Agricultural Assessment Report
For

OSU Vegetable Farm

34346, NE Electric Rd
Corvallis, OR 97333

Oregon State University

ENERGY / EFFICIENCY CENTER

OREGON STATE UNIVERSITY
ENERGY / EFFICIENCY CENTER

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PREFACE

The work described in this report is a service of the Oregon State University Energy/Efficiency Center.

The primary objective of the E/EC agricultural assessment is to identify and evaluate opportunities for energy conservation, waste minimization, and productivity improvements through visits to agricultural sites. Data is gathered during a one-day site visit and assessment recommendations (ARs) are identified. Some ARs may require additional engineering design and capital investment. When engineering services are not available in-house, we recommend that a consulting engineering firm be engaged to provide design assistance as needed. In addition, since the site visits by E/EC personnel are brief, they are necessarily limited in scope and a consulting engineering firm could be more thorough.

We believe this report to be a reasonably accurate representation of energy use, waste generation, production practices, and opportunities in your facility. However, because of the limited scope of our visit, the Oregon State University Energy/Efficiency Center cannot guarantee the accuracy, completeness, or usefulness of the information contained in this report, nor assumes any liability for damages resulting from the use of any information, equipment, method or process disclosed in this report.

Pollution prevention recommendations are not intended to deal with the issue of compliance with applicable environmental regulations. Questions regarding compliance should be addressed to either a reputable consulting engineering firm experienced with environmental regulations or to the appropriate regulatory agency. Clients are encouraged to develop positive working relationships with regulators so that compliance issues can be addressed and resolved.

The assumptions and equations used to arrive at energy, waste, productivity, and cost savings for the recommended ARs are given in the report. We believe the assumptions to be conservative. If you would like to revise the assumptions you may follow the calculation methodologies presented to develop your own adjusted estimates of energy, waste, productivity, and cost savings.

Please feel welcome to contact the E/EC if you would like to discuss the content of this report or if you have another question about energy use or pollution prevention. The E/EC staff that visited your site and prepared this report is listed on the preceding page.

TABLE OF CONTENTS

1. INTRODUCTION

This report describes how energy is used in your plant, and includes our recommendations on cost effective steps you can take to reduce your energy and waste costs and increase productivity. The contents are based on our recent visit to your plant. The report is divided into 6 major sections and 3 appendices:

1. **Introduction.** The purpose, contents and organization of the report are described in this section.

2. **Narrative.** This section contains a description of the processes at your site and efficiency measures we discussed.

3. **Assessment Recommendations.** This section contains our Assessment Recommendations (AR), briefly highlights the current and proposed systems and summarizes the cost savings available upon implementation. Some of our recommendations will require a significant investment to implement, while others will cost little or nothing.

4. **Other Measures Considered.** These measures are just estimations made with limited data or analysis because; (1) we were unable to obtain the information necessary to estimate savings or cost accurately; (2) the measure would adversely affect production. Some measures are included in response to specific questions you raised during the plant visit, but which do not appear to be feasible.

5. **Energy Balance.** Your energy use and waste generation costs, productivity, energy, and waste savings, are summarized here.

6. **Calculation Methodology.** This section includes the detailed calculations for the Assessment Recommendations (AR). It includes any data that was collected during the audit, assumptions we use to estimate savings, our estimate of the implementation cost, and the simple payback of implementation.

Appendix A: Utilities. Your utility bills and energy use by process are summarized and plotted in detail. Due to the changes in rate schedules and adjustments our calculations are an approximation and may not be exactly consistent with your bills. When available, we also include water and solid waste bills.

Appendix B: Lighting. The number and type of lighting fixtures are recorded for each area. This appendix also includes the Lighting Worksheet Definitions, which describe the symbols and terminology used in our lighting calculations. The lighting power and annual energy use for each plant area are summarized in the Lighting Inventory worksheet.

Appendix C: Ecosystem Services. A background of ecosystem services and a summary of services that may be available at your facility. Also included is a collection of resources and articles.

2. NARRATIVE

This section includes a summary of processes and equipment used at your site and brainstorm ideas discussed on site.

Processes: Below is a summary of the processes at your site.

- **Hazelnut Processing:** Hazelnuts are grown in various plots. They are harvested in the fall and sent to Hyslop farm for drying. Once dried, they are bagged and sold.

- **Bean Processing:** Beans are grown and harvested in various plots. The beans are then solar dried and stored.

- **Seed Conservation:** The genetic record of various plants is banked in storage.

Equipment: Below is a list of your large equipment and its application.

- **Irrigation Pumps:** A 25 hp 500 gpm pump, a 15 hp 225 gpm pump, and a 15 hp 300-400 gpm pump are used to irrigate plots.

- **Walk in Cooler:** Packaged refrigerator unit used for sample storage.

- **Furnace:** A diesel furnace used to heat residences.

- **Tractors:** Various tractors for agricultural use.

- **Trucks:** One-Ton truck for transporting cargo.

Brainstorm Ideas: Below is a list of ideas we developed during the assessment and considered recommending in our report.

- **Cover Fuel Tanks:** We considered covering fuel tanks to reduce fuel vaporization as the tank warms up in the sun. This would reduce fuel loss to atmosphere.

- **Ecosystems Services:** We considered claiming carbon credits for growing trees. This would produce an alternate income source.

- **Electric Tractors:** Use an electric powered tractor for light duty operations in the field. This could be irrigation changes, small plantings, or minor projects. This would reduce the fuel consumption of a large tractor or vehicle needed to perform the same task.

- **Electric People Movers:** Replace a regular vehicle with an electric runabout (golf cart) or electric vehicle for light duty projects. From a run to town in an electric vehicle to checking the irrigation water, this would remove a conventionally fueled vehicle from operation, saving the fuel for that vehicle.

- **Integrated Compost Management:** We considered using mulch or compost to reduce water and fertilizer consumption. This would reduce your irrigation and fertilizer costs.

- **Solar:** We considered installing a photovoltaic array on the roof to collect solar energy. This would reduce your electricity costs.

- **Roof Recommendations:** We considered installing truss beams to connect the tractor sheds walls and roof to improve structural stability. This will reduce the chance of the structure collapsing. We also considered replacing the shingles on the work room, increasing the roof's lifespan.

- **Moisture Sensing Irrigation:** We considered installing soil moisture sensors to aid in determining when fields need to be watered. Moisture sensors would reduce water use in the summer and provide information on whether or not fields are too saturated.

- **Low Pressure Irrigation:** Use a low pressure irrigation system to reduce the electricity required by the well pump.

- **Irrigation Pump Efficiency:** Improve irrigation pump efficiency to reduce energy consumption.

- **Tractor Operation**: Change tractor governor settings for operation at a lower RPM to save fuel. Check tractors for clean air filters, correct tire pressure, proper ballast weight etc.

- **Baseboard Heaters:** We considered replacing the baseboard heaters with a more efficient and safer method of heating the facility.

- **Windows:** We considered replacing current single pane windows with more efficient ones with functioning latches for ventilation in warmer weather.

- **Dryer:** We considered installing a dryer to dry hazelnuts to reduce dependence and cost associated with having them dried off site.

- **Lighting:** Upgrade current incandescent lights to T-8's for increased efficiency, reducing your electricity usage.

- **Refrigerator:** We considered upgrading your current refrigeration unit with a more modern one that may be more efficient.

Recommendations Summary: Recommendations that we were able to quantify into cost savings, implementation cost and energy saved are summarized in the following table.

Assessment Recommendation Summary					
AR#	Description	Energy (MMBtu)	Cost Savings	Implementation Cost*	Payback (years)
1	Electric Tractors Conversion	66.3	$1,457	$5,300	3.6
2	Electric People Movers	64.8	$945	$0	0.0
3	Composting: Hazelnut Plots	11.1	$963	$5,400	5.7
4	Composting; Vegetable Plots	16.6	$1,445	$5,400	3.7
5	Photovoltaic Array	130.9	$2,900	$10,500[1,2]	3.6
Totals		**289.7**	**$7,710**	**$26,600**	**3.5**

** Implementation Cost in this column represents your final cost after any applicable incentives as noted*
1 This final cost is reduced by an Oregon Department of Energy Business Energy Tax Credit.
2 This final cost is reduced by Energy Trust of Oregon Incentives.

Total savings are the sum of the savings for each recommendation. Some of the recommendations may interact. Therefore, actual savings may be less than the total indicated above. In our calculations we indicate where we have assumed that other recommendations will be implemented in order to provide a realistic estimate of actual savings. When either one or another recommendation can be implemented, but not both, we have included the recommendation we recommend in this table and the alternate recommendation in a later section, Other Measures Considered. Total savings, including interactions among recommendations, can be better estimated after you select a package of recommendations.

3. ASSESSMENT RECOMMENDATIONS

Electric Tractors Conversion

While visiting your facility we discussed a small Allis-Chalmers gas cultivator that had been converted to run on electricity instead of gasoline. We recommend converting tractors to run on electric power instead of gasoline. This reduces the carbon footprint of tractors while maintaining horsepower. Converting tractors to electric power will result in annual energy cost savings of 97%.

