Sponsored by:

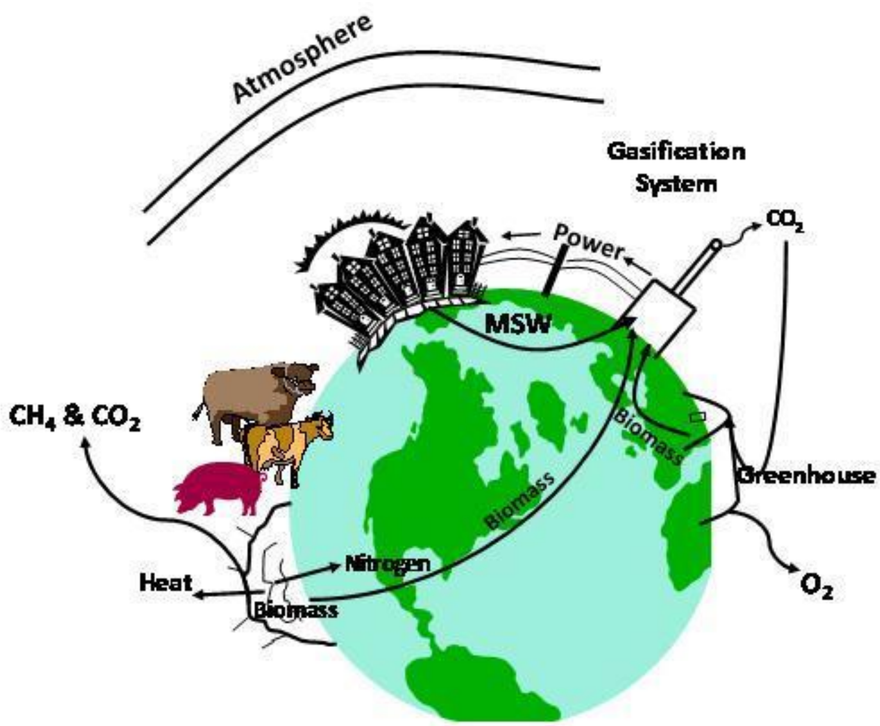
San Luis Valley Resource Conservation & Development

# San Luis Valley SEED Park Stakeholders' Meeting

## December 1, 2007

# Building a SEED Park

## (Sustainable Environmental and Economic Development Park)




Conducted by:

**Global Scientific, Inc.**

Hosted by:

ADAMS STATE COLLEGE
COLORADO
Great Stories Begin Here

Prepared for:

**San Luis Valley Resource Conservation and Development Council**

Council Members:
Harold Anderson, Chair
John Drake
Roger Doane
Doug Davey
James Mietz, RC&D Coordinator
Carol Gurule, RC&D Secretary

Prepared by:

**Global Scientific, Inc.**

Nick C. Parker, PhD, Clifford B. Fedler, PhD, and Robert D. Rogers

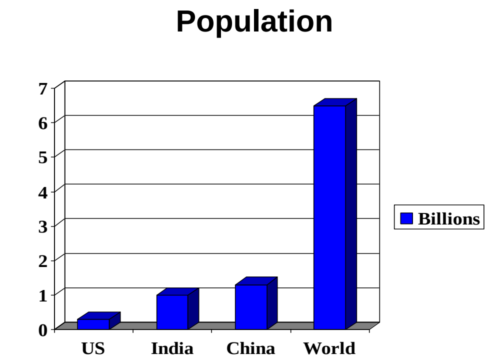
Global Scientific, Inc.
3255 Oberlin St.
Lubbock, TX 79415
www.globalscientific.org

**Table of Contents**

## Introduction

### A SEED Park: A Sustainable Environmental and Economic Development Park

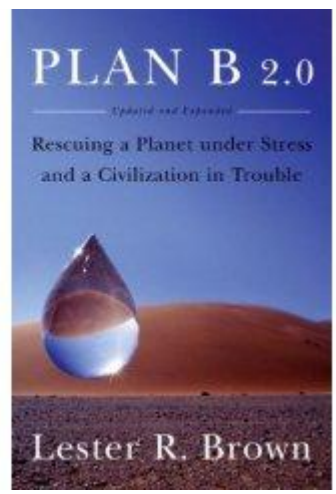
When gasoline was $.35, or even $1.35, per gallon we apparently could afford to be a throw-away society. With gas now above $3.00 nationwide and above $5.00 per gallon on the West Coast, it may be time to rethink our throw-away economy.




The demand of consumers in India, China, and the rest of the world to achieve a life style similar to that in the US is forcing us to examine the sustainability and economics of our agricultural and industrial enterprises.

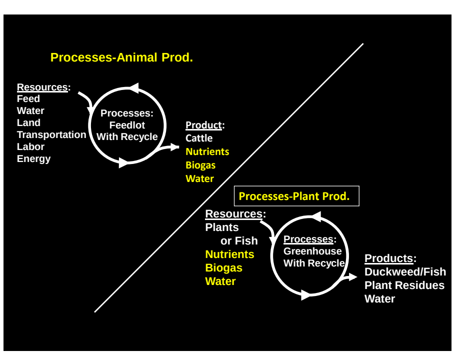
The United States, with just less than 5% of the world's population, uses 25% of the world's energy. US industry produces residues and effluents from agriculture, construction, manufacturing, municipalities, and households that all contain energy – waste energy – and can be recycled. Except for nuclear power and geothermal, all sources of energy are ultimately derived from the sun. Even fossil fuels are a form of solar energy, captured by plants and stored in geologic deposits millions of years ago. Extraction and utilization of this stored energy today far exceeds the rate of replenishment. Therefore, if tomorrow's society is to enjoy the quality of life we know today, we must change our ways. The economy can help us make the right decisions.

The Earth Policy Institute has published a book "Plan B 2.0: Rescuing a planet under stress and a civilization in trouble" by Lester Brown. "Plan B 2.0" calls for a restructuring of society to utilize the waste stream of one business as the raw input product into the next business. A series of businesses integrated together could become a dynamic economic powerhouse.




We're familiar with plastic composite decking material made from recycled plastic bottles, with aluminum cans manufactured from other recycled cans, with printer paper made from recycled paper, ad with other products made from recycled goods. In Japan, NCE, the large electronics firm, has clustered its various production facilities so that usable waste products from one can be fed as the raw ingredient to the next downstream facility, etc. India, now the world's number one producer of milk, has adapted a similar strategy for agriculture. The milk industry of India depends solely on agricultural residues as feed stock for the dairy cattle. The San Luis Valley (SLV) has similar agricultural wastes, and we need to know if the Japanese strategy will work for the SLV.

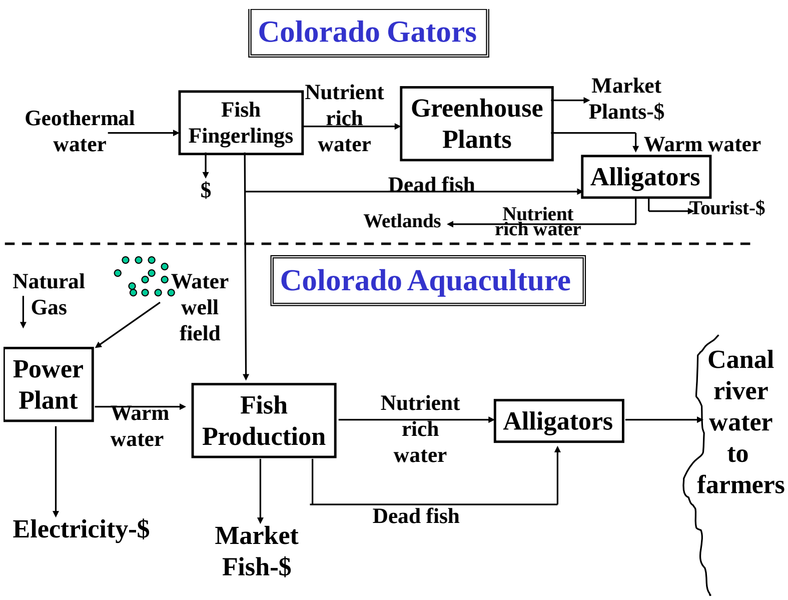
An agriculture- or organic-based SEED Park could be centered around a dairy operation, a cattle feedlot, a municipal wastewater treatment plant, the forestry industry, or an electric power plant gasifying municipal solid waste to produce a renewable and clean fuel. With the open space and clear skies of the West, this region is ripe for development of extensive photovoltaic solar parks producing commercial quantities of electricity. These solar parks could be a key component of a SEED Park.




The production of animals produces residues (nutrients, biogas, and water), commonly discharged as wastes, but which have value as input resources for production of plants.

