Best Management Practices for Climate Friendly Nurseries

Oregon Association of Nurseries
Oregon Environmental Council
Oregon State University
Ecos Consulting

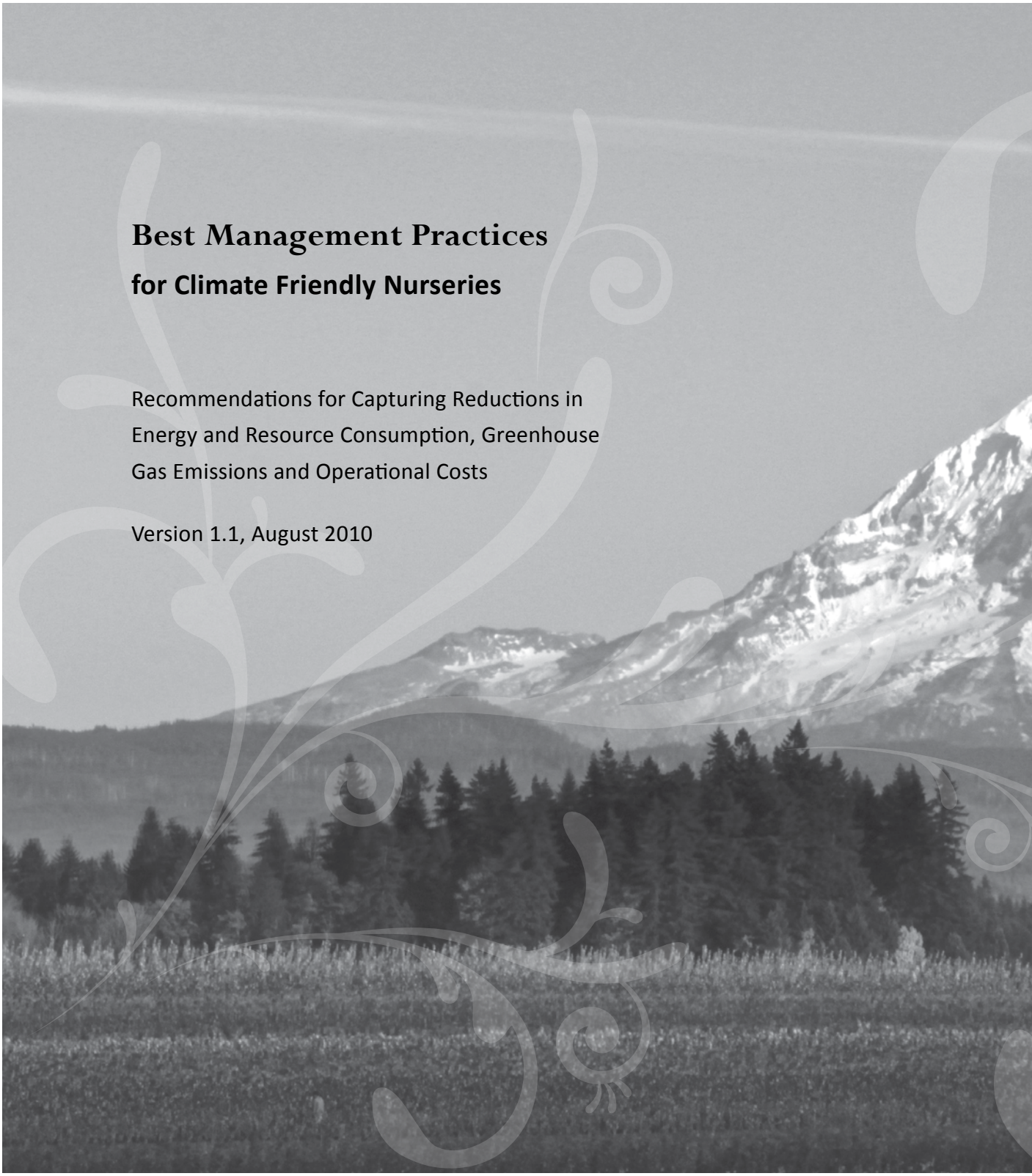
2010

Best Management Practices

for Climate Friendly Nurseries

Recommendations for Capturing Reductions in Energy and Resource Consumption, Greenhouse Gas Emissions and Operational Costs

Version 1.1, August 2010



This guide was developed as part of the Climate Friendly Nurseries Project (CFNP), a collaborative partnership between the Oregon Association of Nurseries and the Oregon Environmental Council. The first of its kind in the nation, the project's central goal is to help participating nurseries reduce energy, resource inputs and greenhouse gas (GHG) emissions while achieving greater economic efficiency and profitability. Ecos Consulting and Oregon State University serve as invaluable resources for the CFNP, both bringing research expertise and technical assistance that benefit participating nurseries. This guide provides:

- Recommendations for best practices that will reduce your energy and resource use, reduce costs, and at the same time, make your nursery more climate-friendly
- Case studies of Oregon nurseries that have already implemented these best management practices
- An overview of incentives to help nurseries pay for resource efficiency improvements

We hope you find this guide a valuable resource, and encourage you to find more resources and information about operational efficiencies that protect our natural resources at www.climatefriendlynurseries.org. On this website, you'll find tools to help you track your energy and resource use and calculate potential return on investment for best management practices (BMPs). We'll continue to add information about additional BMPs to the website as they are developed.

