or trials undertaken to assess the potential for reuse. These investigations included both local assessments and overseas assessments.

There were a number of key findings from these initial investigations. A major issue was market capacity and market establishment.

In terms of market capacity, the evaluation of compositing suggested that local demand is such that, typically, only 20% to 25% of biosolids can be reused in compositing. This was based on experience with a number of operations across Australia with this conclusion reinforced with biosolids management strategies undertaken for other clients that currently utilise composting as a component of their biosolids reuse program. Thus, although composting may be an attractive alternative for beneficial reuse, it does not necessarily provide a complete solution.

The investigation of the establishment of new markets or demands for biosolids demonstrated that, for many markets, there were significant establishment costs to be borne. As an example, the reuse of biosolids as a fuel in concrete or brick manufacturing, as practised at a number of locations overseas, requires modification or additions to gas scrubbing facilities. The economic benefit of the use of the biosolids as a fuel replacement is generally insufficient to warrant the expenditure incurred for materials handling and off gas treatment incurred at the construction materials production facility. This evaluation was undertaken within the context of a commercial operation where the "payback" period is relatively brief compared to the typical timeframes used in the water industry. The construction industry generally only uses "alternative fuels" to satisfy regulatory requirements to minimise green house gas emissions rather than as a commercially beneficial action. Often, a "tipping fee" is charged to offset additional handling and monitoring requirements. Thus there would be a large initial capital investment required by the water authority to make available this market without necessarily assuring an ongoing disposal pathway and without achieving a significant return on investment, if any at all.

Lower entry cost markets such as forestry that was locally available were evaluated. Again, some entry costs were required for purchase of all weather vehicles and spreading equipment. The cost of this equipment was not considered prohibitive however, potential risks associated with access to treated areas by motor bike riders and the like indicated that a dedicated area with restricted access would be required. The cost of purchase of a large tract of locally suitable land made this option unfavourable. However, forestry reuse of biosolids is practised in many parts of the world and can be a viable alternative subject to local conditions.

A number of the potential markets evaluated appeared economically attractive *per se* based on reduced haulage and disposal costs. However, these markets required a significantly improved product quality requiring Stabilisation Grade A. Thus there would be additional costs incurred at the treatment plant or through the provision of a centralised biosolids treatment facility. Inclusion of these capital and operating costs made the remaining alternative markets economically unattractive.

3.1.4 CONCLUSION

The upfront conclusion was not really surprising. The current market represented the lowest cost disposal path given the level of treatment provided at the treatment plants. This was demonstrated by local commercial biosolids firms only relying on mine site rehabilitation or beneficial agricultural reuse. If a viable alternative existed, it is more than likely that a more entrepreneurial private industry would have "filled the void" rather than a more conservative water authority identifying a commercially attractive venture capital type enterprise.

(A) ENHANCEMENT OF EXISTING MARKETS AND VALUE ADDING

Where a market is existing, steps can be taken to reduce costs associated with retention of that market. Costs associated with the key Australian market of agricultural reuse include transport and spreading of the biosolids. Initially, a small tipping fee was incurred when disposing of biosolids from sewage treatment plants. However, as the benefits of biosolids reuse on previously low yield agricultural land was realised, end users were prepared to pay for the biosolids due to its replacement potential for fertilisers. This has been seen with clients in South East Queensland where the rates applied in biosolids contracts (typically for a three year period) have been reducing for the past decade despite escalating haulage costs.

The world is facing a potential phosphorus crisis. Phosphorus is essential for all life; animal and plant; and, unlike nitrogen fertilisers that can be manufactured from nitrogen in the air, phosphorus can only be mined. Studies claim at current rates of extraction, global commercial phosphate reserves will be depleted in 50-100 years. The remaining potential reserves are of lower quality or more costly to extract.

It was determined for this biosolids strategy that the use of enhanced biological phosphorus reduction would form the preferred basis of future sewage treatment capacity to be provided. The phosphorus would either be recovered in the form of struvite or calcium hydroxyapatite or retained within the biosolids through aerobic digestion, to make the phosphorus available for beneficial agricultural reuse. The use of chemical phosphorus removal with alum or ferric salts was considered undesirable as the phosphorus is tightly bound in the chemical matrix and not available for crop uptake. Where residual aluminium hydroxide or ferric hydroxide is present in the biosolids, reuse of these biosolids can result in the binding of phosphorus from the soil during agricultural reuse thus having a detrimental impact.