Today, for example, Colorado Gators employs elements of a SEED Park. Colorado Gators is first, and foremost, an aquaculture facility producing tilapia as food fish. Tilapia are warmwater fish and can be produced in Colorado only because of the availability of geothermal water. The alligators were brought in to consume the offal and any dead fish. The greenhouse structures provide protection during both summer and winter. The heat from the geothermal water keeps the greenhouses operational throughout the winter. The greenhouses provide space for a range of terrestrial and aquatic plants with value in the food, fiber, ornamental, horticultural, and landscape industries. The fish excrete waste products into the water, degrading water quality. The plants extract these waste products as nutrients essential for plant growth; this process cleans the water and allows it to be recycled and reused. The multiple reuse of water allows the business to flourish while preserving one of our most precious and declining natural resources – water.

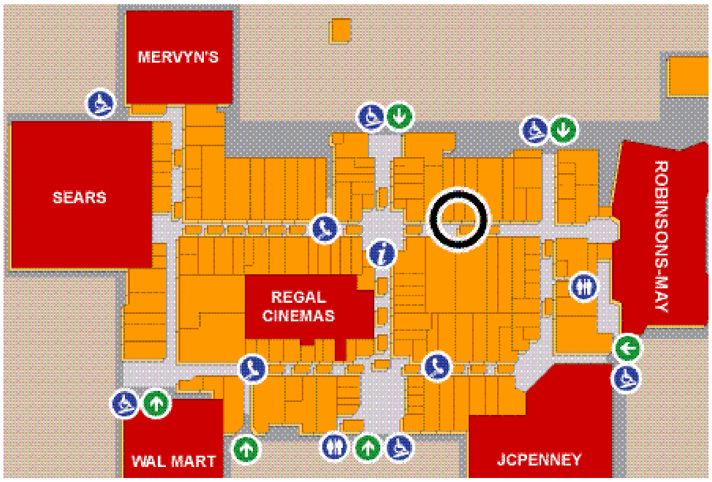
Now, in addition to the production of fish, alligators, turtles, bamboo, watercress and other plants and animals, Colorado Gators attracts a stream of tourists. Of course, they are attracted by alligators in Colorado, but also by the opportunity to see the basic principles of a SEED Park. Discard nothing, recycle it all; our future depends upon it.




Unused agricultural byproducts provide the resources to move to renewable energy, to create jobs, to reduce imports, and to improve life for our children and their children. A SEED Park can be part of the answer. Look within your community for resources now going to waste, to the landfill, or accumulating in piles, as cattle manure and automobile tires often do. These are all resources we can use. If we can restructure our production, manufacturing, wastewater treatment, disposal of municipal solid waste, energy production and energy consumption, then we can improve our world both environmentally and economically.

The San Luis Valley Resource Conservation and Development is pursuing grants to determine if a SEED Park is one way to make economic improvements while being environmentally conscience. The question, is now the time to build a sustainable environmental and economic development park, a SEED Park? Will the first commercially developed, fully integrated SEED Park be in your community? As the study develops conclusions, and if the SEED Park concept is appropriate for the San Luis Valley, the process of how to make it work for the San Luis Valley will become evident.

**Building a SEED Park: Part I – Business Mix**




A SEED Park is an agricultural or natural resource-based complex featuring Sustainable Environmental and Economic Development. Building such a park requires at least the same level of planning and selection as that required to build a shopping mall. A shopping mall typically has two major types of stores – the large, anchor stores such as Sears, Dillard's, Macy's and J.C. Penney, and the smaller specialty stores such as Zales Jewelers, Hallmark Cards, the Nature Shop, and fast food outlets in the food court.

By comparison, a SEED Park must have at least one large anchor operator, such as a dairy, a forestry products industry, an electrical power plant, or a cattle feedlot. This large facility becomes the core operation around which all other businesses are centered. The secondary businesses could include fish farms, organically grown produce, aquatic ornamental plants, or even a butterfly ranch.

Think about all the specialty items on the market and their relative value. Rare and non-essential items are usually priced high, but are targeted to only a small sector of our communities. Essential items, such as basic foods, have a broad market with (by comparison to specialty items) low prices.

The challenge to developing a successful SEED Park is to select the right mix of natural resource-based businesses. Let's examine some of the possible scenarios. A dairy and a series of greenhouses are a quite compatible mix. However, today's dairies are rather large with thousands of cows and are frequently located in the region of a cheese plant. How would milk and cheese produced in the San Luis Valley compete with dairy products from Eastern New Mexico, or West Texas? There would have to be some advantage, either in reduced transportation or a difference in quality. For example, goat milk, goat cheese, soap, lotions, and candles made from goat-based products are very expensive, as compared to similar products made from cow's milk. The goat-based products are specialty items, whereas similar products derived from cow's milk are commodity items. The byproducts from a dairy operation are manure and nutrient-rich water. Both of these byproducts can be used in a greenhouse operation. The nutrient-rich water provides both water and fertilizer for plants. The solids from the manure could also be burned directly for heat, or gasified to yield carbon monoxide (CO) and hydrogen (H) as combustible gases.

Another key anchor business could be a poultry farm. Many poultry operations are located in Arkansas, East Texas, and other areas of the South. Poultry farms apparently do well in those regions, yet must contend with the high humidity and the high heat of summer. The high temperature is especially problematical to large fowl such as tom turkeys. The large, 40+ lb birds cannot easily expel body heat as do smaller birds. The San Luis Valley, with its low humidity and low night-time summer temperature could be very attractive for the production of tom turkeys.

The low winter temperature of the San Luis Valley is another asset. Specially designed houses could be constructed to produce ice at a very low cost during the winter. The ice could then be stored to cool poultry houses as needed during the summer. The ice could also be used to cool vegetables and produce in shipment originating in the San Luis Valley or even those in transit from California to the East.

NOTES

**Building a SEED Park: Part II -- Energy**

In Part I of this series a SEED Park, a Sustainable Environmental and Economic Development Park, was defined and building it was compared to building a shopping mall. The SEED Park will be centered around some major agricultural- or natural-resource-based industry. A SEED Park will require energy, but could also be a producer of energy. To understand the role of energy in a SEED Park, let's examine the sources of energy.

With the exception of nuclear, geothermal and tidal energy, all energy on earth is derived from the sun. We see energy from the sun as light and feel the warmth. Through photosynthesis, plants have been capturing solar energy and converting it to sugar since the earliest days of the earth. The plant cells have used the energy in the sugar to drive the cellular machinery to produce all other organic materials. Over geologic time, the deposition of plant material, primarily marine algae, produced coal, oil and gas. Today we extract these non-renewable fuels to provide the bulk of the energy upon which society depends.

> "new clean energy technologies present the same kind of transformative opportunity in the 21st century as the digital revolution provided in the second half of the 20th…"
>
> Sen. Ken Salazar and Timothy Wirth, Jan. 2006

We recognize wind, solar and biomass as renewable forms of energy, but all of these are forms of energy from the sun. Wind results from sunlight heating the oceans and the atmosphere. Hot air expands and rises; cold air contracts and falls. Movement of the air through this heating, cooling, expansion and contraction produces the wind. When turbines are used to capture the energy from the wind and to produce electricity, the turbines are actually capturing energy from the sun stored as heat in the oceans and the atmosphere.

Today, solar energy can be captured by photovoltaic cells and converted to electricity. This form of renewable energy is available only during the daylight hours. Solar energy is more readily available at high altitudes where the atmosphere is thinner, sunlight is stronger, and cloud cover is minimal. The San Luis Valley is an excellent location for capturing solar energy through photovoltaic cells.

Biomass is the source of the third form of renewable energy. Plants capture and convert solar energy to organic materials including wood, straw, and other biomass products. Wood is used worldwide as a major source of energy for heating homes and for cooking. At the industrial level, wood, in the form of forestry residues, is used as a fuel to produce steam from water; the steam is then used to turn turbines for production of electricity. Agricultural residues including corn stalks, wheat straw and animal manure are used as forms of renewable energy. The offal and by-products from slaughter houses and animal processing plants include oils and fats, both of which are very high in energy. These have been combusted directly to extract energy, but today they are also being converted into biodiesel as fuel for transportation. Biodiesel is now being produced in many locations and could be one product of the SEED Park.

> **Wood Chips – for heat –**
>
> $31,000 worth of wood chips replaced heat provided by $400,000 in electrical costs
>
> **Annual Operation Savings of:**
> **$400,000 - $31,000 = $369,000**
>
> **Mount Wachusett Community College, MA**

> **Global consumption of food**
> **380g/person/day**
>
> **Global consumption of wood**
> **1,800g/person/day**

Nuclear energy is being used to propel submarines, power some satellites, and to produce electricity. Following the accidents at Three-Mile Island and at Chernobyl, the world is acutely aware of the risks posed by nuclear energy were an accident to occur. Of current national and international news is the global threat of terrorists to obtain weapon-grade plutonium. France is one country that has successfully embraced nuclear power to produce a major portion of its electrical energy. Other countries, including the US, are awaiting development of a new generation of safer, low risk nuclear power plants before developing nuclear energy as a major supplier of electricity.

