CONCLUSIONS & RECOMMENDATIONS

Overall Position

While a manure-to-electricity initiative generally is not a current competitive energy production investment, it makes excellent sense as an energy conservation program for Connecticut. Dairy farmers, and perhaps poultry farmers as well, could be motivated to use this approach because of their need to: 1.) mitigate the impacts of environmental regulations, both current and anticipated, 2.) reduce their costs of operation and 3.) perhaps, expand operations into new, related product lines.

From the state's perspective, there is strong legislative support for the development and increased reliance upon this type of renewable energy source. With some federal and state financial support in terms of grants or credits, as may be provided under the 2002 Farm Bill, the cost of the energy produced could be competitive with current nonrenewable energy sources. In essence, the study shows that in all cases the farmers would reduce their demand of grid delivered electricity and be left with several options to choose from for improving the economics of their business.

Specific Conclusions

From this work there are several pertinent conclusions that can be drawn.

1. First and foremost, good evidence is presented that the manure-to-electricity concept has proven to be a viable one in the USA when operated at the right scale. Thus, one can assert that such farm biomass waste can be viewed as a truly renewable, reliable, economical energy source. However, while the underlying manure-to-electricity technology seems very effective, it is very tedious and can be operationally very time consuming and messy. The manure handling technology seems still at an early stage of development, especially relative to simplifying the equipment for farm-based maintenance, repair and overhaul. Nonetheless, it does appear quite clear that electricity production from agricultural biomass has been proven doable and viable from a technology standpoint. For dairy cattle application, the current separator-digester-power generation systems seem best suited for a minimum of 600-head operations.

2. A key element of most such operations is the manure digester system. This study indicated that there is a very large and widespread amount of digester-related activity around the world (2 to 3 million digesters) being applied for treatment of various organic waste streams. Thus one must realize that digester technology development and maturation, which is critical to future manure-to-electricity systems, is being driven by a large marketplace independent of, but potentially useful to, agriculture waste treatment. Digester technology is therefore likely to continue to improve due to the presence of a mature but growing market, from which the manure-to-electricity initiatives will be able to benefit. Further, it is possible that once larger digester systems become more widely established in Connecticut, they may be able to gain economy of scale by processing other waste streams.

3. For large poultry operations it appears a combustion-based system is the only option that is currently in use, although other alternatives are under study. It remains to be seen just how these technologies will be of utility or accepted at the moderate scale appropriate to Connecticut poultry operations. For the Connecticut poultry industry, no detailed economic analysis was possible for a stand-alone chicken-litter-to-electricity operation because its scale would be too small compared with those in operation elsewhere in the country to produce a meaningful analysis. The only such systems in the US burn the chicken litter to drive steam turbines and are nearly 30 to 40 times the scale appropriate to Connecticut. It seems apparent that for Connecticut, some of the newer technologies (pyrolysis, plasma torch, etc.) for gasifying the litter offer a more meaningful approach. In this case, the gas might be useful as an alternative fuel in the farm-based cattle manure to electricity systems discussed above.

4. An interesting concept, used elsewhere in the USA and one that should be given consideration for Connecticut, is one in which farmers handle waste material processing, which they are most familiar with, while the utility company or other third party is responsible for power generating operations.

   This also fits nicely with the concept of using multiple, farm-based digester operations to produce tanked gas, which is subsequently hauled to a local power generation site, thereby also avoiding the possible complications and hazards associated with the hauling of raw manure on Connecticut's public roads. In this way, each site operates at its natural highest state of productivity due to efficiency and effectiveness. For this approach, farms would operate the digester and store the gas generated for scheduled pick-up. Thus the on-farm digester labor costs would be absorbed as normal manure management costs and the costs of shipping raw and spent manure would be replaced with a likely lower cost of shipping gas on a less frequent basis. The central site would eliminate operating costs associated with handling of raw manure and process residuals. The digester and separator capital costs revert to those of the individual farms and the costs for gas storage must be added as well. Capital costs for central site digester and separator systems are eliminated and replaced by what are likely to be lower cost gas handling equipment and trucks.

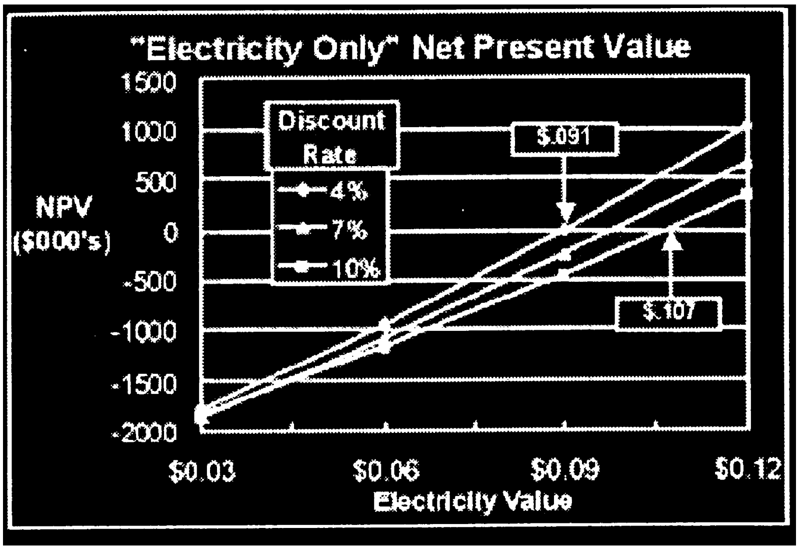
5. It is apparent that the key element of the economic analysis for the farms is the use made of the generated electricity, in particular, how much is used to directly replace grid purchased electricity valued at $.09/Kwh and how much is sold into the power grid for somewhat less. Thereafter, one needs to account for potential benefits and/or costs from related activities using or disposing of process residuals.