As detailed in the Electric Tractors Conversion - Calculation Methodology, there is a 3.6 year payback with a $5,300 implementation cost and $1,457 annual savings.

Electric People Movers

When you purchase a new on-farm vehicle, buy an electric one. Because there are many unknowns and differences in maintenance for electric and gas vehicles we make the simplified assumption that purchase costs are equal for gas and electric vehicles and that over the life of the vehicle, maintenance costs will be equal for gas and electric vehicles. We therefore make the comparison between a gas vehicle's fuel cost per mile versus an electric vehicle's fuel cost per mile plus battery costs.

As detailed in the Electric People Movers - Calculation Methodology, there is an immediate payback with no implementation cost and $945 annual savings.

Composting: Hazelnut Plot

There is a large amount of fertilizer and water used for the Hazelnut tree plot. Since there is a significant amount of wood debris each year, we recommend chipping it and adding it to commercially available compost to improve nutrient value and water retention. This will help reduce water consumption by up to 40% while providing a natural source of fertilizer and reduce chemical fertilizer use by up to 30%.

As detailed in the Composting: Hazelnut Plot - Calculation Methodology, there is a 5.7 year payback with a $5,400 implementation cost and $963 annual savings.

Composting: Vegetable Plot

There is a large amount of fertilizer and water used for the Vegetable crops. Since there is a significant amount of wood debris each year, we recommend chipping it and adding it to commercially available compost to improve nutrient value and water retention. This will help reduce water consumption by up to 40% while providing a natural source of fertilizer and reduce chemical fertilizer use by up to 30%.

As detailed in the Composting: Vegetable Plot - Calculation Methodology, there is a 3.7 year payback with a $5,400 implementation cost and $1,445 annual savings.

Photovoltaic Array

Photovoltaic arrays take energy from the sun, and convert it into useful electricity. They can last over 30 years, require minimal maintenance, and produce zero carbon emissions once they have been installed. Although the government has heavily incentivized photovoltaics, incentives are changing continuously so review them in detail before purchasing a system. We recommend installing a photovoltaic array on the roof. This will reduce the facility's electricity costs by 51%.

As detailed in the Photovoltaic Array - Calculation Methodology, there is a 3.6 year payback with a $10,500 implementation cost and $2,900 annual savings.

4. OTHER MEASURES CONSIDERED

Fuel Tank Cover

Storage tanks can lose a considerable amount of fuel due to evaporation and leaks. In extreme cases up to 40 percent of a tank's capacity can be lost per year through evaporation. This can be reduced to around 0.5 percent by following these tips:

- Keep fuel tanks well shaded.
- Tank should be aluminum or white to reflect the suns heat and reduce evaporation.
- Use pressure-relief vacuum caps instead of conventional caps.
- Lock unattended fuel tanks
- Regularly inspect tanks for leaks. During inspections tighten all fittings.

Although we could not develop an exact number for savings associated with this project we do recommend putting a cover over fuel tanks as savings could be significant.

Tractor Operation

Tractor operators can obtain a number of forward speeds by adjusting the transmission gear ratio while maintaining the same engine RPM. Within each gear there is further adjustment available with the governor setting lever. Most tractor field speeds are determined by the implement and not by the tractor power available. While visiting your facility we were informed that most operators run the tractors at full throttle using the transmission gear ratio to vary speed. Significant increases in fuel efficiency are expected if the governor speed lever is reduced and a faster gear ratio is selected. This is particularly true in operating conditions of less than half load. Additional savings are available by keeping a maintenance schedule, proper ballasting, and proper tire inflation. Savings of up to 4 percent in fuel can be achieved by keeping a maintenance schedule and replacing air and oil filters as necessary. We were unable to determine how much savings would be available because not enough data on how the tractors are currently operated was available, but with no implementation cost the savings will be immediate and significant.

Low Pressure Irrigation

While visiting your facility we were informed that you use a standard irrigation system. This is less energy efficient than a low pressure irrigation system. Low pressure irrigation systems generally operate between 10 and 50 percent of standard pumping pressure. These systems can reduce electricity costs associated with pumping between 10 and 35 percent. One-time cash incentives may also be available on a per acre basis depending on your location. After further investigation we determined that such a system would be economically and practically unfeasible for your current size and layout. In order for such a system to work you need either a network of linears or central pivots, because of your small plot size and variety of crops neither of these systems will work.

Ecosystem Services

Humankind benefits from a number of resources and processes that are supplied by natural ecosystems. These benefits are known as ecosystem services and include products like clean drinking water and processes such as the decomposition of wastes. Ecosystem services are distinct from other ecosystem products and functions because there is human demand for these natural assets. One ecosystem service is carbon offsetting, which is defined as any measure which results in a reduction of atmospheric CO_2. This is providing an ecosystem service which, in this case, can be bought and sold on the open market. We recommend selling your carbon credits as an alternate source of income. Refer to Appendix C – Ecosystem Services, for more details.

Double Pane Windows

Energy-efficient double pane windows can reduce heating bills by 34 percent in cold climates and 38 percent in hot climates compared to uncoated, single-pane windows. During our site visit we were informed that many of your windows are single pane and have broken latches. We recommend that as windows wear out you replace them with energy efficient double pane windows. This will reduce your heating electricity consumption and allow you to open them in the warmer months to provide circulation and cooling. This doesn't appear as a full recommendation because your heating costs are minimal compared to the price of new windows, yielding a long payback.

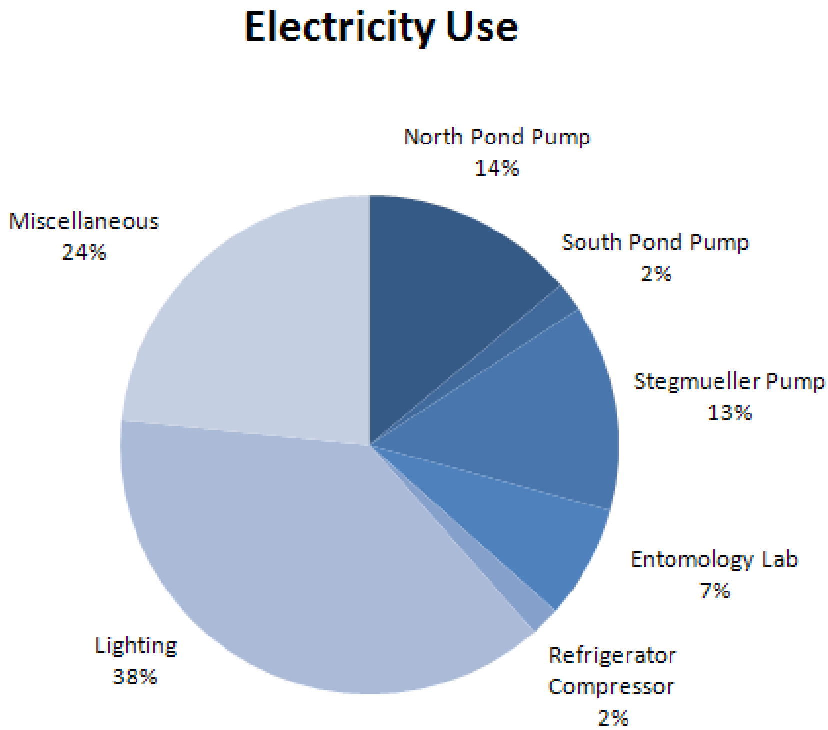
5. ENERGY BALANCE

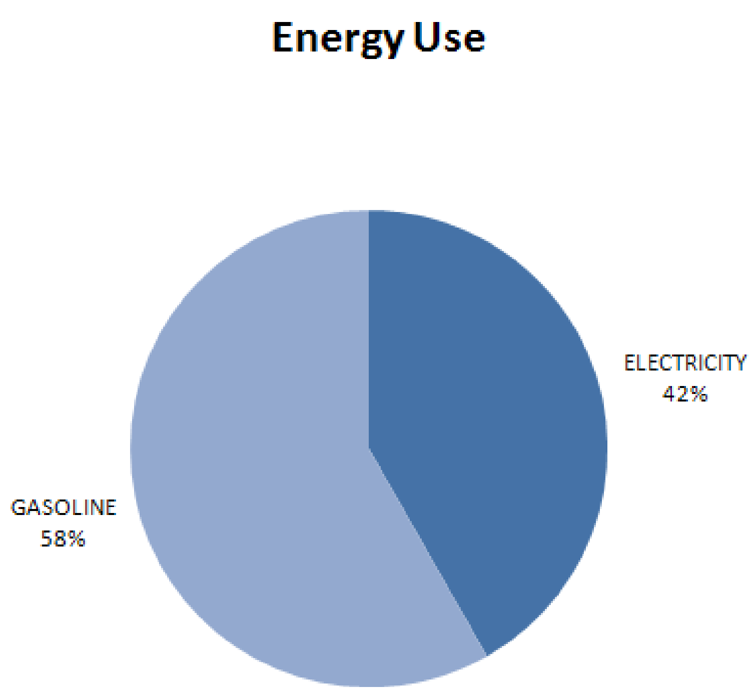
Your energy use and waste generation costs, productivity, energy, and waste savings, are summarized here.