Geothermal energy is readily available from geothermal wells in the San Luis Valley. This energy is being used to heat greenhouses and to provide the warm water necessary for tilapia and alligators. Geothermal energy can be tapped to provide household heating and, where temperatures are sufficiently high, to drive stream turbines to produce electricity. Geothermal energy could be a component of a SEED Park in the San Luis Valley.

Tidal energy is a renewable form of energy waiting to be tapped. The gravitational system of the sun, the moon and the earth produces the tides. Prototypes systems have been designed to capture the energy from the tides to produce electricity. The harsh environment of the ocean, and high capital costs, have limited interest in commercialization of tidal energy. Being miles from the coast, tidal energy will be unavailable within the San Luis Valley.

People power, manual labor and animal power are indirect forms of sun power. All people and animals require food as fuel, and their energy is derived from the food. Food is basically plants, or plants fed to animals to produce meat. The energy in food is ultimately derived from the sun and is a form of renewable energy. Manpower, people power, will be a key component of a SEED Park producing jobs in the San Luis Valley.

The Mid-West has been described as the bread-basket of the world. Using today's technology and practices, every product (including wheat, corn, beef, dairy, and ethanol) requires both water and energy at unsustainable levels.

Fossil fuels are available in a limited supply and prices increase as supply declines. Ethanol is one form of renewable energy. Energy crops such as switch grass, or corn for the conversion into ethanol require considerable tracts of land and other resources to produce a significant amount of energy. These other resources include machinery, fuel, water, transportation, processing facilities, labor, and cooperative weather. Will crops be grown for food or for energy? Cattle feeders, swine producers, and poultry producers have seen the price of animal feeds increase as corn has been directed into the ethanol market. There is, however, another source of biomass that is growing annually in quantity and does not compete with the production of food.

The quantities of municipal solid waste (MSW) and the sludge produced from the treatment of wastewater is growing annually. As the world population increases and becomes even more urbanized, MSW increases. MSW and other biomass must be recycled to capture energy and produce organic products. Also, opportunities to capture solar energy will be required to move the world from fossil fuels to sustainable renewable energy. The San Luis Valley SEED Park can be a shining example demonstrating these processes.

**Building a SEED Park: Part III -- Recycling**

In Part II of this series we explored the sources of energy and distinguished between non-renewable and renewable supplies. Biomass in the form of municipal solid waste (MSW) and the sludge produced by wastewater treatment plants was identified as a renewable energy source which is expanding even more rapidly than the population growth.

On average, each person in the US produces about 4.5 lbs of MSW/day. In Colorado, the per capita waste production was 1.7 lbs/day in 2006. If individual production of MSW remains constant as the population grows, the volume of MSW produced annually will double by 2050, if not by 2030. MSW and sludge are the only sources of biomass that expand unintentionally as the population grows.

What's in MSW? Typically, about 40 to 60% is organic and the remainder is inorganic. Organic constituents include wood, paper, food wastes, fabrics, plastics, and even the tar component of asphalt. Organics, by definition, contain the element carbon. All products made from petroleum are actually organic. Plastics made from petroleum won't necessarily decompose to produce compost, but with time and exposure to ultraviolet sunlight and heat, plastics will eventually break down to final end products of carbon dioxide and water. Similarly coal and even diamonds are organic in origin and certainly won't make good compost.

The renewable organics such as wood, paper, food waste, and agricultural residues will make compost. These organics can also be blended with sludge to produce high-grade compost. Two cities in the US, Pinetop, AZ and Sevierville, TN, now combine MSW and sludge to produce compost. Vancouver, Canada has a very large operation to produce compost from MSW and sludge. The benefits of these operations include minimizing the load of landfills, extracting value from waste, producing a product for both agricultural and horticultural use and is, in many cases, minimizing trips, and therefore transportation costs, to landfills.

In 2005, US residents, businesses and institutions produced over 245 million tons of MSW, or about 4.5 lbs of waste per person per day. By comparison, MSW per person was only 2.7 lbs per day in 1960 and the total quantity generated in the US was only just over 88 million tons. The total volume generated doubled in just about 30 years. The bulk of the waste is paper, followed by yard trimmings and plastics (Figure 1).

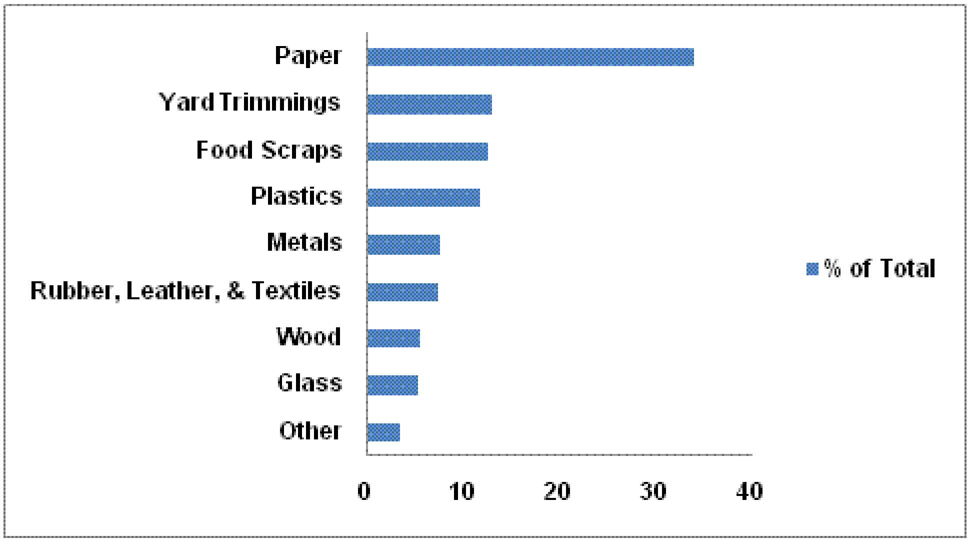



Figure 1. 2006 Total Waste Generation - 251 Million Tons (before recycling). Source: [www.epa.gov/msw/facts.htm](www.epa.gov/msw/facts.htm)

The rate of recycling has increased from about 6.4% in 1960 to 32.1% in 2005. Auto batteries have a recycling rate of 99% with the next highest rate of 62% for steel cans. Yard trimmings are recycled at 61.9% and paper at 50%. All other components of MSW are recycled at less than 50% (Figure 2).

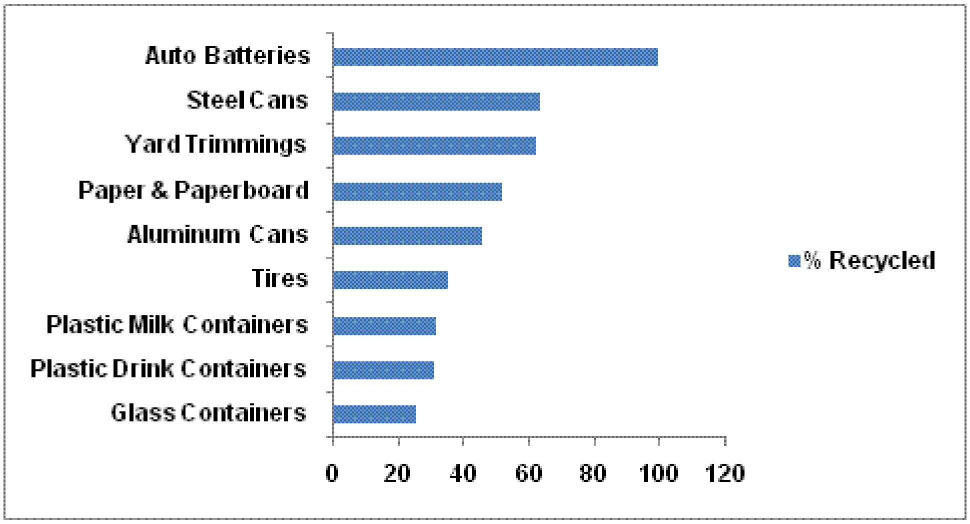



Figure 2. Recycling Rates of Selected Materials. Source: www.epa.gov/msw/facts.htm

These figures and data obtained from EPA reflect only MSW and do not include construction and demolition debris, agricultural residues, forestry residues, petroleum contaminated soil, coal combustion ash and other similar large volume wastes.

By comparison to the US, Colorado produced over 8.2 million tons of wastes in 2006 – up from 4.7 million tons in 1995. The solid waste user fee has remained about constant over this period, being $3.2 million in 1995 and increasing to only $3.7 million in 2006. An additional cost not reflected in these figures has been the increasing reliance on foreign oil used to fuel trucks transporting solids to the landfills.

