EXECUTIVE SUMMARY

The need for producing sustainable energy is here. With the high demand for fossil-based fuels and its limited supply, developing alternative energy sources is essential. Since the laws of thermodynamics prove that we cannot “create” energy, the far-reaching goal is to determine how energy can be extracted from our available resources in a situation where water is an increasingly scarce resource. One situation that we must avoid is diverting our drinking water supplies to grow “energy” crops.

Although there is a general awareness of the need to protect our natural resources, business owners generally will only participate voluntarily in a conservation-based program if it is economically feasible. There exist a number of potentially feasible approaches or technologies to generate energy that utilizes existing underutilized waste streams or resources. In many cases these approaches can be most economically sustainable when they are utilized together in a system. The approach of this study is to develop and apply a systemic combination of several existing technologies together in a system. This overall system is an integrated modular production system where the mass and energy balances are completed for various production systems in order to find the combination of systems that are both economically viable and environmentally sound while not utilizing human consumable water resources.

The objective of this study was to investigate the viability of utilizing the integrated modular production systems on the basis of profitability and environmental constraints. Various scenarios of the modular production system are examined for their economic feasibility, yet based on the principle of preserving natural resources. Economic analyses and modeling are conducted on the estimated costs of raw material, equipment, labor, and transportation. The resulting model shows that the integrated modular systems approach is a promising alternative solution to our current mode of operation. The system provides a solution that will improve economic, environmental, and social issues for our economy.

The modular production systems examined were composed of growing aquatic plants from livestock waste, feeding fish with a portion of these aquatic plants, and then harvesting some aquatic plants to combine with the manure biomass for the production of energy, or the production of other salable by-products. The purified wastewater from the system is then reused to initiate the cycle once again.

This study is limited to the operations described—feedlot, aquaculture operations, hydroponic crop production, and energy production, yet it could be expanded into several other markets,
such as dairy operations, cheese production, and other biomass waste products like corn or peanuts. All of these operations are prevalent in Texas and could be easily integrated into this energy-producing system.

The various systems examined all begin with a similar base, the cattle production industry. In these analyses, the cattle feeding operations were either an open feedlot, most similar to the cattle finishing operations found in the Texas Panhandle region or a closed feedlot system where all of the manure produced by the cattle is collected and which can be converted to energy or other by-products. The base size feedlot examined for comparison purposes was 50,000 head. From the feedlot operation, the next component of the system includes a gasifier system where the dry biomass (manure solids) are converted to a synfuel, and thus, to electricity via an electrical generation system. In addition, all liquid waste or runoff from the open feedlot is collected and recycled to produce plant biomass that was also gasified for electricity production. The next modular production system that was integrated into the overall system was the production of fish. Since the aquatic plant production system acts as a water purification system, the water quality is sufficient for the production of fish. The last modular production component considered was the addition of growing tomatoes in a hydroponic system. Ten different scenarios of these systems were analyzed for their feasibility and subsequent payback periods. In all of the cases analyzed, renewable energy credits were considered at the rate of $4.50/MW-h whereas no value was given to the carbon credits, the heat and ash by-product produced from the gasification system, nor the avoidance cost of tipping fees.

Of the various scenarios considered, the worst situation involved the system where only energy was produced and sold at the wholesale market price of $0.0404/kW-h from the waste biomass collected from the feedlots. The closed feedlot system resulted in a payback period of over 20 years whereas the open feedlot required only 16 years for the greenfield system (this includes the total cost of a newly constructed feedlot) and 11 years for the system that does not include the installation costs of the feedlot. Naturally, if this electricity could be sold directly to a consumer at the current market prices, the payback period would be greatly reduced. When the fish operation was added to the open feedlot, non-greenfield system, the payback period was reduced to four years for the multi-million dollar investment required.

When the total system of a closed feedlot that includes energy, fish and hydroponic tomato production are considered, the payback period resulting was 11 years for the greenfield system, but only five years for the non-greenfield system. This large reduction in payback period verifies that the integration of the technologies, where the by-products of one component of the system is utilized in another component of the system, is a more efficient and cost effective system.

Another industry in the Texas Southern High Plains that produces millions of tons of biomass that must be either processed or disposed is the cotton industry. Over 732,000 tons of gin trash is produced annually at ginning facilities within a 100-mile radius of Lubbock, Texas. That amount of biomass could feasibly produce 84 MWe of sustainable, renewable electrical power. If this biomass is gasified via the system considered in this analysis and all of the electricity is sold at the wholesale price, the payback period for this operation would be about 4 years. This payback period includes the transportation costs FOB the gin in addition to paying $2/ton for the biomass.
Considering that available natural resources are finite and that the population will continue to grow, it is appropriate to consider the mechanisms of incorporating biomass and water reuse technologies into every facet of life. The economic feasibility of an integrated modular production system that combines energy production from biomass, aquaculture, feedlot operations, and water recycling management into an interdependent operating unit is not only positive, but necessary for our future quality of life. Therefore, if the recycling system can pay for itself and provide an economic return on the investment, making these investments should be seriously considered.