The value of the nutrient content of biosolids is demonstrated by one client that undertakes enhanced biological phosphorus reduction at its major plant (connected population approximately 160,000 EP). The waste activated sludge is aerobically digested by a procedure that retains the phosphorus within the biosolids in the biologically available form. The rate for biosolids haulage and disposal has progressively decreased with each successful tender (approximately 3 year contract period) over the past 10 years as the end user of the biosolids has gone from charging a "tipping fee" to actually paying for the biosolids received once the benefits of the application of biosolids on crop growth was demonstrated. Although it is reasonable to expect reduced costs when beneficial reuse can be demonstrated, it is difficult to forecast what price the end user will be prepared to pay. This further reinforces potential issues when attempting to develop a business case for development of a new market.

(B) TECHNOLOGY AND COST BENEFIT

The study identified that, in order to retain the existing biosolids market of beneficial agricultural reuse, all of the biosolids should be stabilised to Grade B as described in the New South Wales Environmental Guidelines for the Use and Disposal of Biosolids which are used as the defacto guidelines for Queensland. A number of the plants produced waste activated sludge only without further stabilisation, placing these plants "at risk" for reliable biosolids disposal. A technology evaluation was carried out using Technolics and CPES to determine the preferred method of achieving Stabilisation Grade B. It was important that the technology adopted was compatible with the future achievement of a Stabilisation Grade A product should a suitable market be identified and prove economically attractive.

The evaluation identified that the proven systems of anaerobic digestion or aerobic digestion were the most appropriate methods of producing a Stabilisation Grade B product whilst retaining the flexibility for future augmentation to produce a Stabilisation Grade A product. Capital and operating costs were developed for a range of plant sizes utilising either of these technologies. The outcomes from this evaluation demonstrated that there existed a "cutover" point where anaerobic digestion was preferred for the stabilisation of the waste activated sludge. Below this critical population, aerobic digestion proved to be more economically favourable (refer Figure 1).