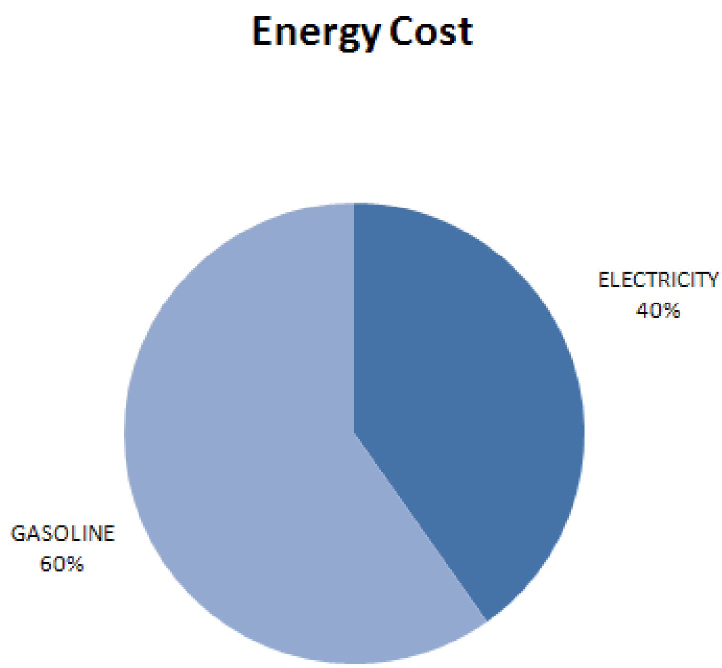
END USE SUMMARY		
Average Electricity Cost:	$0.07499	/kWh
Average Gasoline Cost:	$3.00000	/gallon

ELECTRICITY	USE	UNIT	MMBtu	ENERGY %	COST	COST%
North Pond Pump	11,081	kWh	38	13.9%	$831	13.9%
South Pond Pump	1,515	kWh	5	1.9%	$114	1.9%
Stegmueller Pump	10,676	kWh	36	13.4%	$801	13.4%
Entomology Lab	5,866	kWh	20	7.4%	$440	7.4%
Refrigerator Compressor	1,520	kWh	5	1.9%	$114	1.9%
Lighting (See Lighting Inv.)	30,341	kWh	104	38.1%	$2,275	38.1%
Miscellaneous	18,644	kWh	64	23.4%	$1,398	23.4%
TOTALS	79,643	kWh	272	100.0%	$5,972	100.0%

FUEL SUMMARY	USE	UNIT	MMBtu	ENERGY %	COST	COST%
ELECTRICITY	79,643	kWh	272	41.8%	$5,972	40.2%
GASOLINE	2,959	gallons	379	58.2%	$8,878	59.8%
TOTALS			651	100.0%	$14,850	100.0%


Electricity Use
North Pond Pump
14%
South Pond Pump
2%
Stegmueller Pump
13%
Entomology Lab
7%
Refrigerator
Compressor
2%
Lighting
38%
Miscellaneous
24%


Energy Use
ELECTRICITY
42%
GASOLINE
58%


Energy Cost
ELECTRICITY
40%
GASOLINE
60%

6. CALCULATION METHODOLOGY

AR No. 1
Electric Tractors Conversion
Calculation Methodology

Recommendation

Convert tractors to run on electric power instead of gasoline. Switching fuels reduces the carbon footprint of the tractor while maintaining horsepower. Converting tractors to electric power will result in annual energy cost savings of 97%.

Assessment Recommendation Summary			
Energy (MMBtu)	Cost Savings	Implementation Cost	Payback (years)
66.3	$1,457	$5,300	3.6

Data Collected Summary

While visiting your facility we discussed a small Allis-Chalmers cultivator that had been converted to run on electricity instead of gasoline. This action is most viable when the current gasoline engine needs to be rebuilt, as opposed to replacing a usable engine with batteries.

We collected the following from farm personnel and electric tractor conversion experts:

- Conversion Parts: $3,600
- Batteries: $1,500
- Conversion process takes about 10 hours
- 4-5 hours of operation per charge
- 8 Volt Batteries (6) charged by a 120 Volt, 18 amp battery charger
- Original horsepower: 12 hp
- Converted horsepower: 25 hp
- Weighing the tractor down for adequate traction may be the biggest problem

We assumed the following for our analysis:

- Tractor pre-conversion gas usage: 2 gallons per hour
- Gas cost: $3.00/gallon
- Overall efficiency of the battery charging system: 50%
- Average Energy cost: $0.07499/kWh
- Number of days tractor in use per year: 50 days per year
- Number of hours tractor in use per day: 5 hours per day
- Electrical maintenance costs will be approximately equal gas maintenance costs

Savings Analysis

Annual cost savings are calculated by finding the associated cost difference between current and proposed conditions.

CS	=	Cost Savings
	=	CT - ET
	=	$1,500/yr - $43/yr
	=	$1,457/yr

Where,

CT	=	Current Tractor Annual Energy Cost
	=	HR x GH x $G
	=	250hr/yr x 2 gal/hr x $3.00/gal
	=	$1,500/yr
ET	=	Proposed Electric Tractor Annual Energy Cost
	=	D x B x BV x AH x EC ÷ KW ÷ CE
	=	$\frac{50 Days}{Year} \times \frac{6 Batteries}{} \times \frac{8 Volts}{Battery} \times \frac{120 Amp-Hours}{Day} \times \frac{\$0.07499}{kWh} \times \frac{kW}{1000W} \times \frac{}{50\% Efficiency}$
	=	$43/yr

Where,

HR	=	Hours of Operation per Year
	=	50 days/year x 5 hours/day
	=	250 hr/yr
GH	=	Gallons per Hour of operation
	=	2 gal/hr
$G	=	Dollars per Gallon of Gasoline
	=	$3.00/gal
B	=	Number of Batteries
	=	6
BV	=	Battery Voltage
	=	8 V
AH	=	Amp-Hour Rating of Batteries
	=	120 Ah
EC	=	Electrical Energy Cost
	=	$0.07499/kWh
CE	=	Estimated Charging Efficiency
	=	50%

KW = Watts per Kilowatt
= 1000

Total annual cost savings are summarized in the following table:

Saving Summary			
Source	Quantity	Units	Cost Savings
Energy Use	66.3	MMBtu	$1,457

Cost Analysis

Costs for such a conversion relate directly to the quality of the batteries chosen. As a general rule, the more expensive the battery, the longer its useful life will be. We therefore recommend using high quality batteries to minimize battery purchases throughout the life of the vehicle.

IC = Implementation Cost
= MC + LC
= $5,100 + $200
= $5,300

Where,
MC = Material Cost
= BC + PC
= $1,500 + $3,600
= $5,100

LC = Labor Cost
= IT x CL
= 10 x $20
= $200

Where,
IT = Installation Time
= 10 hours

CL = Cost of Labor
= $20/hour

BC = Battery Costs
= $1,500

PC = Parts Cost
= $3,600

Total implementation costs are summarized in the following table:

Implementation Summary				
Source	Quantity	Units	$/Unit	Cost
Parts Costs				$3,600
Battery Cost	6	Batteries	$250	$1,500
Labor Costs	10	Hours	$20	$200
Total				**$5,300**

Savings will pay for implementation in 3.6 years.

AR No. 2
Electric People Movers
Calculation Methodology

Recommendation

When needed, replace the current on-farm vehicle with an electric vehicle (EV). Due to the increased energy efficiency of electric vehicles, this will reduce your energy use by the equivalent of 506 gallons of gasoline each year.

Assessment Recommendation Summary			
Energy (MMBtu)	Cost Savings	Implementation Cost	Payback (years)
64.8	$945	$0	Immediate

Data Collected Summary

One challenge in calculating true savings associated with replacing a gas-powered vehicle with an electric vehicle is that it is difficult to accurately calculate the true cost of ownership over the life of the vehicle. The two main areas of cost associated with any vehicle are maintenance and fuel. We assume that all other costs, like insurance and registration, are essentially equal for the two vehicle types. As for the gas-powered vehicle, there are many "True Cost to Own" websites[1] particularly for new vehicles. We were not able to find any such "True Cost to Own" data for electric vehicles and therefore contacted the University to collect maintenance cost data for electric vehicles operated and maintained on campus.

University maintenance records show that the average annual maintenance costs for three electric vehicles were $2,150, $3,050, and $1,000 with an average of $2,066. These maintenance costs are higher than gas vehicle maintenance costs, possibly due to the relative scarcity of electric vehicle parts. An additional maintenance cost for electric vehicles is battery replacement costs. Batteries are critically important to a proper and efficient functioning electric vehicle and they also are expensive. University records show that an electric vehicle recently replaced its batteries after five years of service for $2,400. That is an average annual cost of $480.

