Visual Management and Energy Consumption on Hog Farms

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Why Target Energy Consumption

Hog producers have traditionally focused on managing feed consumption while usually ignoring electrical, fuel and water consumption. The main reason has been the lower cost of these resources. However, in today's hog market, each penny saved is precious. It is therefore very important to examine these resources and ask whether it is possible to reduce their costs. The answer to this question is not only a profound yes, but reduced costs are easily achievable. This is possible because there is strong evidence that wasted energy exists in any hog operation, regardless of the farm size, management skills and whether such waste is small or big. Lower costs are easily achievable if one understands the relationship between pig's performance on one hand and energy consumption on the other, as reflected in managing farm operations such as heating, ventilation, lighting, washing or manure disposal. Although such understanding may exist for the majority of farm managers through training and experience, it is not very effective unless there is a continuous reminder that workers are aware of all the time. Once a reminder system becomes available, it is easy to manage farm energy consumption. In this paper, you will see that using visual management tools can save up to $0.80/pig. On the other hand the $0.80/pig annual saving is translated into 0.075 GJ/pig of energy saving or 4 kg/pig of CO_2 emitted from the farm. Targeting energy consumption saving is important for both survival in the current economy as well as for the environment.

Abstract

Puratone has developed a resource consumption management tool called BarnMax. The tool is based on the powerful "visual management" concept

where people worked in or managed a hog farm are continually and visually exposed to the status of resource consumption. In this unique system, the consumption status is displayed in two forms:

- the actual, reflecting “as is” consumption levels, which are directly measured from the sources
- the projected (or optimum) consumption, reflecting what the farm is supposed to consume, as calculated using the farm’s own conditions

The tool was tried in a rudimentary form in 15 finisher farms at Puratone during 03/04. Results showed significant reduction in annual cost of energy. Farm workers’ skills in managing some of the essential operations such as heating, ventilation, lighting and manure disposal also improved.

To capitalize on this opportunity, Puratone began improving the rudimentary system used earlier by automating the measuring, monitoring and reporting mechanisms of the tool. The improvements included: adding feed and water consumption management, development of user friendly software and inexpensive measuring/monitoring process. The tool is currently in the final testing and debugging before application to all Puratone farms. Benefits gained in finisher farms were $200,000 in annual savings in energy consumption cost. Projected annual savings of $1,800,000 are expected from extending use of the system to nursery and sow farms.

The following sections describe the BarnMax visual management tool.

▪ BarnMax - Visual Management Tool for Resources Consumption

What is BarnMax

BarnMax is a visual management tool that:

- Continually calculates **optimum consumption** values for electricity, fuel, feed and water in hog farms
- Measures actual consumption through monitoring the processes of supplying electricity, fuel, feed and water
- Displays actual and optimum consumption values and alerts farm workers if abnormal deviation from optimum has occurred

The Concept

Significant amounts of resources are consumed in confined housing. These resources are: electricity, fuel, feed (grain) and water. The consumption of these resources is managed using either automated or manual control systems. Automated systems are used to control indoor conditions as well as feed and water supplies. Manual systems are generally used to manage lighting, waste disposal and cleaning.

Automatically controlled indoor conditions and management of supplies are accomplished by:

- Setting of indoor temperature and humidity controls to pre-determined values that continually control the processes of heating and ventilation to supplying amounts (of heat and fresh air) that are assumed to be optimum for animals optimum performance
- Setting feed and water controls to pre-determined patterns of operations that are assumed to control feeding and watering equipment to supply optimum amounts for the optimum performance of the animals

Manually managed processes, on the other hand, are controlled through on/off switches, and assumed to follow general guidelines of operations or best practices-(SOPs), e.g. hours of light in animals' rooms and frequency of disposing of waste.