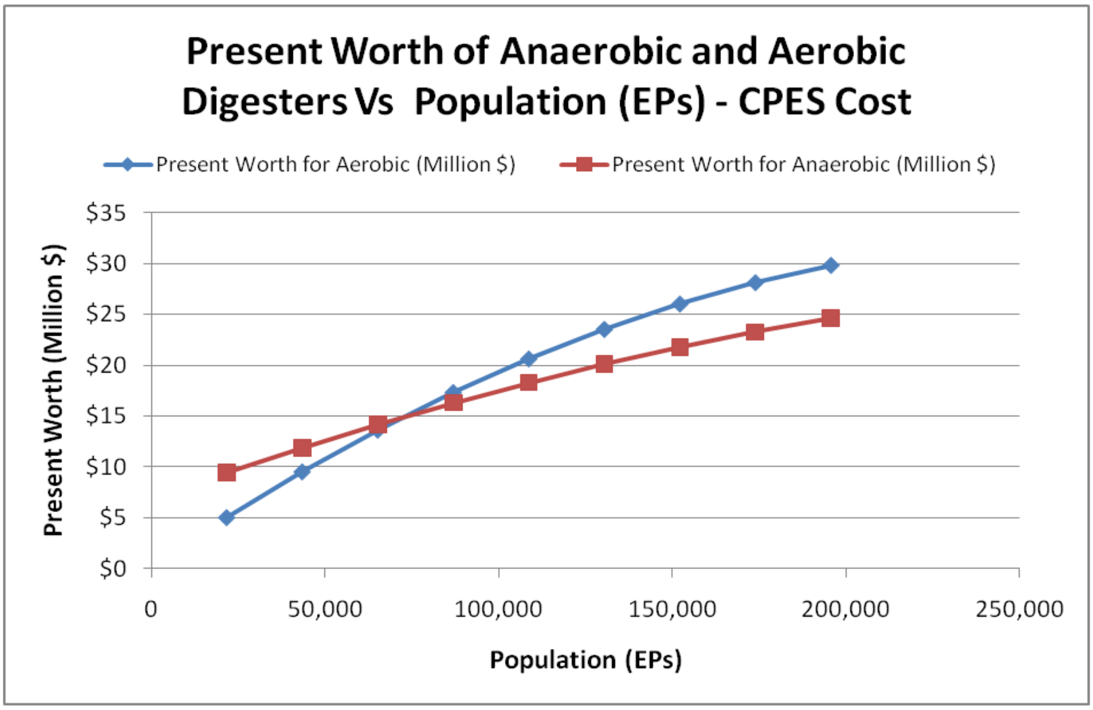

Figure 1: Aerobic vs Anaerobic Digestion Econometrics

The critical population determined in this study was approximately 75,000 EP. Below this value, the evaluation suggested that aerobic digestion would be preferred whist at higher populations, anaerobic digestion would be preferred. Naturally, there are a number of underlying assumptions to the evaluation. The sludge age of the waste activated sludge had to be 15 days or less for anaerobic digestion to prove favourable (a border line situation in South East Queensland for enhanced biological phosphorus reduction plants) and some natural gas consumption would be consumed by the anaerobic digestion system during the coolest periods (factored into the comparison presented in the graph). If anything, the graph is slightly biased towards anaerobic digestion as the power consumption for the aerobic digestion system was somewhat conservative compared to recent full scale plant experience where the power consumption for aerobic digestion has been demonstrated to be approximately half of that predicted by design procedures presented in the literature. Provision for lower power consumption by the aerobic digestion process tended to shift the cross-over point to approximately 100,000 EP which is consistent with recent projects where anaerobic digestion of waste activated sludge only has been considered in detail.

The comparison was not intended to provide a definitive rule for future provision of stabilisation facilities rather, it was intended to provide a guideline as to when the two alternatives should be evaluated in detail within the context of the specific plant. It is also important to understand that the provision of facilities for Stabilisation to Grade "B" was not considered beneficial expenditure as the capital expended was not offset by the reduced solids production and improved dewatering. Rather, this expenditure was considered essential expenditure to "be in business" and to retain the existing biosolids markets. It was therefore important to retain pathways that could utilise this infrastructure if market forces dictated that a higher grade stabilisation was required by legislation or more economically attractive.

(C) CENTRALISED VS DECENTRALISED FACILITIES

Due to the fairly large number of plants involved in the strategy (18 in all with 11 "major" plants of over 25,000 EP) and the relatively close proximity of a number of plants, the potential benefits were evaluated of providing centralised facilities as against the provision of biosolids treatment at each treatment plant site.

Somewhat surprisingly, the provision of centralised treatment did not improve the attractiveness or economic benefits of providing stabilisation to either Grade A or Grade B. Further evaluation of the models demonstrated that the provision of solids dewatering facilities both at the treatment plant site and at the centralised facility substantially negated any cost advantages gained from economies of scale for this strategy. It is expected that a similar result would occur for most situations where plants in the sub 70,000 EP size range are considered.

(D) REDUCING OPERATING COSTS

With potential alternative markets appearing limited, the strategy evaluated means to further reduce operating costs though increased solids destruction and/or improved dewatering. Many of the potential technologies to achieve increased solids destruction had already been evaluated in evaluating the methods to produce a Stabilisation Grade A product and been demonstrated to be uneconomic for current markets. Therefore, additional drying remained the only option to achieve any immediate reduction in operating costs.

3.1.5 OUTCOME.

The outcome of the project was a strategic “roadmap” indicating where new actions should be considered. Key recommendations were;

- Consideration could be given to the provision of a stockpile area or areas as a safeguard against the temporary inability to dispose of biosolids and to achieve possible further drying and volatile solids destruction.
- Potential markets may exist in the future which would substantially reduce biosolids disposal costs but these markets would need to be very local to a plant and biosolids stabilisation would need to be significantly improved to access these opportunities.
- These markets carry significant business risks, including high establishment costs, regulatory and public perception challenges, and heavy competition by alternate providers if the market is successfully established.
- An extensive analysis of a range of "enhancement technologies" for treatment showed that none of them are currently cost effective.

The “roadmap “developed demonstrates where critical points were reached in terms of business drivers, trigger points, costs, and treatment requirements (refer Figure 2).