The inorganics such as metals, stone and concrete can be reclaimed and recycled. Today the aluminum in cans is recycled about seven times per year. In some areas, used tires are recycled into rubber mats and even constituents of road surface materials. Stone, concrete, asphalt, bricks and other inorganics are recycled into paving materials. Glass is recycled to make more glass and is also crushed to produce a mulch used in landscaping. Ferrous materials, such as tin cans, steel and iron are easily reclaimed and recycled. Electronic components contain a variety of high-value metals and components such as antimony, arsenic, copper, cadmium, lead, zinc and tantalum. Many of these elements are hazardous and others are of very high value, both monetarily and environmentally. For example, the metal tantalum, derived from columbite-tantalite ore, is mined in Africa…destroying the habitat of the mountain gorilla. Recycling cell phones, of which there are 500 million in the US, with 100 million new ones added annually, reduces the demand for columbite-tantalite ore and helps preserve gorilla habitat. Tantalum is also used in DVD players, computers, and game consoles.

Dickson Despommier, a microbiologist at Columbia University, has proposed recycling on a grand scale. He has proposed urban farms to be located in skyscrapers. These urban farms could supply the food needs for 50,000 people consuming 2,000 calories/day. He proposed to use sewage water and a series of hydroponic plants to extract nutrients, producing clean water, fruits and vegetables. Additional high-quality water could be captured by condensing water vapor placed in the atmosphere by evapotranspiration of plants. This volume of water collected from each urban farm would supply the needs of 50,000 people.

**Building a SEED Park: Part IV – Biomass**

Biomass is defined as the product of photosynthesis in plants or the products produced by consuming plants, i.e. animals, microorganisms and fungi. Biomass is organic and composed principally of carbon, hydrogen, and oxygen with lesser quantities of nitrogen, sulfur, calcium, phosphorous, potassium, iron and trace elements. We are organic; our food is organic; trees, flowers, grass, corn, milk and even paper are all organic. Organic materials are biomass.

The elements of biomass, especially the carbon, hydrogen, and nitrogen are of great value. Approximately 238 million tons of municipal solid waste, 70% of which is biomass, is generated annually in landfills in the US. Additionally, agricultural, forest industry residues, and energy crops could produce another 512 million dry tons of biomass annually. Some of this biomass is now returned to croplands as fertilizer, other quantities are burned for energy, buried in landfills or discharged into streams and rivers as runoff from the agricultural and forest-based industries. Ground water and surface waters are both degraded by decomposition products of biomass.


**A delegation from the San Luis Valley visited Pinetop, AZ to examine a wastewater treatment facility combining sludge and municipal solid waste into compost.**

In the wonderful design of nature, what we and all animals use for food is what plants produce. Through a process called photosynthesis, plants use the energy of the sun to convert carbon dioxide, water and fertilizer into plant materials including sugars, proteins, oils, vitamins, and other products while releasing oxygen into the atmosphere. We, and all animals, inhale oxygen and exhale carbon dioxide. The waste products, urine and manure, excreted by animals are the fertilizers required by plants for growth. In this wonderful relationship, animals, and humans, need plants and plants need animals and us.

The liquid waste for animals is high in ammonia, $NH_3$. Bacteria convert the ammonia into nitrate and we commonly use ammonium nitrate ($NH_3$-$NO_3$) and other forms of ammonia including urea and anhydrous ammonia to fertilize plants. Compost is organic fertilizer produced from biomass. Waste materials such as leaves, grass, wood shavings, manures, scrap food, etc. are converted by bacteria and fungi into compost. Applied to plants as fertilizer, compost has value. Compost piles typically operate at about 170°F and can be a source of heat extracted to heat greenhouses or other industrial purposes.

**Mark Heberer, of the Pinetop-Lakeside Sanitation District, explains operation of the equipment at the composting facility in Pinetop, AZ.**

Some municipalities use earthworms, or vermiculture, to digest organics and produce high-value compost commonly called worm castings, or vermipost. The worm castings typically have a higher value than do the worms. However, worms have value as protein, as an ingredient in fish feed, as bait for sport fishing, or as live food items for the pet trade.

Municipal solid waste (MSW), more commonly known as garbage and trash, typically contains about 60% organic material, or biomass. Municipal waste water treatment plants also produce biomass in the form of sewage sludge, sometimes referred to as biosolids. To this author's knowledge, only two locations in the US (Pinetop, AZ and Pigeon Forge, TN) combine MSW and sludge to produce compost. Other municipalities truck all MSW and sludge to landfills.

A SEED Park could derive both compost and energy from biomass, including MSW, sewage sludge, agricultural residues and forest industry residues. These residues could be converted into compost or burned as fuel; however, those choices would provide the lowest economic and environmental return. As biomass is fermented it is broken down by microorganisms producing methane gas and carbon dioxide. Methane gas can be converted to methanol, a liquid form of energy similar to ethanol, gasification of biomass uses heat and a restricted amount of oxygen to product carbon monoxide (CO), hydrogen and other gases. These gases can be converted into a series of synthetic fuels, or other high-value organic compounds. Both methane and the products of biomass gasification can be used to produce hydrogen for energy and convert the carbon into other reusable products.

# NOTES

**Building a SEED Park: Part V – Water**

A Sustainable Environmental and Economic Development Park, SEED Park, will require water to operate. Water will be required for primary production (plants), for secondary production (animals, including fish), for processing of products, for heating and cooling, and for domestic use. The San Luis Valley is blessed with an abundance of ground water, including geothermal water, but is extremely short of rainfall with only 7 inches/year. A SEED Park could recycle wastewater, the nutrient-rich discharge from wastewater treatment plants, runoff from animal feeding operations, and discharges from on-site processing operations. Additionally, many industrial processes such as the production of electrical energy from fossil fuels and the processing of corn into ethanol, exhaust heat into the atmosphere by evaporation of water. Condensation of water vapor yields distilled water. Also, internal-combustion engines fueled by hydrogen produce water vapor as the only exhaust emission. Condensation of this water vapor could be another source of distilled water.

If we compare the intrinsic value of water to that of petroleum fuels, water is much more valuable. Today, the world uses about 1.3 trillion gallons of oil per year, but we use 3.9 trillion gallons of water each day. In the US, each person uses an average of 176 gallons of water per day. Compare that to water availability in Africa where the average is only 5 gallons per family per day. There is no substitute for water. There are many substitutes for energy and, especially, fossil fuels.

Most of the ground water withdrawn annually in the United States is used to support irrigated crops and is the life-blood of rural America today. The growing urban population, and the political power therein, is diverting water from rural American to urban areas. Rural America must find ways to use water more efficiently. For example, Peter Doyle of New Zealand has calculated that every $100 worth of rice produced requires 196,263 gallons of water. One hundred dollars worth of cotton requires 42,105 gallons of water; for beef cattle, the figure is 21,368 gallons. However, hydroponic production of fruits and vegetables requires only 158 gallons of water to produce $100 worth of produce. Water requirements for producing $100 worth of crops in the San Luis Valley, and perhaps much of the US, are probably similar to those of New Zealand.

Jim Bordovsky, Texas Agricultural Experiment Station-Plainview, TX, has conducted research trials documenting yield of corn, sorghum, picker cotton and stripper cotton as influence by the amount of water applied to the cropland. Within the range tested, yields typically increased with increasing amounts of water. A yield of corn at 10,000 lb/A required about 27 inches of water, but increasing water to about 38 inches increased yield to about 12,500 lb/A. Water applied at to sorghum at about 25 inches annually produced a yield of about 7500 lb/A. Twenty-five inches of water produced a yield of picker cotton lint of about 1,700 lb/A whereas, with stripper cotton, the yield was only about 1,200 lb/A.

**Water Requirements for Crops**
**Southern High Plains of TX**

| | $H_2O$ (gal)/$100 |
|---|---|
| Cotton (stripper) | 106,396 |
| Corn | 102,390 |
| Sorghum | 81,004 |
| Cotton (picker) | 76,085 |

*Based on data from Jim Bordovsky, TX Ag. Exp. Station-Plainview, TX

Ethanol plants, dairies, and confined animal feeding operations, such as cattle feedlots, swine production facilities and large poultry operations are visible components of big-time corporate farms. Many small, rural towns seek to attract these operations to secure jobs and increase the local tax base. The operations are dependent upon an adequate supply of dependable water. How much water is required to support these operations?

