Energy Management in Sustainable Agriculture

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Concept

Energy is the lifeblood of ecosystem and of the biosphere as a whole. At the most fundamental level, what ecosystem do is capture and transform energy.

The energy flow

Energy is constantly flowing through the ecosystem in one direction. It enters as solar energy and it is converted by photosynthesizing organisms (plant and algae) into potential energy, which is stored in the chemical bonds of organic molecules, or biomass. Whenever this potential energy is harvested by organisms to do work (e.g. grow, move, reproduce), much of it is transformed into heat energy that is no longer available for further work or transformation – it is lost from the ecosystem.

Agriculture, in essence is the human manipulation of the capture and flow of energy in ecosystem. Humans use agroecosystem to convert solar energy into particular forms of biomass – forms that's can be used as food, feed, fiber and fuel.

The agricultural 'modernization' of the last several decades has been largely a process of putting ever greater amounts of energy into agriculture in order to increase yields. But most of this additional energy input comes directly or indirectly from non-renewable fossil fuels.

Moreover, the return on the energy investment, in conventional agriculture is not very favorable; for many crops, we invest more energy than we get back as food. Our energy intensive form of agriculture, therefore cannot be sustained into the future without fundamental changes.

Prospective agricultural practices to save energy

Fertilizer and pesticide use

More than half of all energy used in agriculture goes to commercial fertilizer and pesticide production. Producers can readily impact their bottom line by reducing these energy inputs. Successful strategies include the use of cover crops and manures, nitrogen-fixing crops in rotations, composting, and integrated pest management (IPM). In addition, precision farming can reduce overlap of fertilizer applications.

Irrigation

On average, about 25% of the electrical energy used for irrigation in developing countries being wasted due to poor pump and motor efficiency. Properly designed systems promote correct soil moisture levels, leading to crop stress, reduced yields, wasted water, runoff, soil erosion, and many other problems. Energy (and money) can be saved in many ways:

- Efficiency irrigation pumps, including variable speed pump motors;
- Frequent management/maintenance of irrigation systems;
- Proper pump-sizing; and
- Upgrade to more efficient irrigation system, e.g. from wheel lines to pivot or linear sprinkler systems.

Farm vehicles

The biggest opportunities for energy savings from farm vehicles can be found in tillage systems and tractor fuel efficiency. Tractor fuel efficiency can be as simple as proper tire inflation, regular vehicle maintenance, and reduced idling. Such measures can not only save fuel, but prolong the life of the tractor.

Where applicable, the biggest gains in tillage reduction are found in reduced-till or no-till cropping systems. These systems can also offer benefits such as increased crop yields, soil moisture conservation and reduced time in the field. Farmers can also use overlap reduction systems such as auto-steer, obstacle isolation, and proper equipment sizing to gain significant reductions in fuel use and equipment wear.

Greenhouse agriculture

Typical annual greenhouse energy usage is 75% for heating, 15% for electricity and 10% for vehicles. Producers who put resources where the greatest savings can be realized have clear opportunities for savings. Energy conservation solutions range from common-sense to extremely efficient heating, cooling and watering systems:

- Reduce Air Leaks by using door closers, weather stripping (doors, vents, fan openings) and lubricating louvers (a partially open louver may allow several air changes per hour).
- Poly with an infrared inhibitor on the inner layer can give 15% energy savings.
- Thermal Blankets can achieve 20%-50% energy savings.
- Foundation and Sidewall Insulation.

Future energy conservation

Clearly sustainable food production depends to a large extent on more efficient use of energy, as well as less reliance on industrial cultural energy inputs and fossil fuels in particular. They key to more sustainable use of energy in agriculture lies in expanding the use of biological cultural energy. Biological inputs are not only renewable, they have the advantages of being locally available and locally controlled environmentally and able to contribute to the ecological soundness of agroecosystem.

Strategies for energy conservation

- Using minimum or reduced tillage systems that require less mechanized cultivation.
- Employing practices that reduce water use and water loss in order to reduce the amount of energy expended for irrigation.
- Using appropriate crop rotations and associations that stimulate recovery from the disturbance caused by each cropping cycle without the need for artificial inputs.
- Developing renewable, energy-efficient cultural sources and uses of energy to replace fossil fuels.

- Developing on-farm sources of industrial cultural energy (e.g. electricity, wind energy, small scale hydropower) wherever possible.
- Using industrial cultural energy more efficiently by reducing waste and making more appropriate matches between the energy's quality and its use.
- Reducing energy use in the agricultural sector by regionalizing production, and putting consumers and producers more directly in contact both seasonality and geographically.

Increasing the use of biological energy

- Viewing human energy as an integrated part of energy flow in agriculture rather than as an economic cost that must be reduced or eliminated.
- Returning harvested nutrients to the farm land from which they came.
- Making more extensive use of manures to maintain soil fertility and quality.
- Increasing the local and on-farm use of agricultural products in order to lessen the energy costs of long distance transport.
- Expanding the use of biological control and integrated pest management.
- Encouraging the presence of mycorrihizal relationships in the roots of crops in order to lessen the need for eternal inputs.

Model agroecosystem which require lower levels of cultural energy inputs

- Making greater use of nitrogen fixing crops, green manures and fallows.
- Making greater use of biological pest management through cover-cropping, intercropping, encouragement of beneficial, etc.
- Introducing crops that are appropriate or adapted to the local environment rather than trying to alter the environment to meet the needs of the crop.
- Incorporating wind breaks, hedge rows and non crop areas into cropping systems for habitat and microclimate management.
- Designing agroecosystems using local natural ecosystems as a model.
- Maximizing the use of successional development in the cropping system (e.g. through agroforestry) in order to maintain better agroecosystem regeneration capacity.

Sustainability concerns of energy use

Energy sources	Sustainability concerns		
	Environmental	*Social*	*Economic*
Biomass fuels	• Land use conversion • Nutrient mining • Erosion • Loss of biodiversity	Adequate supply	• Operation and maintenance • Declining yields
Conventional fuels	Air pollution	• Equitable distribution • Access	• Foreign exchange costs • Return on investment
Solar energy	• Selected indirect impacts from panel production • Ecofriendly	—	• Rate of return • Operation and maintenance • Higher investment cost

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