So why would anyone choose an electric vehicle if they're more expensive to maintain?

- The incremental fuel cost is drastically lower with an electric vehicle as we will demonstrate in the calculations below.

- There are other amenities (like quite operation, zero emissions and low carbon footprint) that make EVs worthwhile for some applications.

[1] http://www.edmunds.com/

EV technology is still developing and isn't appropriate for all applications. We're used to thinking of a vehicle, like a gas pickup truck, that would move farm personnel to and from the farm on surface streets at high speeds as wells as cruise around the farm at low speeds with a load of equipment. EVs would not be able to completely replace that pickup truck because it's not permitted on a section of road where the posted speed limit is above 45 mph—the limit for neighborhood electric vehicles or NEVs. EVs could however replace the pickup truck's on-farm activities—which are the most inefficient miles a gas vehicle drives because when idling, your miles per gallon go to zero. Our calculations are based on an exclusively on-farm vehicle and mileage estimates provided by farm personnel of 15,000 miles per year.

Because there are many unknowns and differences in maintenance needs for electric and gas vehicles we make the simplifying assumption that purchase costs are equal for gas and electric vehicles and that over the life of the vehicle, maintenance costs will also be equal. We therefore make the comparison between a gas vehicle's fuel cost per mile versus an electric vehicle's fuel cost per mile plus battery costs. We assume the gas vehicle gets 25 miles per gallon[2] and that the cost of gasoline is $3.00 per gallon. We also assume that an electric vehicle has an average fuel economy of 3 miles per kilowatt hour (kWh)[3] and that the average cost per kWh of electricity is $0.07499.

Savings Analysis

Annual cost savings are calculated by finding the associated cost difference between the current and proposed conditions.

CS	=	Cost Savings
	=	FM x (GV – EV) – BC
	=	15,000 x ($0.12 – $0.025) – $480
	=	$945 / year

Where,

FM	=	On-Farm Mileage
	=	15,000 miles/year
GV	=	Gas Vehicle Fuel Cost per Mile
	=	$G / GM
	=	$3.00 / 25
	=	$0.12 / mile

[2] Based on CAFÉ standards at http://www.nhtsa.dot.gov/cars/rules/cafe/FuelEconUpdates/2003/index.htm
[3] http://avt.inl.gov/pdf/fsev/costs.pdf

EV = Electric Vehicle Fuel Cost per Mile
= (1 / KM) x $K
= (1 / 3) x $0.07499
= $0.025 / mile

Where,

GM = Gallons of Gasoline per Mile
= 25 mi/gal

$G = Price per Gallon of Gasoline
= $3.00

KM = Miles per Kilowatt-hour
= 3 mi/kWh

$K = Price per Kilowatt Hour
= $0.07499

BC = Battery Cost per year
= $480 / year

Total annual cost savings are summarized in the following table:

Saving Summary			
Source	Quantity	Units	Cost Savings
Energy Use	64.8	MMBtu	$1,425
Battery			($480)
Total			**$945**

When the current on-farm vehicle needs to be replaced, we recommend replacing it with an electric vehicle to take advantage of the calculated cost savings.

AR No. 3
Composting: Hazelnut Plot
Calculation Methodology

Recommendation

We recommend chipping wood debris and adding it to commercially available compost to improve the nutrient value and water retention. This will help reduce water consumption by 40% while providing a natural source of fertilizer and reduce chemical fertilizer use by 30%.

Assessment Recommendation Summary				
Energy (MMBtu)	Energy (kWh)*	Cost Savings	Implementation Cost	Payback (years)
11.1	3,244	$963	$5,400	5.7

**1 kWh =3,410 Btu*

Background

To reduce water consumption, use mulch or compost to retain water in the soil. To reduce fertilizer consumption, decomposition of the compost will provide natural fertilizer to the plants instead of using a chemical fertilizer.

Data Collected Summary

We collected the following during our site visit:

- Area of Hazelnuts: 20 acres (Sections 15 and 16)
- Watering rate of Hazelnuts: 0.5 in-water/week
- Watering time frame: 32 weeks (over 2 years)
- Incremental Electricity Cost: $0.07499 /kWh
- Fertilizer for Hazelnuts: 40 lbs of nitrogen/acre
- Cost of nitrogen fertilizer: $75/50 lb bag ($1.50/lb)
- Middle pump flow rate: 225 gpm
- Middle pump Hp: 15 Hp
- Compost purchase price: $20/ton
- Compost per acre: 1 Ton

Assumptions

We assume the following for our analysis:

- Reduce fertilizer by: 30% (use only 70% of current)
- Reduce water by: 40% (use only 60% of current)
- Chipper cost: $5,000 (confirmed by bid)

Savings Analysis

TS	=	Total Annual Cost Savings
	=	EC + FC
	=	\$243+ \$720
	=	\$963

Where,

EC	=	Energy Cost Savings
	=	ES x IE
	=	3,244 kWh x \$0.07499 /kWh
	=	\$243
FC	=	Fertilizer Cost Savings
	=	$(CF_{H1} – CF_{H2})$ x 2 years
	=	(\$1200 - \$840) x 2
	=	\$720

Where,

ES	=	Energy Savings
	=	P x H
	=	12.6 kW x 257 hrs
	=	3,244 kWh
IE	=	Incremental Energy Cost
	=	\$0.07499 /kWh
CF_{H1}	=	Current Fertilizer Cost
	=	A_H x F_H x NF
	=	20 acre x 40 lbs/acre x \$1.50/lb
	=	\$1200
CF_{H2}	=	Proposed Fertilizer Cost
	=	CF_{H1} x 70%
	=	\$1,200 x 0.7
	=	\$840

Where,

P	=	Pump Power Consumption
	=	(HP ÷ EF) x C_1 x LF
	=	(15 Hp ÷ 0.80) x 0.746 kW/Hp x .90
	=	12.6 kW
H	=	Run Time Hours Saved
	=	WS ÷ MH
	=	3,475,744 gal ÷ 13,500 gph
	=	257 hrs

A_H = Area of Hazelnuts
= 20 acres (Sections 15 and 16)

F_H = Fertilizer for Hazelnuts
= 40 lbs/acre

NF = Cost of Nitrogen Fertilizer
= $1.50/lb

Where,

HP = Motor Horsepower
= 15 Hp

EF = Motor Efficiency
= 80%

CF_1 = Conversion Factor
= 0.746 kW/Hp

LF = Load Factor
= 90%

WS = Water Savings
= $W_{H1} - W_{H2}$
= 8,689,360 gal – 5,213,616 gal
= 3,475,744 gal

MH = Middle Pump Hourly Flow Rate
= MM x CF_2
= 225 gpm x 60 min/hr
= 13,500 gph

Where,

W_{H1} = Water for Hazelnuts
= $I_H \times N_H \times A_H \times CF_3 \div CF_4$
= 0.5 in/week x 32 weeks x 20 acres x 325,851 gal/acre-ft ÷ 12 in/ft
= 8,689,360 gal

W_{H2} = W_{H1} x 60%
= 8,689,360 gal x 0.60
= 5,213,616 gal

MM = Middle Pump Flow Rate per Minute
= 225 gpm

CF_2 = Conversion Factor
= 60 min/hr

Where,

I_H	=	Inches of Water per Week
	=	0.5 in/week
N_H	=	Number of Weeks Watered
	=	32 weeks
CF_3	=	Conversion Factor
	=	325,851 gal/acre-ft
CF_4	=	Conversion Factor
	=	12 in/ft

Total annual cost savings are summarized in the following table:

Savings Summary			
Source	Quantity	Units	Cost Savings
Energy Use	3,244	kWh	$243
Fertilizer Use			$720
Total			**$963**

Implementation Cost

TC	=	Total Implementation Cost
	=	C_C + CC
	=	$400 + $5000
	=	$5,400

Where,

C_C	=	Compost cost
	=	P_C x CA x A_H
	=	$20/ton x 1 Ton/Acre x 20 Acres
	=	$400

Where,

P_C	=	Price of Compost
	=	$20/ton
CA	=	Compost per Acre
	=	1 Ton/Acre
CC	=	Wood Chipper Cost
	=	$5,000

Total implementation costs are summarized in the following table:

Implementation Summary				
Source	Quantity	Units	$/Unit	Cost
Compost	20	Tons	$20	$400
Chipper	1	Chipper	$5,000	$5,000
Total				**$5,400**

Savings will pay for implementation in 5.7 years.

Note

Labor and fuel costs are not included in this calculation. If you can spread the compost over a larger area, this will lead to greater savings in water and fertilizer, further reducing the payback. If at any time you can reduce the cost of the chipper, this will improve the payback timeframe also. This recommendation does not cover the increased yield of the crops grown in the improved fields, or the changes in electrical savings due to operating different water pumps. The calculations here only describe two summers worth of savings. We believe the compost will last over 2 years, significantly increasing the savings per year, and as the composting program becomes more established, the soil quality will improve, providing additional savings.