   Focusing initially only on the power use issue for dairy farms, in all scenarios studied, it appears that more electricity is likely to be generated at a single site than needed to replace its purchased power. The analysis for dairy cattle indicates that each dairy cow consumes nominally 800 Kwh/yr while their manure can be converted to 1500 to 2000 Kwh/yr in electricity employing currently available technology. Thus the use to which the excess is applied is a major aspect of the viability of any approach. For Connecticut dairy farms that choose “going it alone” with an on-farm digester/generator system, the electricity generation economics generally are unfavorable because the excess power is relatively small and only produced intermittently. It can therefore be sold to the grid only at the $.04/Kwh “fuel replacement” value to the utility. For such cases, the decision to proceed must be rationalized based on the other factors, such as income or cost avoidance from use of process residuals or from corollary environmental and/or socio-economic benefits. Dairy operations of 600 head appear to be right in the cross over range: less than that seems dubious and more than that seems just doable. Connecticut has only 14 operations with over 500 head and 100 or so with fewer than that.

6. The geocoding and mapping results have provided very valuable insight into the utility of the small farm clustering concept for Connecticut. While some of the farm operations are large enough to consider "going it alone" two things are apparent from these results: (1) the majority of the farms are not large enough and thus the bulk of the opportunity will be missed and (2) it could be beneficial to all if the larger farms can take advantage of the tight clusters in which they are embedded.

From the analysis, it appears that 5-6 natural cluster sites might be possible for some sort of centralized operations. The data indicates that for dairy farms, several larger farms could be used as central sites for operating at the 3000-4000 head level.

Although the study indicates that from a strict energy production investment view, an "electricity only" approach is not a viable option for the case where the bulk of the electricity is valued at $.04/Kwh, a parametric sensitivity analysis has since indicated the potential for a less negative, even positive assessment. As depicted in the Figure on the right, it is seen that for discount rates from 4% to 10%, the breakeven point is reached for electricity valued at approximately $0.10/Kwh.



With this in mind, combinations of three options should be considered going forward for bringing the central digester approach to a viable investment state:

- increasing the electricity generated value, with each $.01/Kwh increase over $.04 improving the yearly revenue by approximately $60K,
- improving the operating cost structure to capture efficiencies and/or effectiveness

- improving the capital cost structure for productivity gains

Each of these options is discussed in more detail below.

For increasing the electricity value, several possible alternatives for consideration are:

A. In order to gain more of the $.09Kw-hr benefit derived from not using grid delivered power, consideration should be given to rewiring to distribute power back to local farmers.
B. Because each centralized site of 3000 head will be able to generate significant excess electricity (3 to 4 million Kwh/yr or more) on a 24 hour, seven day a week basis, they can be considered as a reliable source of renewable energy. As such they will be able to negotiate not only for the $.04/Kw-hr for fuel cost avoidance but will also be able to gain another $.02/Kwh or more for available capacity.
C. By negotiating a higher rate from the utility authority because of socioeconomic benefits to local regions and/or renewable energy credits.

For improving the operating costs structure, several alternative examples for consideration are:

A. Centralizing gas-fired power generation but distributing gas generation to the individual farms as discussed in #4 above.
B. Importing of other, compatible waste streams.
C. Selling process residuals in the open market.
D. Creating a milk processing plant at the power generation site.
E. Accounting for avoidance of environmental-impact control costs.
F. Accounting for available and/or new clean energy related tax credits.

For improving the capital cost structure, several alternative examples for consideration are:

A. Taking advantage of US Farm bill based investment opportunities such as grants, reduced loan rates, etc. The U.S. Department of Agriculture in collaboration with the U.S. Department of Energy recently announced that funding was available to pay for up to 25% of the cost of eligible renewable energy initiatives through the Rural Development for the Renewable Energy Systems and Energy Efficiency Improvements programs.

B. Taking advantage of Connecticut's economic development investment assistance programs for reducing the cost of capital.

C. Taking into consideration the sale of processed manure for fertilizer and cost avoidance of unprocessed waste streams.

Recommendations

1. An effort should be launched to create a consortium of farmers, possibly through Connecticut's Agriculture Cluster, to explore the feasibility and interest in developing and
running a centralized digester pilot program.

2. Gasification of chicken litter should be explored further because of its potential for producing usable gases while providing a reduction in residual material bulk. No such systems are operating now. Technologies other than those reviewed here for generating
the required high temperatures should be considered.

3. Plans should be formulated for launching State-of-the-Art (SOA) technology based pilot demonstration chicken and dairy programs in Connecticut in the near future.

4. The environmental and socio-economic benefits of such systems for Connecticut should
be calculated and included in the analysis as soon as possible in order to provide accurate estimates of the overall impact of a manure-to-energy program in the state.