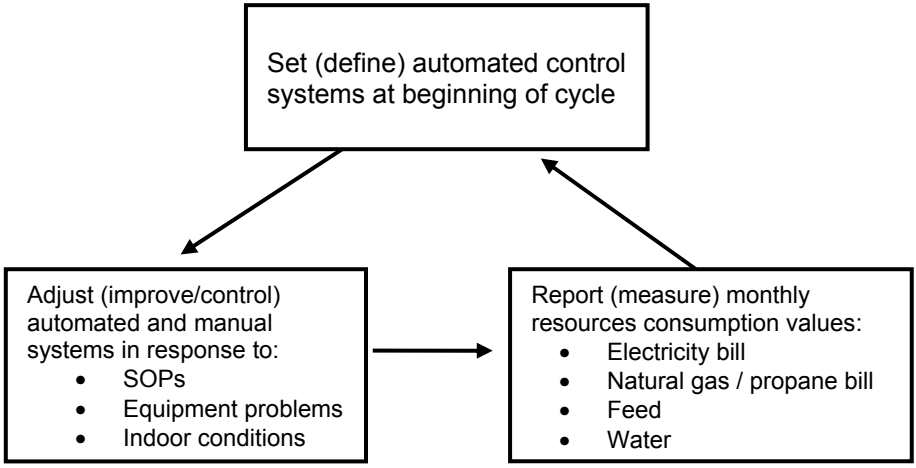
The main concept on which all of those processes are based is: "to supply optimum resources required to achieve optimum performance of animals".

Unfortunately, all above processes share a major problem: the concept of supplying optimum resources that guarantee optimum performance of animals is very vague (if exists at all). This problem becomes clear if we study the general map of any of those processes (**Figure 1**).

As seen in **Figure 1**, measuring actual consumption occurs monthly (after the fact) and is used mainly for reporting and accounting purposes. Also notice the lack of any indicator or metric that can be used as a base line. This, in turn, means there is no analysis task for comparing the actual with the optimum consumption. This also means there is no process for assessing strategies for improvements prior to applying improvements/control.

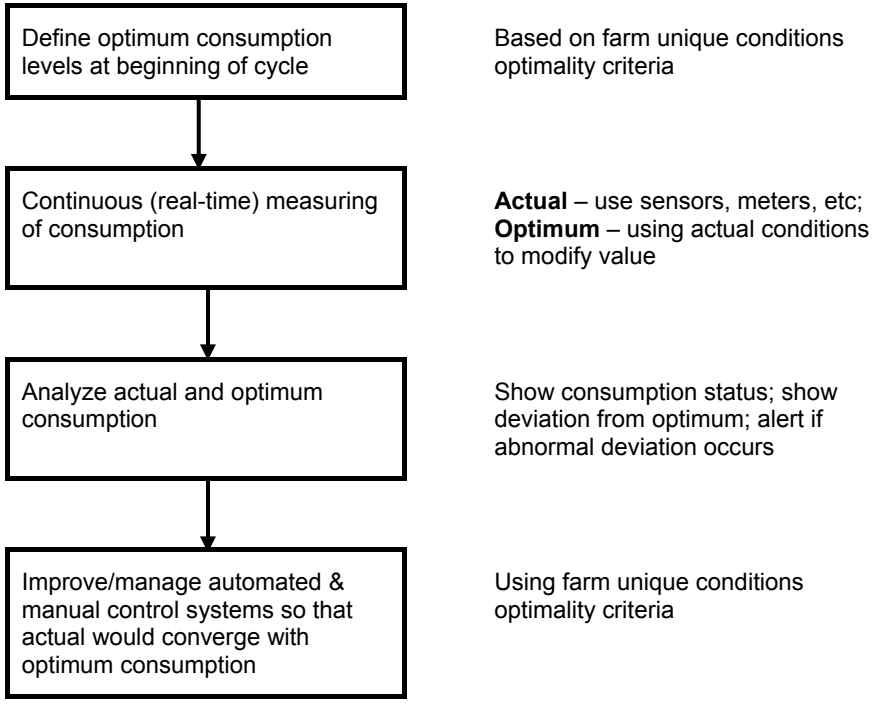
Those missing (or misplaced) tasks make the existing process description as follows: "to manage indoor environmental conditions, water and feed supply to sustain and improve the animals' performance". As result, the processes often become "wasteful" as evident from the enormous (at times) and inconsistent (all times) differences between actual consumption of resources and optimum or "should be" values.

Figure 1. Typical, and inadequate, process map.



In order to adhere to the main concept that would guarantee "supply of optimum resources required to achieve optimum performance", the above process map has to be re-drawn as follows (**Figure 2**):

Figure 2. Improved Process Map



The improved process map (Figure 2) became the basis for developing the BarnMax technology.