AR No. 4
Composting: Hazelnut Plot
Calculation Methodology

Recommendation

We recommend chipping wood debris and adding it to commercially available compost to improve the nutrient value and water retention. This will help reduce water consumption by 40% while providing a natural source of fertilizer and reduce chemical fertilizer use by 30%.

Assessment Recommendation Summary				
Energy (MMBtu)	Energy (kWh)*	Cost Savings	Implementation Cost	Payback (years)
16.6	4,866	$1,445	$5,400	3.7

**1 kWh =3,410 Btu*

Background

To reduce water consumption, use mulch or compost to retain water in the soil. To reduce fertilizer consumption, decomposition of the compost will provide natural fertilizer to the plants instead of chemical fertilizer.

Data Collected Summary

We collected the following during our site visit:

- Area of vegetables: 20 acres (Sections 13 and 14)
- Watering rate of vegetables: 1 in-water/week
- Watering time frame: 6 months (over 2 years)
- Incremental Electricity Cost: $0.07499 /kWh
- Fertilizer for vegetables: 60 lbs of nitrogen/acre
- Cost of nitrogen fertilizer: $75/50 lb bag ($1.50/lb)
- Middle pump flow rate: 225 gpm
- Middle pump Hp: 15 Hp
- Compost purchase price: $20/ton
- Compost per acre: 1 Ton

Assumptions

We assume the following for our analysis:

- Reduce fertilizer by: 30% (use only 70% of current)
- Reduce water by: 40% (use only 60% of current)
- Chipper cost: $5,000

Savings Analysis

TS	=	Total Annual Cost Savings
	=	EC + FC
	=	\$365 + \$1,080
	=	\$1,445

Where,

EC	=	Energy Cost Savings
	=	ES x IE
	=	4,866 kWh x \$0.07499 /kWh
	=	\$365
FC	=	Fertilizer Cost Savings
	=	(F_{V1} - F_{V2}) x 2
	=	(\$1,800 - \$1,260) x 2
	=	\$1,080

Where,

ES	=	Energy Savings
	=	P x H
	=	12.6 kW x 386 hrs
	=	4,866 kWh
IE	=	Incremental Energy Cost
	=	\$0.07499 /kWh
F_{V1}	=	Current Fertilizer Cost
	=	V_A x V_F x NF
	=	20 acre x 60 lbs/acre x \$1.50/lb
	=	\$1,800
F_{V2}	=	Proposed Fertilizer Cost
	=	F_{V1} x 70%
	=	\$1,800 x 0.7
	=	\$1,260

Where,

P	=	Pump Power Consumption
	=	(HP ÷ EF) x C_1 x LF
	=	(15 Hp ÷ 0.80) x 0.746 kW/Hp x .90
	=	12.6 kW
H	=	Run Time Hours Saved
	=	WS ÷ MH
	=	5,213,616 gal ÷ 13,500 gph
	=	386 hrs

V_A = Area of Vegetables
= 20 acres (Sections 13 and 14)

V_F = Fertilizer for Vegetables
= 60 lbs/acre

NF = Cost of Nitrogen Fertilizer
= $1.50/lb

Where,

HP = Motor Horsepower
= 15 Hp

EF = Motor Efficiency
= 80%

CF_1 = Conversion Factor
= 0.746 kW/Hp

LF = Load Factor
= 90%

WS = Water Savings
= $W_{V1} - W_{V2}$
= 13,034,040 gal – 7,820,424 gal
= 5,213,616 gal

MH = Middle Pump Hourly Flow Rate
= MM x CF_2
= 225 gpm x 60 min/hr
= 13,500 gph

Where,

W_{V1} = Water for Vegetables
= I_V x N_V x A_V x $CF_3 \div CF_4$
= 1 in/week x 24 weeks x 20 acres x 325,851 gal/acre-ft ÷ 12 in/ft
= 13,034,040 gal

W_{V2} = W_{V1} x 60%
= 13,034,040 gal x 0.60
= 7,820,424 gal

MM = Middle Pump Flow Rate per Minute
= 225 gpm

CF_2 = Conversion Factor
= 60 min/hr

Where,

I_V = Inches of Water per Week
= 1 in/week

N_V = Number of Weeks Watered
= 24 weeks

CF_3 = Conversion Factor
= 325,851 gal/acre-ft

CF_4 = Conversion Factor
= 12 in/ft

Total annual cost savings are summarized in the following table:

Savings Summary			
Source	Quantity	Units	Cost Savings
Energy Use	4,866	kWh	$365
Fertilizer Use			$1,080
Total			**$1,445**

Implementation Cost

TC = Total Implementation Cost
= C_C + CC
= $400 + $5000
= $5,400

Where,

C_C = Compost cost
= P_C x CA x A_V
= $20/ton x 1 Ton/Acre x 20 Acres
= $400

Where,

P_C = Price of Compost
= $20/ton

CA = Compost per Acre
= 1 Ton/Acre

CC = Chipper Cost
= $5,000

Total implementation costs are summarized in the following table:

Implementation Summary				
Source	Quantity	Units	$/Unit	Cost
Compost	20	Tons	$20	$400
Chipper	1	Chipper	$5,000	$5,000
Total				**$5,400**

Savings will pay for implementation in 3.7 years.

Note

Labor and fuel costs are not included in this calculation. If you can spread the compost over a larger area, this will lead to greater savings in water and fertilizer, further reducing the payback. If at any time you can reduce the cost of the chipper, this will reduce the payback also. This recommendation does not cover the increased yield of the crops grown in the improved fields. This recommendation does not cover the changes in electrical savings due to operating different water pumps. The calculations here only describe two summers worth of savings. The compost will last over 2 years, significantly increasing the savings per year, and as the composting program becomes more established, the soil quality will improve, providing additional savings.

This recommendation does not take into account the Composting: Hazelnut Plot recommendation.

AR No. 5
Photovoltaic Array
Calculation Methodology

Recommended Action

Install a photovoltaic array on the roof. This will reduce the facility's electricity cost by 51%.

Assessment Recommendation Summary				
Energy (MMBtu)	Energy (kWh)	Cost Savings	Implementation Cost	Payback (years)
130.9	38,400	$2,900	$10,500	3.6

**1 kWh = 3,410 Btu*

Data Collected Summary

- To calculate electrical generation capacity, we estimated the roof space percentage available to be 80%. Changing this percentage will change the implementation and cost savings, but not the payback period.
- The solar energy Production Capacity of 1.14kWh/Watts DC-year is provided by the Energy Trust of Oregon[4]
- The industry standard Solar Panel Rating of 12 Watts DC/ft2 and the estimates for labor cost were provided by a local electrician who specialized in photovoltaic systems and is based on the expected output of commercially available photovoltaic systems[5].
- The estimate for costs of solar panels, inverters, and the number of panels it takes to generate a kilowatt was provided by an industry database[6].
- Farm personnel also noted periodic golf ball impacts from the neighboring golf course. Because a golf ball strike could potentially seriously damage a photovoltaic array, some method of minimizing this potential would need to be implemented prior to installing the array. Such a method might include a net but is outside the scope of this analysis.

Savings Analysis

Annual Cost Savings are determined by comparing the photovoltaic system's expected production capacity with the incremental cost of energy of $0.07499 / kWh.

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[4] From http://www.energytrust.org/TA/solar/charts.html
[5] From http://www.aesrenew.com/
[6] From http://www.solarbuzz.com/ModulePrices.htm

CS = Cost Savings
= IE x A x UE
= \$0.07499/kWh x 3,120 ft^2 x 12.3 kWh/ft^2-year
= \$2,900 per year

Where,

IE = Incremental Energy Cost
= \$0.07499/kWh

A = TA x PA
= 3,900 ft^2 x 80%
= 3,120 ft^2

TA = Total Area
= 3,900 ft^2

PA = Percent area to be used
= 80%

UE = Usable Energy
= IL x PC x SP
= 90% x 1.14 kWh/Watts DC-year x 12 Watts DC/ft^2
= 12.3 kWh/ft^2-year

IL = Inverter Loss
= 90%

PC = Production Capacity
= 1.14 kWh/Watts DC-year

SP = Solar Panel Rating
= 12 Watts DC/ft^2

AP = Average Power
= UE x A x YH
= 12.3 kWh/ft^2-year x 3,120 ft^2 x 1 year / 8,760 hr
= 4.4 kW

YH = Years in hours
= 1 year / 8,760 hr

Cost Analysis

We calculate implementation costs on a per kilowatt basis because the major costs in a photovoltaic array are related to how much power the array will generate.