Consider milk – every gallon of milk requires about 38,684 gallons of water for the production process. That includes water for the cows to drink, water to clean equipment, cool the milk, and to flush out the manure and urine from the barns. That figure

**Water into Energy**

**1.8 gal ETOH = 1 gal gasoline**
**2,398 gal H2O = 1.8 gal ETOH**

**therefore**
**2,398 gal H2O = 1 gal Gasoline**

It requires nearly 2,400 gallons of water to produce ethanol with the energy equivalent of 1 gallon of gasoline.

does not include the water required to produce the feed crops supplied to the cows.

At this time, ethanol appears to be the economic engine of focus to produce renewable fuels. How much water does it take to produce ethanol with the energy equivalent of one gallon of gas? It takes about 1.8 gallons of ethanol to yield the energy equivalent of one gallon of gasoline. A bushel of corn will produce about 2.3 gallons of ethanol, but takes about 3,000 gallons of water to produce 1 bushel of corn. Once the corn is in the ethanol plant, another 13 gallons of water are required to convert a bushel of corn to 2.3 gallons of ethanol. On a per-gallon basis, 1.8 gallons of ethanol requires 2,398 gallons of water to produce the energy equivalent to 1 gallon of gasoline.

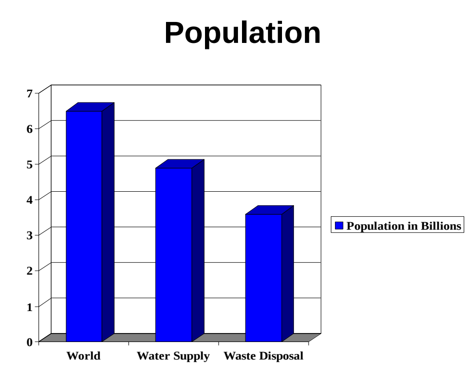
The San Luis Valley does not overlay the Ogallala aquifer, but parts of Eastern Colorado and seven other states do. Pumping of irrigation water from the Ogallala aquifer began around 1940. Water in the Ogallala represents an accumulation of over 100,000 years. In 67 years, the water in some areas has been drawn down to one half of the 1940 level. In some other areas, irrigation from the Ogallala is economically unfeasible today due to the depletion of the ground-water. Water pumpage from the Ogallala Aquifer (about 12 billion $m^3$/yr) is equal to the flow of 18 Colorado Rivers. As water levels in the Ogallala are drawn down, as the population grows, and with global warming there will be increasing pressures to move water from the San Luis Valley to outside the Valley. How much longer can we pump ground water at the present rate without jeopardizing adequate supplies for the future? Water use throughout the world has increased as the population has increased. Today nearly 25% of the world's population does not have a dependable water supply. Nearly 3 billion people in the world, or almost half of the people in the world, do not have a latrine and certainly not a toilet.

**Ogallala Aquifer**

**Depleted at 12 billion $m^3$/yr = the flow of**

**18 Colorado Rivers**

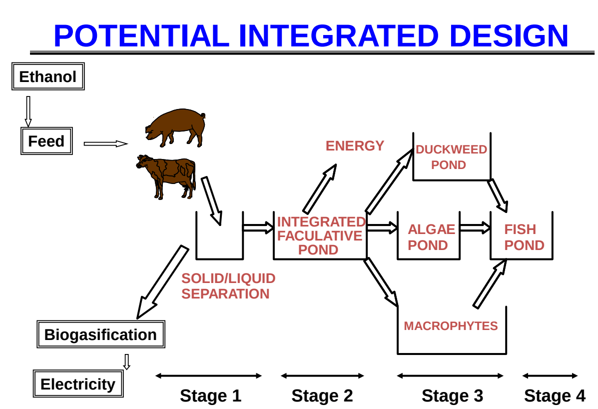
Water withdrawal from the Ogallala Aquifer is at a rate far greater than that of the annual recharge.




Over 1 billion people in the world do not have a dependable supply of water and 2.9 billion do not even have latrines or toilets for waste disposal.

Residents of the San Luis Valley are blessed with water and have fought diligently to keep water in the valley. As the supply of water decreases and its value increases, some may be inclined to sell water for transport out of the Valley. As water is pumped out of the Valley along with it goes the social fabric of the Valley. Water within the Valley is essential for jobs, for agriculture, industry, domestic use, population stability and potential growth. These commercial activities are essential to support the social fabric of communities, including schools, hospitals, government, merchants, parks, and highways. A SEED Park is one way to derive local value from the water resources and retain the social fabric of the Valley.

Making the most of water resources is both environmentally and economically the right thing to do. In a SEED Park, the waste stream, including nutrient-rich water, is discharged from one operation to become a major input in the next downstream operation. For example, water discharged from a dairy, a feedlot, or a city is rich in nitrogen and other nutrients. This stream of water containing waste materials including ammonia, or other forms of nitrogen, phosphorus and potassium is liquid fertilizer available to support plant growth. Runoff from the plants can be used to support production of fish, alligators, snails, or other



aquatic-based organisms. Discharge from these cold-blooded animals contain no coliform bacteria and, therefore, can be used to support food crops such as herbs, vegetables, and other produce.

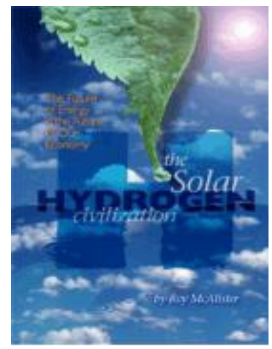
A SEED Park can have a series of natural resource-based businesses recycling one of our most precious resources – water. I'm sure that you can think of many other opportunities for water conservation and recycling.

# NOTES

**Building a SEED Park: Part VI – Solar Hydrogen**

With the exception of nuclear and geothermal, all forms of energy are ultimately derived from the sun. Petroleum, coal and biomass are all forms of solar energy captured by plants through photosynthesis. Biomass and these fossil fuels are composed principally of carbon, hydrogen, nitrogen and oxygen.

When fossil fuels and biomass are burned for energy, the carbon is converted into carbon dioxide and lost to the atmosphere. The hydrogen is combined with oxygen to produce water vapor and is similarly discharged to the atmosphere.



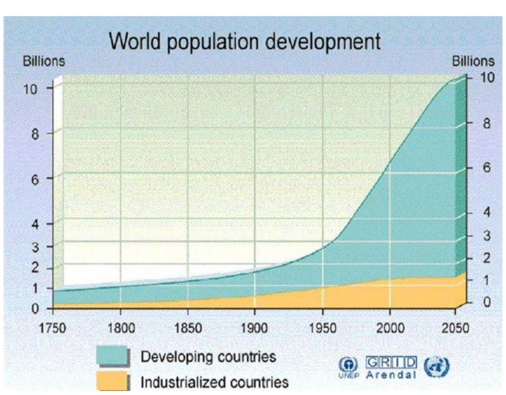

An alternative use of fossil fuels and biomass would be to convert them into gases that can be synthesized into an array of organic products, including plastics, polymers, and carbon fibers. Refineries today produce a series of petroleum-based products, including plastic bottles for beverages and water. Bio-refineries could produce a similar line of products from biomass. The book "The Solar-Hydrogen Civilization" by Roy McAlister provides a view of a solar-hydrogen-based economy.

The San Luis Valley is home to one of the largest (if not the largest) photovoltaic array in the US. Electricity produced by photovoltaics can be used on-site, delivered to off-site users via the electrical power grid or stored in batteries or capacitors. An alternative method of power storage is through production of hydrogen and oxygen gases from electrolysis of water. Hydrogen and oxygen gases can be recombined in a fuel cell to produce electricity and water. Each conversion of energy from one form into another, for example from photovoltaic electric power to hydrogen and from hydrogen back to electrical power, introduces new inefficiencies, yet still provides a way of capturing the energy of sunlight and using it when the sunlight is unavailable. Electricity produced from wind power can similarly be used to produce hydrogen and, therefore, store energy.

Hydrogen can be pressurized, stored in tanks and used as fuel for internal combustion engines. Alternately, hydrogen can be added to liquid fossil fuels to increase energy content of diesel, biodiesel or gasoline.

The exhaust emissions of internal combustion engines operating solely on hydrogen fuel are cleaner than the air taken into the engine. The only emission from hydrogen-fueled engines is water vapor. Condensing this vapor produces distilled water.

Many people often have negative feelings about hydrogen based on perceptions regarding the Hindenberg blimp, the difficulty of transport, the fear of explosions, etc. First, some steel tanks built before, or shortly after, 1900 to store hydrogen at 2000 psi are still being safely used today. The carbon fiber tanks of today safely store hydrogen in excess of 20,000 psi. In the event of an accident and release of hydrogen, it would dissipate up and into the atmosphere, presenting far less danger than a spill of gasoline flowing down and across the ground. Unquestionably, the hydrogen in the Hindenberg burned, but the cause of the fire is believed to be the highly flammable coating on the outside of the blimp that initiated the blaze.