In 2003, 15 hog finisher farms were selected to investigate the reason(s) for the significant variability noticed in energy consumption/cost in Puratone's 2001/2002-year end statement. The annual energy consumptions (cost) ranged from **75 MJ/pig ($0.9/pig) to 300 MJ/pig ($3.5/pig)** and the corresponding standard deviation values were also significantly high. The investigation focused on determining the optimum levels of energy that each of these farms were supposed to consume according to their own equipment, building design and location conditions. The investigation revealed that although equipment capabilities and building designs may have some effects on the variability, the largest contributing factor was "**The Management Of The Processes**". The investigation also showed that lack of proper or inconsistent management of the processes was largely due to lack of "**Visual Monitoring Of The Energy Consumption"**.

Based on the findings, the following hypothesis was then developed:

> *If projected (optimum) energy consumption pattern (values) are displayed side-by-side with actual consumption values and made visible on continuous (real-time) basis, farm workers and technicians would then improve their management of energy consumption by reacting to significant and unnecessary deviations, in a timely manner.*

■ What is the optimum consumption?

Consumption levels of electricity, fuel, feed or water are calculated based on each individual farm's unique conditions (e.g. building/equipment types), optimality criteria (e.g. animals optimum performance, rooms optimum conditions, equipment optimum efficiencies, etc.), as well as changing environmental conditions (e.g. temp., humidity). The significance of these values is that they reflect optimum performance of animals while maintaining consumption values at minimum.

■ What is so unique about BarnMax

- Use of the optimum consumption levels instead of historical values as a "base line". The use of historical consumption values or training a control system to follow on-going pattern of consumption as a base line has a serious drawback. This is because if mismanagement of consumption is historical, then no control system may detect, correct or improve a wasteful consumption process.

- Continuous updating of optimum consumption levels instead of using "static" targets or specifications.
- Use of the visual management concept to improve and sustain improvements.
- Use of simple and non-intrusive tools for sensing and monitoring that eliminates installation or maintenance expenses

The Application:

From October 2003 to October 2004, the above-stated hypothesis was tested at the same 15 finishers' farms. Testing the hypothesis was conducted using the following process:

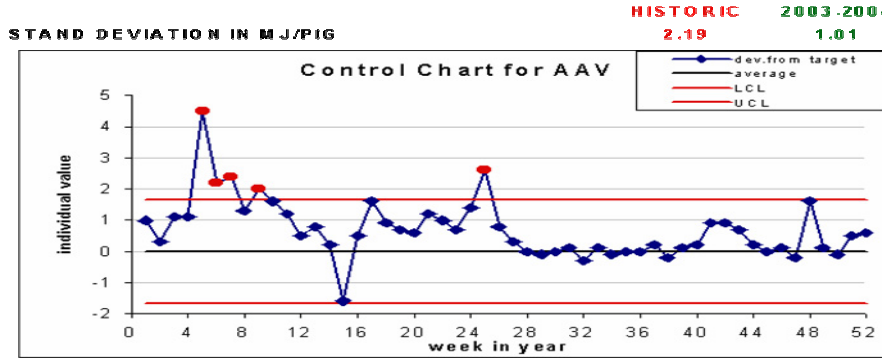
- Specifications were developed to describe the optimum targets of the different processes outputs (e.g. heating, ventilation etc.) which in turn ensured both optimum animal performance and energy consumption levels.

- Workers at the 15 farms were engaged in the process of measuring/monitoring their own farm energy consumption and comparing actual with projected consumptions. This task required producing charts showing projected consumption, according to the developed specifications, starting at day 0 of each cycle. The charts were produced at the company head office using a spreadsheet model. Charts were displayed on farms' office walls. Farm workers read electricity and fuel meters every Monday morning and plotted each week's consumption values on the same charts. Farm managers reported the consumption values to head office the same day.

- Weekly statistical control charts, displaying deviation from optimum, showed whether the consumption processes were in or out of control. Whenever signals of out of control were noticed for a farm, either that farm's manager or company technician was contacted to identify the cause of and fix the problem.