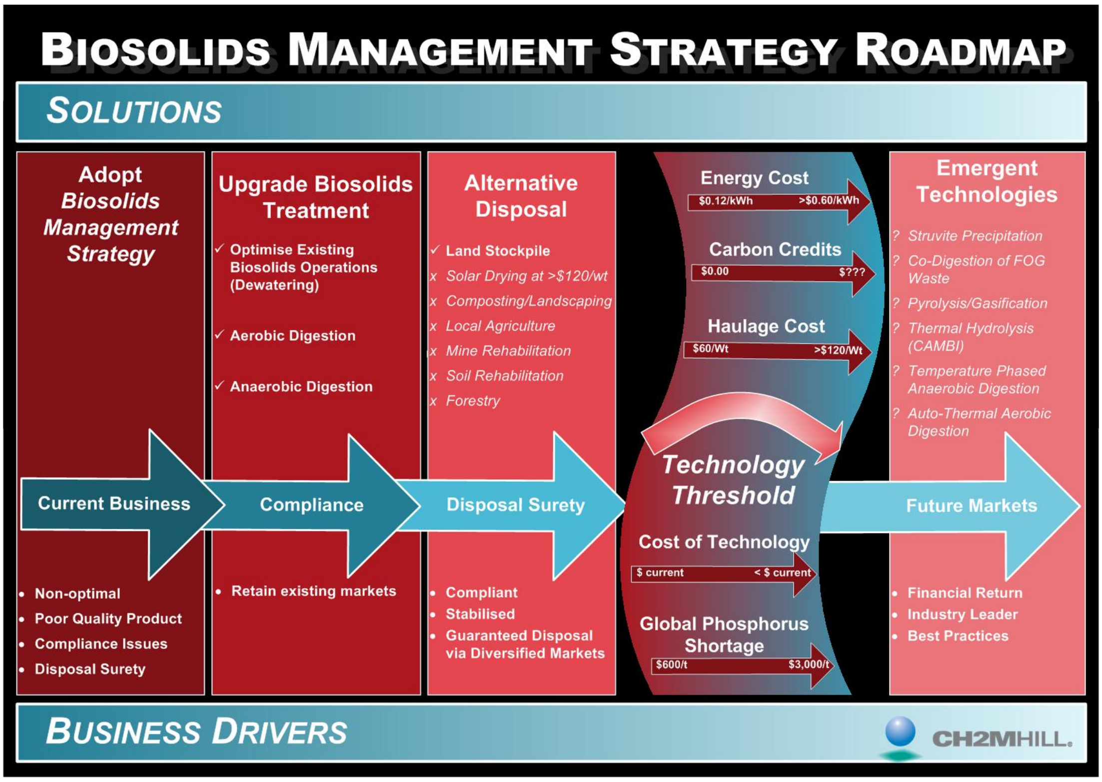

Figure 2: A BMS Roadmap

3.2 STRATEGY 2

3.2.1 BMS DRIVERS

The previous example demonstrates the outcomes that can be expected when purely economic drivers are the prime consideration. However, the treatment, haulage and disposal of biosolids entails significant risk to operations, health and safety and the environment in addition to financial risks and opportunities. This second strategy, although having many similar cost drivers, required consideration of a number of operational factors at the major plants.

In this case, the annual average sludge flows and loads for primary sludge and WAS were used as the input to the Technomic Model along with a peaking factor for the max monthly load. The mass balance, equipment sizing, number of equipment units, and capital cost estimation was based on the max monthly flows and load; however the calculations for heat balance, electricity, natural gas, and chemical consumption were based on annual average flows and load. The model outputs are a mass balance, cost summary, annual averaged burdened labor cost, and annual chemical, electricity and natural gas consumption for the selected process stream.

The Technomic Model is designed to allow the entry of details of existing assets in terms of the number of existing units and their key design criteria (volume, area, hydraulic loading rate, solids loading rate, etc.). The capacities of the existing assets are then subtracted from the required total processing capacity that is calculated by mass balance to determine the new or additional process and equipment capacity requirements. Further, existing equipment was assumed to be re-used wherever possible after restoration to as-built operability, where it could be used in a preferred process train.

3.2.2 CONCLUSION

Within this second strategy, evaluated for a major Australian capital city based authority, the outcomes for the smaller inland plants were much the same as those determined for the previous strategy; continue with anaerobic or aerobic digestion followed by dewatering and beneficial reuse. The risk factors associated with this approach were considered to be manageable without the need for further processing.

However, for the major coastal plants, the risk profile changes significantly due to intense urban development in the vicinity of the treatment plants and the ”unplanned” development along access roads over the decades including schools, shopping centres and the like. Major risks to ongoing operation of the plants included;

- On site storage requirements in the event of biosolids collection being temporarily halted or not possible due to external constraints.
- Odour generation during collection and transport of biosolids through major urban development.
- Truck movements through major urban areas.

The other objectives for the strategy were to maximise energy recovery and reduce operating costs; a common theme in most biosolids management strategies.

The study demonstrated a number of key relationships of significance. These findings are summarised in the following graphical presentations (refer Figure 3).