With all of the concerns for the safety and the perceived problems with hydrogen, why do we now consider hydrogen as a fuel? We only need to look at the global supply and use of fossil fuels to see the critical need for a sustainable energy supply. As the global human population has increased from 1 billion in 1810, to 3 billion in 1960, to 6 billion in 2000, and a projected 10 billion in 2050, the world's demand for fuels has increased accordingly. In one year, the world today consumes the fossil fuels deposited over a 1-million year period. The world's known oil reserves are estimated to be

866 billion barrels, of which over 75% are held by OPEC members. The US has only 22 billion barrels of oil, or 2.5% of known oil reserves. The world demand for transportation has doubled every decade since 1900. Clearly, the world cannot continue on its present course of increasing consumption of non-renewable fuels.

Hydrogen is a renewable fuel resource. It can, and most likely will, be used as a fuel for transportation. The annual US subsidies for fossil fuels are estimated to be $26 billion/yr and for nuclear power to be $19 billion/yr. The true cost of gasoline, when the energy subsidies are factored in, was $5.50/gal before the Iraq war, and $11/gal since the Iraq war. These calculations were based on oil at about $60/barrel and not the current $90+/barrel of today. Hydrogen could be used on-site as fuel for internal combustion engines at the San Luis Valley SEED Park. On-site use of hydrogen would offer an educational demonstration, reduce the SEED Park's dependency on fossil fuels and provide an opportunity to refine and mature the hydrogen technology.

**Building a SEED Park: Part VII – Hydroponic Production**

In the arid parts of the world, it seems strange to speak of cultivating plants in water or hydroponics. This culture technique can, however, be much more conservative of water than are traditional croplands. In "Water", Part V of this series of articles, figures were provided for the water requirements of various agricultural crops and products. These figures were from Mr. Peter Doyle and based on data from New Zealand. Let's now consider the San Luis Valley.

Merlon A. Dillon, Area Extension Agent – Agronomy, provided data obtained from the Colorado Agricultural Statistics for 2006 for the major crops of the San Luis Valley. These data included crop yield (bushels or tons/acre) and production value per acre. Mr. Dillon also provided data on water requirements for these same crops. These three sets of figures were then used to calculate the gallons of water required to produce $100 worth of spring wheat, spring barley, alfalfa hay, fall potatoes, spinach, lettuce, and carrots.

| San Luis Valley Crops | | |
|---|---|---|
| | Water/A (gal) | Gal/$100 |
| Alfalfa Hay '05 | 749,406 | 187,821 |
| Spring Wheat '05 | 553,908 | 180,426 |
| Spring Barley '05 | 456,160 | 100,920 |
| Spinach '03 | 325,829 | 12,398 |
| Fall Potatoes '05 | 390,994 | 11,409 |
| Lettuce '05 | 325,829 | 7,670 |
| Carrots '04 | 325,829 | 4,973 |

*__Merlon Dillon, Extension Agent__

The most water-efficient crops growing in the San Luis Valley are carrots, lettuce and potatoes. Even as efficient as these crops are, they are still inefficient as compared to hydroponic production, which uses only 158 gallons of water to yield $100 worth of produce.

| Water for AG Products* | |
|---|---|
| **Product** | **Gallons of water/$100 output** |
| Rice in the husk | 196,263 |
| Seed Cotton | 42,105 |
| Dairy & whole milk | 38,684 |
| Sugar cane | 32,368 |
| Beef cattle | 21,368 |
| Vegetables & fruit | 9,974 |
| Wheat & grains | 6,710 |
| Hydroponic vegetables | 158 |

***Peter Doyle, New Zealand. 2006.**

What's required for hydroponic production? One doesn't need big tractors and big fields, but one could use large greenhouses and barriers or containers to control the flow and dispersion of water. Some hydroponic plants are produced with their roots submerged in water, whereas others are grown using the nutrient film technique (NFT). With NFT systems the roots are kept moist, but not flooded in water. For demonstration, Disneyworld's pavilion "The Land" has plants suspended from overhead containers on a moving track that passes through a spray of nutrient-rich water. The roots are in the air.

In commercial-level NFT systems, plants are commonly maintained in plastic containers or troughs and the roots are kept moist by cyclical flooding. Many plants that would not survive with their roots flooded do very well when briefly flooded and then exposed to air as the water drains away.

In an arid environment, getting rid of nutrient-rich water discharged from feedlots, dairies, meat processing plants, or from municipal wastewater treatment plants is sometimes as difficult as finding fresh water. Nutrient-rich discharges typically contain various levels of nitrogen and phosphorous. These nutrients that threaten quality of ground and surface water are the same nutrients farmers buy and apply to croplands as fertilizers.

Nutrient-rich effluents can be used in hydroponic culture to produce plants destined for the ornamental, energy, or fiber markets. Hydroponic plants will remove the nutrients, cleaning the water in the process, producing both and additional crop and the opportunity to further recycle the water. Water never wears out; it just gets dirty. Hydroponics is a method of maximizing production from limited resources.

What are some of the plants one could produce hydroponically? High-value plants are those that people want – not those that they must have. For example, organic produce is typically priced higher than is non-organically grown produce.

One fish producer in Oklahoma used nutrient-rich effluent from a tilapia tank to grow chives hydroponically. His chives were marketed by contract at over $5/lb throughout the year. Chives available from typical farm production were very seasonal and the price plummeted to about $0.10/lb when harvest was at its peak. Furthermore, the chives produced hydroponically were crisp and had a shelf life of about 2 weeks, as compared to the 2 to 3-day shelf life for field grown chives.

Lettuce, spinach, water cress, and even melons have been grown hydroponically. Some ornamental plants are produced hydroponically in to provide larger, more vigorous plants for springtime planting. Texas Tech University, has recently reported annual production of 58 tons (dry weight)/acre for water hyacinth grown in a greenhouse in water with levels of nutrients similar to that in discharges from wastewater treatment plants. This quantity of water hyacinth could yield 158 kWh if converted into methane by anaerobic digestion. Hydroponic systems producing energy plants, or algae containing oils, for biodiesel production yield not only a high-value crop, but also a cleaner effluent.

South of the San Luis Valley and just north of Taos, NM there is a group of homes known as earthships. These structures are built with south-facing windows and earth-bermed north walls. Many of these homes are energy and water self-sufficient. They generate their own power, via solar and wind, and capture all precipitation from the roofs. Water is cycled and recycled through hydroponic plants and sub-surface flowconstructed wetlands. The individuals in the earthships are proving today that hydroponic culture is economically viable.

Many fish production facilities, such as Colorado Gators in the San Luis Valley, employ hydroponic plants to extract nutrients. Removing nutrients from the water allows the water to be recycled for multiple times, increasing production of both fish and plants.

**Building a SEED Park: Part VIII – Aquaculture**

Aquaculture, or fish farming, seems to be a strange industry to find in an arid part of the world. However, the geothermal water available in the San Luis Valley, or from power plants, makes aquaculture of warm water species, such as tilapia, economically feasible. Water, feed and oxygen are the three major ingredients required for fish culture. All requirements for fish culture are available in the Mid-West and can be available in the San Luis Valley.

Tilapia

Tilapia are one of the most widely cultivated fish in the world, they are grown in the San Luis Valley and shipped live to primarily specialty markets in Colorado.

One might wonder "where's the demand for aquaculture products"? The demand is world-wide, but the local demand in Colorado is for fresh, live fish in the Denver and surrounding markets. The demand is also there for hobby fish to support the aquarium trade. However, on the global scale the demand for fish is huge.

The global supply of fish from fishing fleets and aquaculture was 132.5 million tons in 2003. Harvests from the wild were 77.7 million tons and from aquaculture 54.8 million tons, or 41% of the total world supply. Of the approximately 30,000 species of fish, only about 1,000 species are marketed as food fish. Only about four types of fish (Pollack, anchovies, bluefin tuna, and jack mackerel) produce about 13% of the global wild catch. Aquaculture is based on production of 10 species, of which the major ones are carp, tilapia, catfish, and salmon.

Fish are rather efficient at converting dry feed into weight gain. Many fish can put on 1 pound of weight after consuming 2 pounds of dry feed – a 2:1 feed:weight-gain conversion factor. Warm-blooded animals, such as poultry, swine, and cattle are far less efficient at feed conversion.

At a 2:1 feed conversion rate, the 54.8 million tons of fish produced by aquaculture in 2003 required nearly 110 million tons of feed. Much of the feed contains soy, wheat, corn and other grains produced in the Bread Basket of the US are shipped from the US around the world to be formulated into fish feed. Fish feed could be locally produced using the wet grain (corn and grain sorghum) from ethanol plants, plus any dry soy and other ingredients, and the waste heat from the ethanol plant. Converting stillage into a high-value fish feed manufactured in the US should be more economical than drying distillers' grain and shipping US ingredients around the world for manufacture abroad.