Figure 3 shows an example of these charts over one year period

Figure 3. Control Chart for AAV – deviation from optimum over 1 year period



■ Benefits of BarnMax

The application of BarnMax in 15 finisher farms at Puratone Corp. has resulted in annual savings of $200,000 in energy cost alone. It is expected that addition of feed and water modules, as well as introducing the system to other types of farms, nursery and sow, will result in additional savings of more than $1,800,000 per year.

The benefits of BarnMax can be summarized as follows:

Reduced waste in electricity, fuel, feed and water consumption through:

- Maintenance schedules, with tracking capability, to maintain facilities and equipment within conditions necessary to keep actual consumption within the optimum levels
- Real time visual monitoring of the consumption processes, both actual and optimum. This prompts farm workers and production managers to respond in timely manner if levels of actual consumption deviate from the optimum.
- Electricity demand control system to automatically keep demand within set limits

Improved and sustained good management practices on-farm through:

- The visual management tool in encourages farm workers to participate in managing the different consumption processes and thus improve their skills and understanding of the components of these processes (e.g. heating, ventilation, etc.)

- Real time feed storage inventory for feed mills to assist in better planning for feed delivery
- Real time records of water consumption that help in assessing animals health/performance as well as in better planning of managing manure (pit disposal, lagoon emptying)

The Benefits

At the end of October 2004, implementing this process, i.e. visual **management of energy consumption**, has directly resulted in a total annual savings of **17,000 GJ ($193,000).** It has also resulted in a better understanding of how to manage energy related processes inside the farms. **Figure 4** shows the energy consumption cost in the 15 finisher farms before and after the implementation of the visual management process. **Figure 5** shows the resulting reduction in variation in energy consumption for the same 15 farms.

Figure 4. Energy cost comparison (historical, optimum, actual) at the end of Oct 04 for the 15-finisher farms

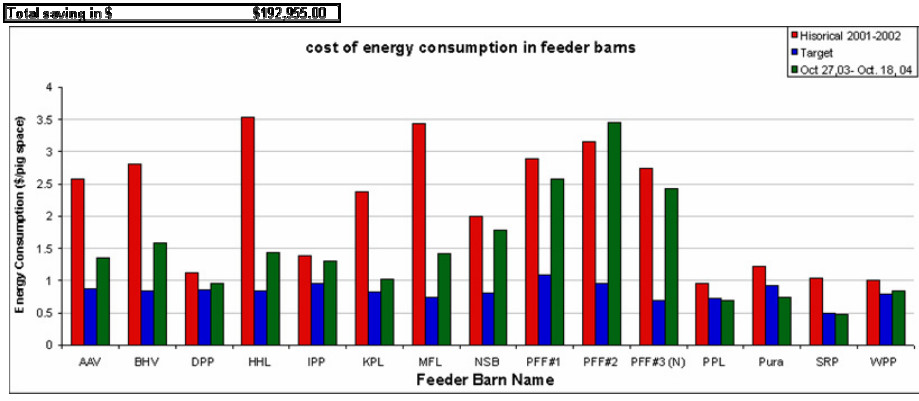


Figure 5. Variability in energy consumption before and after the application of BarnMax in the 15-finisher farms

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Farm	AAV	BHV	DPP	HHL	IPP	KPL	MFL	PPL	Pura	SRP	WPP	NSB	PFF#1	PFF#2	PFF#3 (N	case 1	case 2	case 1	case 2
																MJ/pig	MJ/pig	MJ/pig	MJ/pig
Historical	205.3	217.6	83	307.6	102.9	198	306.2	67	87.9	68.2	73.7	161.6	237.7	260.5	248.9	175.07	156.13	88.447	89.822
Target	65	60.3	60.8	65	67	57.9	56.3	62.6	61.9	41.4	55.1	59.2	75.3	66.7	54.7	60.613	59.391	7.5604	6.7023
2003-2004	102.6	116.9	62.1	111.6	91.3	70.6	109.7	60.3	45.5	40.6	56.8	141.5	184	256.1	201.7	110.09	78.909	62.565	32.385
																$/pig	$/pig	$/pig	$/pig
Historical	2.58	2.8	1.12	3.54	1.39	2.38	3.43	0.96	1.22	1.04	1.01	1.99	2.89	3.16	2.74	2.15	1.9518	0.9496	0.9654
Target	0.87	0.84	0.86	0.84	0.95	0.82	0.75	0.73	0.93	0.49	0.79	0.8	1.09	0.96	0.7	0.828	0.8064	0.1371	0.1186
2003-2004	1.35	1.58	0.96	1.43	1.3	1.03	1.42	0.69	0.74	0.48	0.84	1.78	2.58	3.45	2.43	1.4707	1.0745	0.8107	0.4008