IC	=	Implementation Cost
	=	AP x (NC + LC + PC)
	=	4.4 kW x ($721/kW + $893/kW + $4,821/kW)
	=	$28,300

Where,

NC	=	Inverter Cost
	=	$721/kW
LC	=	Labor Cost
	=	T x CW x PW
	=	2 hr/Panel x $85/hr x 5.25 Panels/kW
	=	$893/kW

Where,

T	=	Time for Installation
	=	2 hr/Panel
CW	=	Crew Wage
	=	$85/hr
PW	=	Number of panels per kW
	=	5.25 Panels/kW
PC	=	Panel and Mounting Cost
	=	$4,821/kW

Before incentives, savings will pay for implementation cost in approximately 14.9 years.

Incentive Summary

You may be eligible for the Oregon Business Energy Tax Credit (BETC). For photovoltaic arrays meeting efficiency and longevity standards, the tax credit is 50% of eligible project costs. This credit is claimed over five years (10%, 10%, 10%, 10%, 10%), or over one year for projects with implementation costs of less than $20,000. The BETC has a pass-through option in which the tax credits can be sold to another company in exchange for a lump sum equal to 33.5% of the implementation cost. The pass-through calculation is used below.

BETC	=	Oregon Business Energy Tax Credit		
	=	The lesser of (33.5% x EC	or	$20,000,000) - AF
	=	The lesser of (0.335 x $28,300	or	$20,000,000) - $170
	=	The lesser of ($9,481	or	$20,000,000) - $170
	=	$9,300		

EC	=	Eligible Cost
	=	The lesser of IC or ME
	=	The lesser of $28,300 or $36,300
	=	$28,300
ME	=	Maximum Eligible Cost
	=	ODOE Rate x AP
	=	$8.25/W x 1000 W/kw x 4.4 kW
	=	$36,300
AF	=	Application Fee
	=	The lesser of (0.6% x IC) or $35,000
	=	The lesser of (0.006 x $28,300) or $35,000
	=	$170

You may also be eligible for the Federal Investment Tax Credit. Photovoltaic projects receive a tax credit equal to 30% of implementation costs, although this is reduced to 10% for projects that apply for the incentives after December, 2008.

FITC	=	Federal Investment Tax Credit
	=	30% x IC
	=	0.3 x $28,300
	=	$8,500

In Oregon, renewable energy systems are exempt from property tax.

The following table summarizes incentives and net costs.

Incentive Summary	
Description	Cost
Pre-incentive Cost	**$28,300**
Business Energy Tax Credit	($9,300)
Federal Investment Tax Credit	($8,500)
Total After Incentives	**$10,500**

As calculated above, savings will pay for implementation in 3.6 years after incentives.

Note: If the full BETC tax credit is used, savings will pay for implementation in 2.0 years. Also, the cost savings, incentives, and implementation costs depend on average wattage, which is dependent on total size. This means that the total cost savings per square foot, implementation cost per square foot, and incentives per square foot will all be constant. Therefore, the controlling factors for determining the square footage of a photovoltaic array are available roof space and electrical demand.

APPENDIX A

UTILITIES

A.1. Energy Definitions

An essential component of any energy management program is tracking energy. When utility bills are received, we record energy use and cost in a spreadsheet and get the appropriate graphs. A separate spreadsheet may be required for each type of energy used, such as oil, gas, or electricity. A combination might be merited when both gas and oils are used interchangeably in a boiler. In such a case we suggest using a common energy unit for a cost-benefit analysis that can represent most fuel options: the Btu.

We have prepared a utility spreadsheet analysis based on the information provided by you or your utility companies. The worksheets are in section A.3, Energy, Waste, and Production Accounting. They show how energy is used and help identify potential energy savings.

We use specific terminology and calculations in analyzing and discussing your energy, water, and waste expenses. Energy related terms and calculations are detailed below followed by those for waste and water.

Electricity Definitions:

Average Energy Cost. The total amount billed for 12 months of energy, divided by the total number of energy units. Each energy type (oil, gas, electricity, propane, etc.) has its own average energy cost. The average cost per energy unit includes the fees, taxes and unit cost.

Average Energy Cost = (Total Billed $) ÷ (Total Energy Units)

Average Load Factor. The ratio of annual electrical energy use divided by the average kilowatts (kW) and the hours in a year.

Average Load Factor = (Total kWh/yr) ÷ (Average kW x 8,760 hrs/yr)

Average Load Factor expresses how well a given electrical system uses power. A higher load factor yields lower average energy cost.

An example of how load factor applies: A large air compressor has high electric demand for small periods of time and is not a large energy user. It will usually have low load factor and relatively high demand charges. A smaller air compressor that runs for longer periods of time at higher part load efficiency will have higher load factor and lower demand charges.

Basic Charge. The fee a utility company can charge each month to cover their administrative, facility, or other fixed costs. Some companies have higher energy or power rates that compensate for no or low basic charge.

Energy. The time-rate of work expressed in kWh for electric energy. The common unit is million Btu. For a more complete description, see Power.

Energy = Work ÷ Time = (Force x Distance) ÷ Time

Incremental Demand Cost. It is the price charged by your utility company for the capacity to meet your power needs at any given time. Peak demand is the highest demand level required over a set period of time and is calculated by continuously monitoring demand levels. Demand is usually billed based on peak power, but charges such as facility charges and other fees billed per kW are also included in the incremental demand cost. If your utility company has stepped demand cost rates, the step with the greatest demand is considered in the incremental demand cost. If your utility company bills one set rate for all power needs, this value is used as the incremental demand cost.

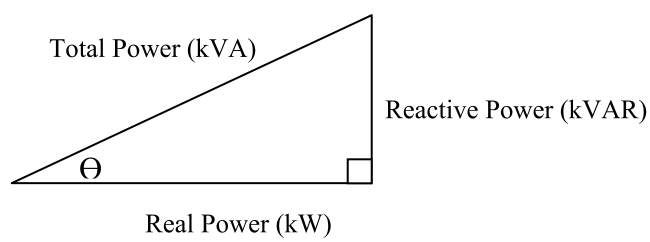
Incremental Energy Cost (Electricity). It is cost of one more unit of energy, from current use. This cost is usually taken from your utility rate schedule. When all large meters are on the same rate schedule, the incremental energy cost is the cost from the highest energy tier, or tail block. To further clarify this method: if a company is charged $0.05/kWh up to 100,000 kWh, and $0.03/kWh over 100,000 kWh and they are consistently buying over 100,000 kWh each month, any energy savings will be calculated using the $0.03/kWh cost.

If your company has multiple meters on different rate schedules or tariffs, the incremental cost is calculated by adding electrical energy costs and dividing by the total electrical energy use.

Incremental Energy Cost = (Total kWh $) ÷ (Total kWh)

Minimum Charge. The least amount billed by a utility at the end of the billing period.

Power (and Energy). The rate at which energy is used, expressed as the amount of energy use per unit time, and commonly measured in units of watts and horsepower. Power is the term used to describe the capacity the utility company must provide to serve its customers. Power is specified three ways: real, reactive and total power. The following triangle gives the relationship between the three.



Real power is the time average of the instantaneous product of voltage and current (watts). Apparent power is the product of rms (root mean square) volts and rms amps (volt-amps).

Demand

The highest electrical power required by the customer, generally averaged over 15 minute cycling intervals for each month. Demand is usually billed by kW unit.

Kilovolt Amperes (kVA)

Kilovolt amperes are a measure of the current available after accounting for power factor. See the triangle on the previous page. Power is sometimes billed by kVA.

Reactive Power

Reactive power is measured in units of kVAR. Reactive power produces magnetic fields in devices such as motors, transformers, and lighting ballasts that allow work to be done and electrical energy to be used. Kilo Volt Amperes Reactive (kVAR) could occur in an electrical circuit where voltage and current flow are not perfectly synchronized. Electric motors and other devices that use coils of wire to produce magnetic fields usually cause this misalignment of three-phase power. Out-of-phase current flow causes more electrical current to flow in the circuit than is required to supply real power. kVAR is a measure of this additional reactive power.

High kVAR can reduce the capacity of lines and transformers to supply kilowatts of real power and therefore cause additional expenses for the electrical service provider. Electric rates may include charges for kVAR that exceed a normal level. These charges allow the supplying utility to recover some of the additional expenses caused by high KVAR conditions, and also encourages customers to correct this problem.

Power Factor

The ratio of real power to total power. Power factor is the cosine of angle θ between total power and real power on the power triangle.

$$PF = \cos\theta = kW \div kVA$$

Disadvantages of Low Power Factor

- Increases costs for suppliers because more current has to be transmitted requiring greater distribution capacity. This higher cost is directly billed to customers who are metered for reactive power.
- Overloads generators, transformers and distribution lines within the plant, resulting in increased voltage drops and power losses. All of which represents waste, inefficiency and wear on electrical equipment.
- Reduces available capacity of transformers, circuit breakers and cables, whose capacity depends on the total current. Available capacity falls linearly as the power factor decreases.