Fish supplies nearly 30% of the protein for about 1 billion people. Asians consume far more fish per capita than do non-Asians. The US is both the world's greatest importer and the world's greatest exporters of fish and fish products.

A local example within the San Luis Valley, Colorado Aquaculture (co-located with Colorado Gators) is currently producing tilapia in the San Luis Valley to supply markets in Denver and other places. The demand for live fish in the large urban markets is primarily to meet the demand of Asian residents.

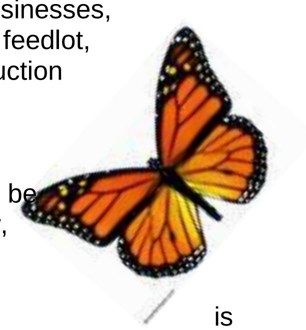
The demand for hobby fish and sport fish is also huge. Attractive fish such as koi have sold for hundreds to thousands of dollars ($250,000 in Japan for one white koi with a red dot on its head resembling the Japanese flag). In this country, fish that people desire for display command far higher prices than do fish for the food market.

Sport fish such as largemouth bass, bluegill and trout have sold for hundreds of dollars as trophy fish. It's not uncommon today to find tanks of fish in shopping malls, at boat shows, or at sporting goods stores to provide on-site fishing for potential customers. It's a reflection of our time that some people never have the time to go fishing, but have the dollars to bring fishing to them. Aquaculture in the San Luis Valley can support the food industry, the hobby market, and tourism.

**NOTES**

**Building a SEED Park: Part IX – Butterfly Ranch (Specialty products)**

The first in this series of articles compared building a SEED Park, a Sustainable Environmental and Economic Development Park, to building a shopping mall. The mall has a series of major retailers, or anchor stores. A SEED Park must have a series of primary businesses, or anchor businesses, around which secondary businesses are structured. The easiest example might be a feedlot, dairy, or ethanol plant as the primary business around which greenhouses, fish production facilities, or even a butterfly ranch are placed.



These secondary businesses can each have a revenue stream adequate to provide products for small niche markets. An example of one such secondary business could be goats for milk, cheese, soap and lotion. The market for these products is very narrow, but such operations do exist and support multi-generational families.

A rabbit production facility could be another secondary business. Again, the market is narrow, but specialty items include rabbits for the pet trade, rabbits for the food market, rabbit skins and even rabbit manure. As warm-blooded animals, rabbits generate a fair amount of heat. This heat has been used to heat closely coupled greenhouses. Rabbit manure has been processed by earthworms to produce vermicompost, a desirable and expensive form of fertilizer sought after by horticulturists for their ornamental plants.

Many people start off as hobbyists raising angelfish, reptiles, water lilies, or other desirable products, and soon find that people wish to buy from them. The hobbyist becomes a commercial, but small order, producer. They often do not have the space or other resources to support their hobby. A SEED Park can provide an excellent setting for such businesses.

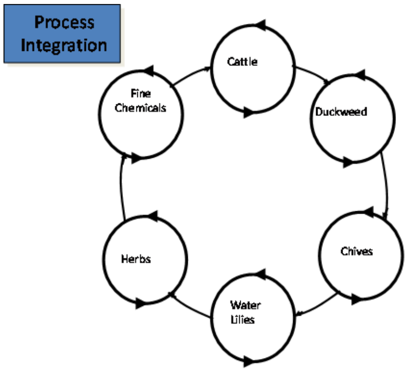
If you pick up many magazines directed to children, you'll find an advertisement in the back for sea monkeys. Parents and grandparents will spend $10 to $15 for a small vial of artemia, or brine shrimp, eggs. Children place these eggs in salt water to watch them hatch and the brine shrimp are commonly called sea monkeys in this trade. Brine shrimp are sold by the millions and hatched to produce feed for larval fish. Brine shrimp for the children's market is very much a specialty product with a narrow consumer potential. How many other strange, and perhaps exotic, animals do you see in pet shops? What's the source of all the tarantulas, hissing cockroaches, turtles, snakes, frogs, salamanders and hermit crabs? Most likely someone somewhere started producing them as a hobby and then grew to a commercial scale.

Unusual animals for which there are steady markets include ladybugs, crickets, mealworms, earthworms, and mice. All of these could be produced more reliably and economically in a SEED Park than as a stand-alone business outside of the SEED Park.

There are several butterfly ranches, or farms, scattered across the US. Butterfly collectors will pay handsomely for some rare specimens pinned and framed. Others will pay to stroll through a greenhouse, or net-covered structure, to see butterflies feeding, flying or emerging from a chrysalis. Cultured butterflies are sometimes placed in a box to be released as a new bride strolls down the aisle following her wedding. Dad usually doesn't even want to know what he paid for those butterflies.

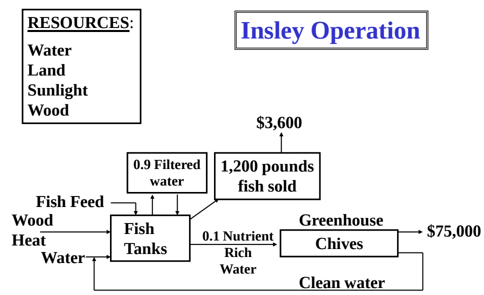
The "All-a-Flutter Butterfly Farm" in High Point, NC has been in operation for 6 years and has become so popular that they are turning down requests from school groups to visit. They sell 16 live butterflies for release at weddings and funerals for $120, plus shipping. Fifty butterflies in one container are priced at $350. Visitors to the farm pay $5 per adult and $4 per child to enter the 20- x 48-ft screened flight house. They also host special events such as birthday parties, summer workshops, training programs, non-profit fund-raisers and are the subject for many news articles.

A SEED Park provides the opportunity to create new jobs and income in rural area. The major export from most small, rural towns today is their youth. They move to find jobs. A recent article in US News and World Report (12 Nov 2007) quoted John Molinaro of the Aspen Institute as saying "the Toyota lottery doesn't work". Small, rural America cannot look to outside sources to come to their town and save them by providing jobs in a big factory. The answer is right here. If rural America is to be saved, it will save itself. One way to do so is through a SEED Park.

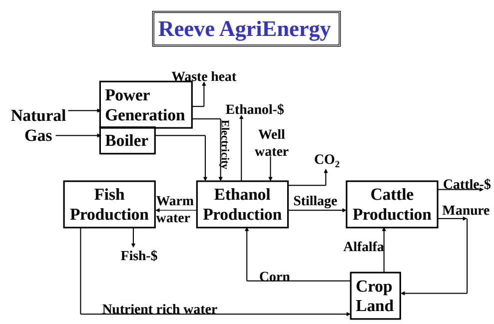



The discharge from one agricultural-industrial operation can be the input to the next downstream operation.

Examples of integrated recycling agro-industrial businesses existing today include a fish farm and chive production facility in Oklahoma, the Inslee Operation, and an ethanol plant, cattle feedlot, fish production facility, and agricultural crops in Garden City, KS, Reeve AgriEnergy. Both of these facilities have been in operation for well over 10 years. A new and much larger integrated system in Mead, NE produces ethanol, feeds the distillers' grain to cattle, produces methane for power, and applies nutrient-rich water to cropland to produce corn. The corn becomes the stock from which ethanol is produced. These are some of the components of a SEED Park. Recycling and reusing resources is the first step toward sustainability.




The first step in building a SEED Park is to identify the local resources available. Resources include land, water, sun, wind, heat, cold, people, finances, training, transportation, engineering, equipment, and multiple other items. The second step is to closely examine what we are doing now and ask ourselves, is it sustainable? If not, how do we move toward sustainability? What does our community, the state, the nation, and the world need that we can provide? This evaluation defines the market. Once we have an assessment of resources and have defined markets, the third step is to identify the processes of converting local resources into marketable products.




A proposed 10,000-A SEED Park, adequate to support growth over 30-50 years, can be built in the San Luis Valley. The Stakeholders will identify potential businesses to be located within the park and rank them by priority as primary, anchor, businesses or as secondary, supporting, businesses. The top ranked businesses should be those capable of being established today – all technology, design, and operational requirements are readily available. Other potential businesses might be based on technology or markets that are in the developing stage and these businesses would be built in 5, 10, 20, or 30 years as markets and technology mature. The secondary tier of businesses could be natural-resource based and site-specific businesses such as education, tourism, and even research and development.

A successful SEED Park in the San Luis Valley is doable and could be a model for rural development in the US. This Stakeholders' Meeting is the focus point for the self-examination and provides a collective, community-wide vision for the future. Data collected during the Stakeholders' Meeting will be used to develop business plans for the community-identified, and ranked, economic ventures.

## Suggested Readings

Assadourian, E. (Project Director). 2006. Vital signs 2006-2007: Trends that are shaping our future. The World Watch Institute. W.W. Norton & Co. New York, NY. 160pp.