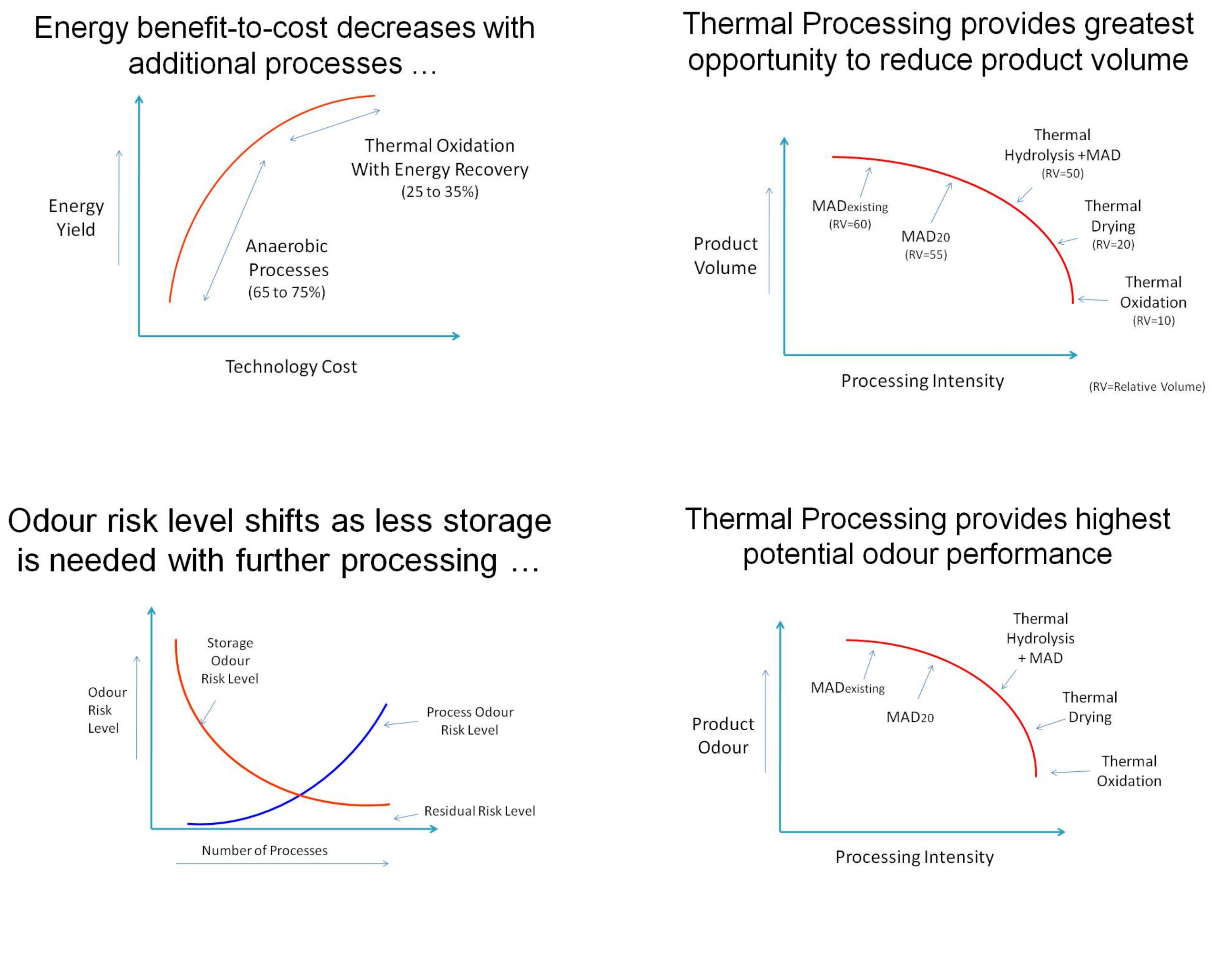

Figure 3: BMS Decision Making Relationships

A key finding is that there is a diminishing return, in fact a negative return at current pricing, for energy recovery with further processing of biosolids generally resulting in the cost benefit being unfavourable to provide further processing. It should be highlighted that this is a limitation of the current established technologies (this strategy required immediate proven solutions) and that this situation is likely to be reversed in the foreseeable future with the application of alternative emergent approaches to energy recovery from biosolids residuals.