■ The Plan for BarnMax

- BarnMax was first introduced to Puratone finishing farms in 2003/2004 in a semi-automated form
- A fully automated system is currently in operation in some farms
- Extending the concept to sow and nursery farms where combined potential saving is estimated at $1,800,000/yr
- Possible marketing to other producers is planned by end of 2007 if market study indicates potential

The Evolution of BarnMax

The success and savings achieved have prompted the company to begin working on developing that process into a fully automated one. The objectives of developing the technology were to improve the rudimentary measuring/monitoring/analyzing/communicating system used during 2003/04, to sustain the success and savings achieved in the 15 farms, and to introduce the process to all other Puratone farms. The objectives also included possible marketing of the developed technology to other hog producers.

In August 2005 a development committee was formed to discuss the potential commercialization of the system. The committee included members from Manitoba Hydro, University of Manitoba, farms workers, control systems suppliers, and agriculture engineering consultants. The committee concluded that the system has the potential for commercialization. However, the committee advised that such commercialization might be dependent on:

- Adding more components to it, such as water and feed consumption
- Keeping the system sale price as low as possible, and
- Testing the system extensively in different settings to ensure its flexibility and reliability

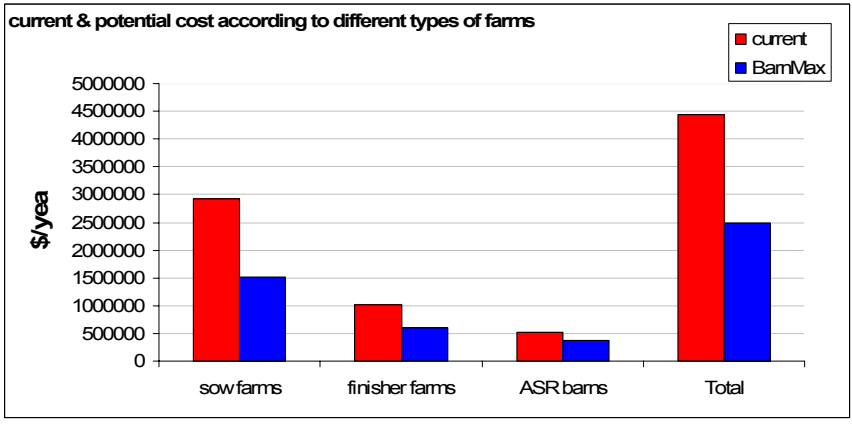
From August 2005 to August 2006, development work was completed on the following:

- Converting the spreadsheet files used for producing consumption projections and monitoring actual consumption into a “stand alone” computer program.
- Replacing the manual process of measuring consumption (mainly weekly reading of meters) with an automated one. A combination of “off-the shelf” transducers and sensors as well as an in-house developed circuit board were developed and tested for this purpose.

- Feed and water consumption were added to the process.

Figure 6 shows potential savings in all types of farms and with addition of feed and water modules to BarnMax.

Figure 6. Potential savings with the application of BarnMax in all Puratone Barns



What does BarnMax unit include?

- A hardware component: to measure consumption of electricity, fuel, feed and water in real time as well as to limit demand for electricity within optimum levels
- A software component: to calculate and update optimum consumption values, collect actual consumption values and analyze the variability between them
- A communication system: to visually report on consumption status, alert workers if any of the processes of supplying electricity, fuel, feed or water is out of control and to enable off-site communication with farms

Conclusion

Resource consumption is a major cost control centre for pork production. The Puratone experience has shown that very considerable savings are possible in energy consumption by implementing an improved process control system. This system is based upon using optimum consumption as the benchmark, rather than historical consumption. Successful application of the system is a result of active monitoring and involvement by the farm staff.