Low Power Factor Charges

Most utilities penalize customers whose power factor is below a set level, typically in the range of 95% - 97%, or kVAR greater than 40% of kW. Improving power factor may reduce both energy and power costs, however these are generally much less than savings from real power penalties enforced by electrical utilities. Energy savings are also difficult to quantify. Therefore in our recommendations, only power factor penalty avoidance savings are included.

Improving Power Factor

The most practical and economical power factor improvement device is the capacitor. All inductive loads produce inductive reactive power current (lags voltage by a phase angle of 90°). Capacitors, on the other hand, produce capacitive reactive power, which is the opposite of inductive reactive power (current leads…). Current peak occurs before voltage by a phase angle of 90°. By careful selection of capacitance required, it is possible to totally cancel out the inductive reactive power, but in practice it is seldom feasible to correct beyond your utilities' penalty level (~95% for kVA meters).

Improving power factor results in:

- Reduced utility penalty charges.
- Improved plant efficiency.
- Additional equipment on the same line.
- Reduced overloading of cables, transformers, and switchgear.
- Improved voltage regulation due to reduced line voltage drops and improved starting torque of motors.

Power Factor Penalty

Utility companies generally calculate monthly power factor two ways. One way is based on meters of reactive energy and real energy.

$$\text{Monthly PF} = \cos\left[\tan^{-1}(\text{kVARh} \div \text{kWh})\right]$$

The second method is based on reactive power and real power.

$$\text{Monthly PF} = \cos\left[\tan^{-1}(\text{kVAR} \div \text{kW})\right]$$

Power Factor is often abbreviated as "PF". Also see the Power Factor definition below.

Cost Calculations

Annual operating expenses include both demand and energy costs. Demand cost (DC) is calculated as the highest peak demand (D) multiplied by your incremental demand charge and the number of operating months per year:

$$\text{DC} = \text{D x demand rate (\$/kW·mo) x 12 mo/yr}$$

Energy cost (EC) is energy multiplied by your incremental electric rate:

$$\text{EC} = \text{E x energy rate (\$/kWh)}$$

Natural Gas Definitions:

Rate Schedules. (Or tariffs) specify billing procedures and set forth costs for each service offered. The state public utility commission approves public utility tariffs. For example: an electric utility company will set a price or schedule of prices for power and energy and specify basic and PF charges. A natural gas utility will specify cost to supply or transport gas and include costs such as price per therm, basic charge, minimum charges and other costs. Current rate schedules can often be found online at the utility company's website. If you think your company belongs in a different rate schedule, your utility representative can help you best.

Tariff. Another term for *rate schedule*.

Therm. The unit generally used for natural gas (1 therm = 100,000 Btu), but sometimes it is measured in 10^6 Btu.

Commodity Rate. The component of the billing rate that represents the company's annual weighted average commodity cost of natural gas.

Transportation. The movement of customer-owned natural gas from the pipeline receipt point(s)

Waste and Water Definitions:

Average Disposal Cost. The average cost per pickup or ton of waste or other scrap material. This cost is calculated using all of the annual expenses to get a representative cost per unit of disposal.

Average Disposal Cost / Ton = (Total Disposal $) ÷ (Total tons removed)

Average Disposal Cost / Pickup = (Total Disposal $) ÷ (Total number of pickups)

BOD Charge. Charge levied by the sewer/water treatment utility to cover extra costs for high strength wastewater. High strength wastewater requires more intensive treatment by the utility and extra processing due to very low oxygen levels. BOD, biochemical oxygen demand, is a measure of how much oxygen will be used to microbiologically degrade the organic matter in the wastewater stream. State agencies such as a Department of Environmental Quality set BOD and other regulations that wastewater treatment facilities must meet to discharge treated water into nearby waterways. Your treatment facility may have ideas that could help lower the strength of your wastewater.

Box Rental Charge. The fee imposed by the waste or recycling utility to cover costs of their receiving containers.

Disposal Cost. Incurred by the waste utility for disposing of your waste in a landfill or other facility. These charges increase when hazardous materials are present in the waste.

Pickup Costs. The cost charged by the waste utility for each pickup of waste or recycling. This charge is usually applied when the utility is working on an "on call" basis. Pickup costs can also be a flat rate for a certain number of pickups per month.

A.2. Energy Conversions

An essential component of any energy management program is a continuing account of energy use and its cost. This can be done best by keeping up-to-date graphs of energy consumption and costs on a monthly basis. When utility bills are received, we recommend that energy use be immediately plotted on a graph. A separate graph will be required for each type of energy used, such as oil, gas, or electricity. A combination will be necessary, for example, when both gas and oil are used interchangeably in a boiler. A single energy unit should be used to express the heating values of the various fuel sources so that a meaningful comparison of fuel types and fuel combinations can be made. The energy unit used in this report is the Btu, British Thermal Unit, or million Btu's (10^6 Btu). The Btu conversion factors and other common nomenclature are:

Energy Unit	**Energy Equivalent**	
1 kWh	3,413	Btu
1 MWh	3,413,000	Btu
1 cubic foot of natural gas	1,030	Btu
1 gallon of No. 2 oil (diesel)	140,000	Btu
1 gallon of No. 6 oil	152,000	Btu
1 gallon of gasoline	128,000	Btu
1 gallon of propane	91,600	Btu
1 pound of dry wood	8,600	Btu
1 bone dry ton of wood (BDT)	17,200,000	Btu
1 unit of wood sawdust (2,244 dry pounds)	19,300,000	Btu
1 unit of wood shavings (1,395 dry pounds)	12,000,000	Btu
1 unit of hogged wood fuel (2,047 dry pounds)	17,600,000	Btu
1 ton of coal	28,000,000	Btu
1 MWh	1,000	kWh
1 therm	100,000	Btu
1 MMBtu	1,000,000	Btu
1 10^6Btu	1,000,000	Btu
1 kilowatt	3,413	Btu/hr
1 horsepower (electric)	2,546	Btu/hr
1 horsepower (boiler)	33,478	Btu/hr
1 ton of refrigeration	12,000	Btu/hr

Unit Equivalent		
1 gallon of water	8.33	pounds
1 cubic foot of water	7.48	gallons
1 kgal	1,000	gallons
1 unit wood fuel	200	ft^3

The value of graphs can best be understood by examining those plotted for your company in the Energy Summary. Energy use and costs are presented in the following tables and graphs. From these figures, trends and irregularities in energy usage and costs can be detected and the relative merits of energy conservation can be assessed.

APPENDIX B

LIGHTING

B.1 Lighting Worksheet Definitions

The following lighting inventory and any lighting worksheets contained in the report use information obtained during the on-site visit to determine any potential energy savings related to lighting improvements. In all cases the value in the Savings column is the existing value less the proposed value. The terminology and calculations are described as follows:

PLANT

Building. A description of the building if the plant includes several buildings.

Area: The lighting calculations may refer to a specific location within the building.

Recommended Footcandles. The recommended footcandle levels come from the Illuminating Engineering Society (IES) Lighting Handbook.

Average Demand Cost (D$). The demand cost ($/kW-month) is taken from the appropriate rate schedule of your utility. Winter and summer rates are averaged, if necessary.

Average Energy Cost (E$). The energy cost ($/kWh) is taken from the appropriate rate schedule of your utility for the least expensive energy block. Winter and summer rates are averaged, if necessary.

Labor Cost ($/H). The cost of labor is estimated for operating and installation cost calculations.

FIXTURES

Description (FID). Fixture type, size, manufacturer, or catalog number may be included here.

Quantity (F#). The number of fixtures in the area are recorded during the site visit.

Operating Hours (H). The number of hours which the lighting fixtures operate each year.

Use Factor (UF). The fraction of fixtures that are used multiplied by the fraction of operating hours (H) that the lights are on.

Lamps/Fixture (L/F). The number of lamps in each fixture.

Ballasts/Fixture (B/F). The number of ballasts in each discharge fixture.

Cost (FC). The cost of the existing and proposed fixtures can be compared when modifying or replacing fixtures.

LAMPS

Description (LID). Lamp type, size, manufacturer, or catalog number may be included here.

Quantity (L#). The number of lamps can be calculated from the number of fixtures and the number of lamps per fixture:

$$L\# = F\# \times L/F$$

Life (LL). Lamp life is defined as the number of operating hours after which half the original lamps will fail. The life recorded here is based on 3 operating hours per start. This provides a more conservative estimate of lamp life than using longer hours per start.

Replacement Fraction (Lf). The fraction of lamps that normally can be expected to burn out during a year can be calculated from the operating hours, the use factor, and the lamp life:

$$Lf = H \times UF / LL$$

Watts / Lamp (W/L). The rated lamp power does not include any ballast power, which is included in the Ballasts section.

Lumens (LM). Lamp output is measured in lumens. Lumens are averaged over lamp life because lamp output decreases with time.

Cost (C/L). The retail cost per lamp is entered here.

BALLASTS

This section applies only to discharge lamps with ballasts. This section will be blank for incandescent lamps.

Description (BID). Additional information such as type, size, manufacturer, or catalog number may be included here.