3.2.3 OUTCOME

Despite the lack of current economic drivers, the drivers of reduced odour, reduced storage requirements at constrained sites and reduced truck movements, drove the strategy towards the adoption of thermal processing. Side benefits to this approach were the production of a Stabilisation Grade A product potentially opening further markets. A major indirect benefit was the dramatically reduced potential for litigation from subsequent transport and reuse of the biosolids. The potential for litigation from minor “spillage” of biosolids during transport through heavily urbanised areas is an ever present threat to the reliable ongoing operation of sewage treatment facilities.

3.3 STRATEGY 3

3.3.1 BACKGROUND

For this project, the authority operated a centralised composting facility for a number of sewage treatment plants within its region. Due to the commissioning of a major biological wastewater treatment facility, the amount of biosolids to be received at the composting facility was expected to increase significantly. Due to this large step change in processing capacity required, it was essential to review current practice and to see if more cost effective alternatives were available. Again, a range of options were considered using the models to develop inputs, outputs, operating requirements and cost data.

3.3.2 CONCLUSION

The investigation highlighted that critical to the ongoing operation of the composting facility was:

- The need for a reliable and continuous supply of bulking agent. Due to the anticipated closure of regional green waste processing facilities, it was considered that this demand could be adequately satisfied with possible economic benefits of charging a “tipping fee” for the green wastes.

- The need for a market demand for the composted material. Typically, the domestic demand for compost would only be of the order of 25% of the total potential production. Due to the large additional load from the trade wastes, the domestic demand would reasonably be expected to be significantly less. However, as the composting facility was centred in an intensive agricultural area, demand was projected to at least match production if not exceed production. Again, the potential for some revenue generation existed.

A potential risk to this project was that the biosolids from the tradewaste treatment facility could not be adequately composted or that odour generation due to the high sulphide content of the wastes would prove prohibitive to successful operation. Fortunately, trials could be carried out at the existing composting facility to demonstrate adequate compositing without detrimental odour generation.

3.3.3 OUTCOME

The economic evaluation demonstrated that ongoing composting was the preferred strategy. This decision was very much influenced by the following factors;

- Process and odour risk could be demonstrated to be minimal by actual field trials.

- The market risk issues of supply (green waste) and demand (compost product) had already been substantially addressed by the client mitigating this issue as a hurdle to adoption of the composting technology.

- The entry costs to the composting market had already been borne on a small scale thus the cost of expanding this market were significantly reduced. The availability of the actual product for trials by end users permits the expansion of the market compared to adoption of a future product that cannot be evaluated prior to adoption.

- As significant capital investment had already been made in the composting facility, expansion of this facility was considerably discounted compared to the implementation of "new" technologies. This is common for many biosolids and sewage treatment strategies where economic evaluations often result in the outcome of proceeding down the current technology path due to already committed capital.

The continuation of the use of composting involved minimal additional capital expenditure as the existing site had sufficient capacity and additional mechanical equipment needs were minimal. This was a critical aspect in the study as, continued operation did not consume valuable capital nor did it preclude adoption of future supplementary processing or alternative technology. Thus, although reliance was placed on a single market currently, the approach did not over commit finances to the point where a change in the strategy would prove cost prohibitive.

4 CONCLUSIONS

A common conclusion for all of the case studies is that any strategy should provide flexibility to respond to the changing markets and external forces. In the first case, "business as usual" was continued with a clear pathway provided for upgrading or augmentation of the current capital investment. In the second case, biosolids treatment "above and beyond " that immediately required was provided to provide increased surety of future operation of the wastewater treatment system in the face of potential future public pressure or outcry. The third case demonstrated the advantages of being to establish an end market approach on a small scale and to then take the opportunity to expand this market where potential demand exists.

The three case studies have a similar initial goal of minimising the overall costs for biosolids disposal however, the outcomes are vastly different due to the consideration of further drivers. We have attempted to demonstrate here that, the running of wastewater treatment systems as a business is not restricted to simply financial considerations. Like any business, there are costs to be borne by simply being in business and these include environmental, health and safety, logistics, legislation, risk mitigation and response to market forces. The landscape for biosolids management is rapidly changing due to new drivers such as renewable energy and the associated green house credits, the diminishing existing markets for reuse or disposal, rapidly escalating costs for haulage and the potential for litigation due to increased research and awareness of potential contaminants in biosolids. The costs of the treatment handling of biosolids will continue to be a major capital and operating cost component of any wastewater treatment operation. The ability to effectively contain current and future costs in the face of numerous external demands is considered paramount in the provision of cost effective wastewater treatment and will be critical for any successful business to achieve in the future.