Brown, Lester. 2006. Plan B 2.0: Rescuing a Planter under Stress and a Civilization in Trouble. WW Norton & Co., New York, NY. 365 pp.

Bourne, J.K., Jr. 2007. Biofuels: Boon or boondoggle. Growing Fuel: the wrong way, The right way. National Geographic (Oct) 212(4):38-59 (see other articles).

Diamond, Jared. 2005. Collapse: How Societies Choose to Fail or Succeed. Penguin Books. 575 pp.

Fedler, C.B. 2007

Goldstein, J. (ed). 2007 (Oct). Biocycle: Advancing composting, organic recycling and renewable energy. The JG Press, Inc. Emmaus, PA. (also see other issues). 14 pp.

Goldstein, J. (ed). 2007 (Aug). Biocycle: Advancing composting, organic recycling and renewable energy: How to launch a food residuals composting program. The JG Press, Inc. Emmaus, PA. (also see other issues). 64 pp.

MacLeod, Greg. 1998. From Mondragon to America: Experiments in Community Economic Development. Goose Lane Editors. 250 pp.

McAlister, Roy. 2005. The Solar Hydrogen Civilization. American Hydrogen Association, Mesa, AZ. 246 pp.

Sheehan, J., T. Dunahay, J. Benemann, and P. Roessler. 1998. A look back at the US Department of Energy's Aquatic Species Program – Biodiesel from Algae. National Renewable Energy Laboratory. NREL/TP-580-24190. 294 pp.

Sirolli, E. 1999. Ripples from the Zambezi: Passion, entrepreneurship and the rebirth of local economies. New Society Publishers, Gabriola Island, BC, Canada. 180 pp.

**Global Scientific, Inc.**
3255 Oberlin St.
Lubbock, TX 79415
www.globalscientific.org

***Global Scientific, Inc.*** (GSI) is dedicated to development of environmental and sustainable production technologies for the purpose of research, education, conservation, mentoring, networking, and economic development primarily for the benefit of local, regional, and global economies, especially those in rural sectors of society. GSI works with agricultural and industrial producers to recycle and convert sustainable products into valuable energy and marketable by-products in the most environmentally sound manner. GSI conserves water resources and biodiversity in the midst of global environmental uncertainty.

When GSI was established in 1992, the original purpose was to enable the export and implementation of research developed in the University research world to commercial applications. It was recognized that to be optimally effective would require that the technologies employed should be the best possible from all available sources rather than be limited to those developed only by the founders. Over nearly two decades, GSI has developed a worldwide network of associates, including research scientists, engineers, entrepreneurs, inventors, crafts people, producers and an ongoing stream of talented students.

***Modular Production Systems***
The basic idea of the modular production system concept is to show that water can be safely used many times in the production of various products and that, in the recycling process, the biomass produced as a result of recycling the water can be used to produce energy. All of this can be done in a synergistic, sustainable system that shows that everything organic can be recycled similar to the processes developed by nature, only much quicker and with value added.

GSI believes that the most viable way to successfully integrate the many possible technologies and a related production module is to co-locate businesses within a planned and balanced industrial-type site called a SEED Park. SEED is the acronym for Sustainable Environmental and Economic Development.

The basis of the sustainable, modular production system is that various technologies are available to allow the potential for by-products from one industry to be recycled into other marketable products by a complimentary industry. The key goal is to show how water can be safely used multiple times using various technologies to produce many marketable products for economic development, especially in rural areas around the world.

***Services Provided***
GSI's consulting services provide you with the information and insight you need to make informed decisions about your operation. These services include:

- Teleconferences and face-to-face meetings
- Business feasibility studies
- Business model development
- Project development
- Project management
- Vendor negotiations, contracting, and procurement

***Key Personnel***
Robert (Bob) D. Rogers, President
rdrogers@globalscientific.org
Phone: 806-789-7799

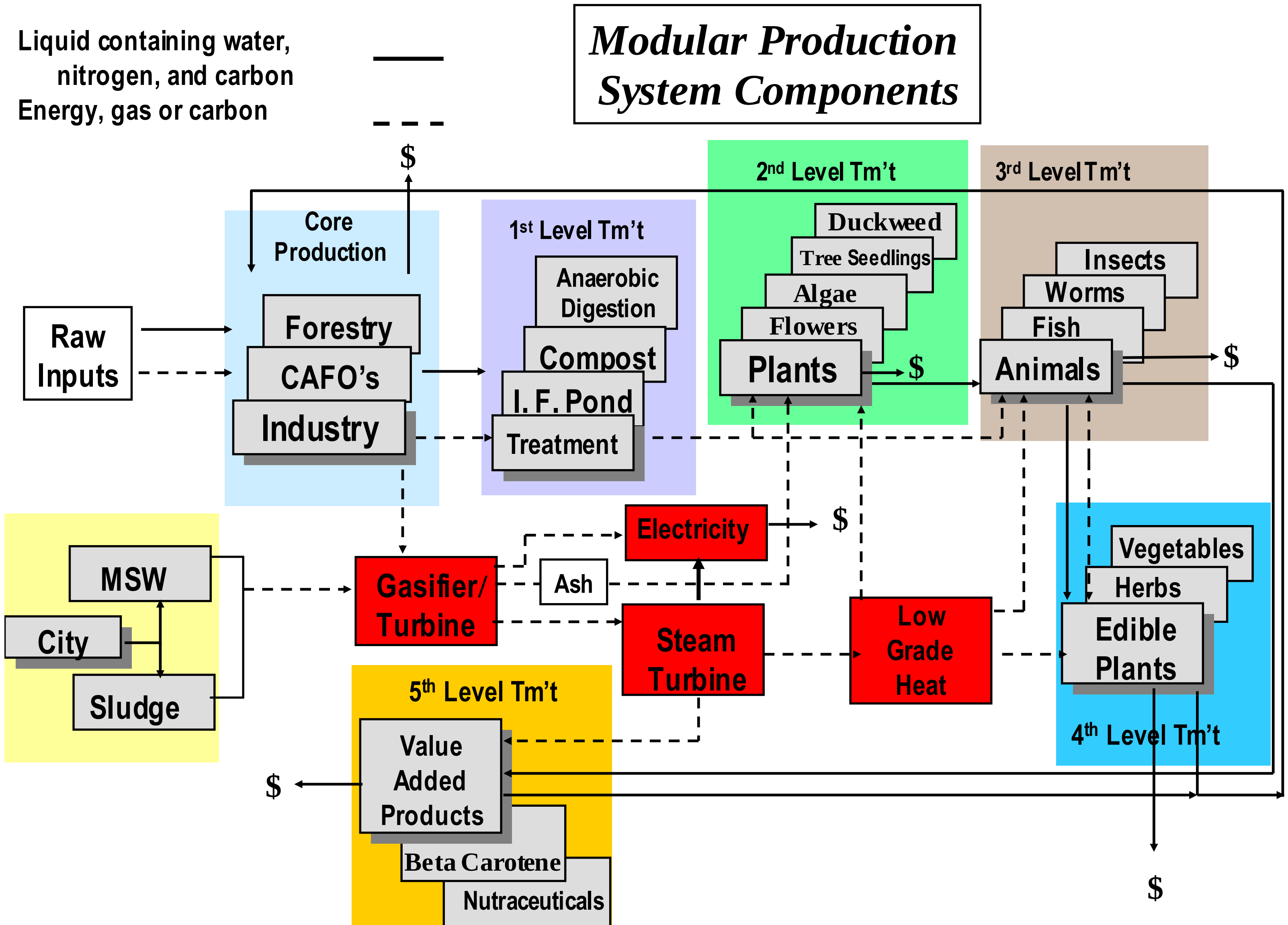
Dr. Nick C. Parker, Chief Scientist
parker@globalscientific.org
Phone: 806-786-0925

Dr. Clifford B. Fedler, Vice-President for Research and Development
cfedler@globalscientific.org
Phone: 806-543-2620

**NOTES**

## NOTES

## NOTES


Liquid containing water, nitrogen, and carbon
Energy, gas or carbon
Modular Production System Components
$
Core Production
Raw Inputs
Forestry
CAFO's
Industry
1st Level Tm't
Anaerobic Digestion
Compost
I. F. Pond
Treatment
2nd Level Tm't
Duckweed
Tree Seedlings
Algae
Flowers
Plants
$
3rd Level Tm't
Insects
Worms
Fish
Animals
$
MSW
City
Sludge
Gasifier/ Turbine
Ash
Electricity
$
Steam Turbine
Low Grade Heat
Vegetables
Herbs
Edible Plants
4th Level Tm't
5th Level Tm't
Value Added Products
Beta Carotene
Nutraceuticals
$
$