Quantity (B#). The number of ballasts can be calculated from the number of fixtures and the number of ballasts per fixture:

$$B\# = F\# \times B/F$$

Life (BL). Ballast life is determined from manufacturer's data. A life of 87,600 hours for a standard ballast and 131,400 hours for an efficient ballast is used in the calculations.

Replacement Fraction (Bf). The fraction of ballasts normally expected to burn out during a year can be calculated from the operating hours, the use factor, and the ballast life:

$$Bf = H \times UF / BL$$

Input Watts (IW). Ballast catalogs specify ballast input watts that include lamp power. The input wattage varies for different combinations of lamps and ballasts.

Cost (BC). The retail ballast cost is entered here.

POWER AND ENERGY

Total Power (P). For incandescent lamps total power is the product of the number of lamps and the watts per lamp.

$$P = L\# \times W/L \qquad \text{(Incandescent Lamps)}$$

For discharge lamps total power is the product of the ballast input watts and the number of ballasts:

$$P = B\# \times IW \qquad \text{(Discharge Lamps)}$$

Energy Use (E). The annual energy use is the product of the total power, the use factor, and the annual operating hours:

$$E = P \times UF \times H / (1{,}000 \text{ watts/kilowatt})$$

LIGHT LEVEL CHECK

Total Lumens (TLM). The existing and proposed lumen levels are summed for all lamps.

$$TLM = L\# \times LM$$

Footcandles (FC). Light is measured in units of footcandles. The existing footcandle level (FC0) is measured, while the proposed level (FC1) is determined from the ratio of the proposed total lumens (TLM1) to existing total lumens (TLM0) times the existing footcandle level.

$$FC1 = FC0 \times (TLM1 / TLM0)$$

The proposed footcandle level can then be compared to both the existing and the recommended levels to determine if there will be adequate light for the work space.

Lumens / Watt (LM/W). The total lamp output in lumens divided by the total power is a measure of lighting efficiency.

LM/W = TLM / P

ANNUAL OPERATING COST

Power Cost (PC). The annual demand cost is the total power times the average monthly demand cost from the worksheet times 12 months per year:

PC = P x D$ x 12 months/year

Energy Cost (EC). The annual energy cost is the energy use times the electricity cost from your utility rate schedule:

EC = E x E$

Lamp O&M Cost (LOM). Operation and maintenance costs are the sum of lamp and labor costs for replacing the fraction of lamps (L# x Lf) that burn out each year.

LOM = L# x Lf x [LC + (0.166 hours x $/H)]

We assume that two people can replace a lamp and clean the fixture and lens in about five minutes (0.166 man-hours/lamp), replacing lamps as they burn out.

Ballast O&M Cost (BOM). Operation and maintenance costs are the sum of ballast (BC) and labor costs ($/H) for replacing the fraction of ballasts (B# x Bf) that burn out each year.

BOM = B# x Bf x [BC + (0.5 hours x $/H)]

We assume that one person can replace a ballast in about thirty minutes (0.5 man-hours/ballast), replacing ballasts as they burn out.

Total Operating Cost (OC). The sum of the annual power and energy costs and lamp and ballast O&M costs.

OC = PC + EC + LOM + BOM

IMPLEMENTATION COST

The implementation costs depend on whether refixturing, group relamping, or spot replacing of lamps and ballasts is recommended.

Refixturing

Materials: The cost is the cost per fixture (C/F) times the number of fixtures (F#) plus the lamp cost (LC) times the number of lamps (L#).

M$ = F# x (C/F) + L# x C/L

Labor: The labor cost includes the removal of the existing fixtures and the installation of the recommended fixtures.

Group Relamping

Materials: When replacing all lamps at one time (group relamping), the cost of materials can be found from

M$ = L# x C/L

Labor: We estimate the labor cost for group relamping to be one half the cost of replacing each lamp as it burns out. We assume that two people can replace two lamps and clean the fixture and lens in about 5 minutes (0.083 man-hours/lamp, H/L). Because relamping does not require a licensed electrician, the labor rate for relamping is often lower than the labor rate for fixture replacement. To calculate the total labor cost for group lamp replacement we calculate the labor cost of group replacing all of the lamps.

L$GROUP = L# x H/L x $/H

Spot Replacement of Lamps & Ballasts

Materials: When replacing lamps only as they burn out (spot relamping), we use the cost difference (LC1 - LC0) between standard and energy-efficient lamps for all lamps.

M$ = L# x (LC1 - LC0)

When replacing ballasts only as they burn out (spot reballasting), we use the cost difference (BC1 - BC0) between standard and energy-efficient ballasts for all ballasts.

M$ = B# x (BC1 - BC0)

Labor: There is no additional labor cost.

Total Cost (IC). Total implementation cost is the sum of materials and labor cost

IC = M$ + L$

SIMPLE PAYBACK.

The simple payback (SP) is calculated on each lighting worksheet.

SP = IC / OC

B.2 LIGHTING INVENTORY & ENERGY CONSUMPTION

Area	CODE	Description	FC	Qty Fixtures	Lamps/ Fixture	Ballasts/ Fixture	Watts/ Lamp	Input Watts	Output Factor	Hr/Yr	kW	kWh
Meeting Room	IF150	150 Watt Incand.		13	1	0	150	0	100%	2,080	2	4,160
Meeting Room	OFT12-5	4 Ft T12 Mag.		8	4	2	34	72	100%	2,080	1.2	2,496
Drying Room	OFT12-5	4 Ft T12 Mag.		12	4	2	34	72	100%	2,080	1.7	3,536
Storage Room	IF150	150 Watt Incand.		2	1	0	150	0	100%	780	0.3	234
Storage Room	OFT12-5	4 Ft T12 Mag.		4	4	2	34	72	100%	780	0.6	468
Refrigerator Motor Room	OFT12-5	4 Ft T12 Mag.		2	4	2	34	72	100%	780	0.3	234
Cold Room	HDT8-2	4 Ft T8 Elec.		4	4	1	32	112	100%	260	0.4	104
Storage Next to Cold Room	HDT12-6	8 Ft HO T12 Mag.		2	2	1	110	237	100%	780	0.5	390
Hazelnut Lab	HDT8-2	4 Ft T8 Elec.		30	4	1	32	112	100%	2,496	3.4	8,486
Workshop/Garage	IF300	300 Watt Incand.		4	1	0	300	0	100%	2,496	1.2	2,995
Workshop/Garage	OFT12-5	4 Ft T12 Mag.		20	4	2	34	72	100%	2,496	2.9	7,238
Totals											**14.5**	**30,341**

APPENDIX C

ECOSYSTEM SERVICES

On a Fact Sheet on Ecosystem Services[7], the Ecological Society of America states that “natural ecosystems perform fundamental life support services upon which human civilization depends. Unless human activities are carefully planned and managed, valuable ecosystems will continue to be impaired or destroyed."

B.1 Services

Ecosystems provide "services" that:

- moderate weather extremes and their impacts
- disperse seeds
- mitigate drought and floods
- protect people from the sun's harmful ultraviolet rays
- cycle and move nutrients
- protect stream and river channels and coastal shores from erosion
- detoxify and decompose wastes
- control agricultural pests
- maintain biodiversity
- generate and preserve soils and renew their fertility
- contribute to climate stability
- purify the air and water
- regulate disease carrying organisms
- pollinate crops and natural vegetation

B.2 Valuation

A more in-depth article[8] on ecosystem services from the Ecological Society of America states that it is very difficult to place a value on these services. While all of humanity would perish in the absence of ecosystem services, it is very difficult to assign a value, for example, to the pollination that occurs due to a particular type of insect. One ecosystem service that has enjoyed lots of press lately and has a market value is Carbon Offsets.

B.3 Carbon Offsets

Wikipedia defines a Carbon Offset[9] as a financial instrument representing a reduction in greenhouse gas emissions. As greenhouse gases buildup in the atmosphere, they trap heat which would otherwise be radiated out into space. This process, referred to as the "greenhouse effect," has been linked to a steady increase in the amount of atmospheric carbon dioxide (CO_2).

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[7] http://www.esa.org/ecoservices/comm/body.comm.fact.ecos.html
[8] http://www.esa.org/science_resources/issues/FileEnglish/issue2.pdf
[9] http://en.wikipedia.org/wiki/Carbon_offset

Therefore, any measure which results in a reduction of atmospheric CO_2 is providing an ecosystem service which, in this case, can be bought and sold on the open market.

As you know, plants provide the ecosystem service of converting this CO_2 into oxygen daily. And that's exactly where farmers and forest managers have an opportunity to get paid to manage their land in certain ways. Although carbon credits are traded on the Chicago Climate Exchange[10], the commodity unit is 100 metric tons which is usually more than any one land user can claim. Aggregators, such as AgraGate[11], bundle up many landowners' offsets and sell them. AgraGate offers contracts for cropland, grassland, and forestlands of varying durations.

[10] http://www.chicagoclimatex.com/
[11] http://www.agragate.com/