We welcome feedback about the guide, and encourage you to share your nursery's experience with efficiency improvements on the website.

Whitney Rideout
Oregon Association of Nurseries

Allison Hensey
Oregon Environmental Counci

For additional information regarding the Climate Friendly Nurseries Project, go to www.climatefriendlynurseries.org, or contact:

Oregon Association of Nurseries:		www.oan.org
	Whitney Rideout	wrideout@oan.org
Oregon Environmental Council:		www.oeconline.org
	Allison Hensey	allisonh@oeconline.org
Oregon State University – North Willamette Research & Extension Center:		
		oregonstate.edu/dept/NWREC
	Jim Owen	jim.owen@oregonstate.edu
Ecos Consulting:		www.ecosconsulting.com
	Brad Denig	bdenig@ecosconsulting.com
	Hester Yorgey	hyorgey@ecosconsulting.com

Introduction

We are pleased to present this Best Management Practices Guide for Climate Friendly Nurseries, compiled as part of the Climate Friendly Nurseries Project (CFNP). The CFNP is an innovative effort that rose out of a collaborative partnership between the Oregon Association of Nurseries and the Oregon Environmental Council, and is an additional step in the nursery industry's work to proactively address natural resource issues. The first of its kind in the nation, the CFNP's central goal is to help participating nurseries reduce energy, resource inputs and greenhouse gas (GHG) emissions while achieving greater economic efficiency and profitability. Ecos Consulting and Oregon State University also serve as valuable resources for the CFNP, both bringing research expertise and technical assistance that benefit participating nurseries. Through the CFNP, participating nurseries quantify their energy and resource use and GHG emissions, and identify specific ways to reduce both. The project team also helps participating nurseries identify grants, low interest loans, and tax credits for energy and resource efficiency upgrades, and technical resources to assist with the upgrades.

The nursery industry is a proactive and innovative one, and many nurseries have already implemented practices that have had a positive impact on their environmental footprints. In addition, Oregon has a relatively clean fuel mix for grid-based energy, causing nurseries' energy-related emissions to be lower than they would be in other regions of the country.

Still, there are always additional opportunities for nurseries to take advantage of when looking for ways to reduce both their environmental impacts and the associated operational costs. The management and reduction of resource consumption and GHG emissions is a long-term process that achieves the following strategic objectives:

- Increase nurseries' understanding of resource-related costs, giving them more information with which to make informed business decisions, increase efficiency and reduce overall operational costs
- Proactively reduce operational GHG emissions and resource consumption
- Enable nurseries to be leaders on climate change in Oregon and beyond

The Best Management Practices Guide for Climate Friendly Nurseries is intended to assist all nurseries with these goals. The guide contains the following sections:

- GHG Basics. A short tutorial on GHG emissions, how they are tracked, and some of the major emission categories affecting the nursery sector.
- Best Management Practices. Six best management practices that, when implemented, possess considerable resource and financial savings for nurseries. These measures were chosen for their applicability to the nursery sector, and by assessing the level of opportunity in terms of energy and GHG reduction for the costs associated with their implementation. These practices have good investment value for many nurseries, and are described in detail, including estimated costs and savings.
- Case Studies. An examination of several nursery participants of the Climate Friendly Nurseries Project. In these case studies, we depict their experience implementing some of the best management practices described in this guide. In these case studies, nurseries describe implementation successes and challenges, as well as lessons learned and where measured, savings captured.
- No-Cost/Low-Cost Opportunities. A list of efficiency measures that nurseries can implement with very little or no cost to their operations.

- Opportunities Requiring Upfront Capital. A list of best management practices that require upfront capital to implement, but that have good GHG reduction and savings potential for the nursery industry.
- Incentives and Rebates. Detailed information regarding the grants, tax incentives and rebates available to businesses implementing recommended best management practices.
- Next Steps. A discussion of the steps that nurseries can take to move towards project implementation including the use of savings calculators and onsite audits to determine project viability and payback.

It is our hope that this guide will not only be used as a tool that can be used in the decision-making process for those of you who wish to implement efficiency measures, but that it will also act as a catalyst for nurseries to share practical experience with your colleagues and discuss results of previously implemented best practices.

There are a multitude of opportunities that nurseries can profit from while reducing their companies' resource consumption and GHG emissions. We plan to publish later versions of this guide with new additions and updates in the future; in upcoming iterations, we plan to include additional best management practices and case studies, and to update all incentive information to appropriately portray opportunities. You can find the most up-to-date information regarding this guide and the Climate Friendly Nurseries Project at www.climatefriendlynurseries.org.

Guide Methodology

Best Management Practices Selection

This guide highlights six strategies that will capture high resource and cost savings for the upfront capital incurred, in addition to providing general descriptions of numerous opportunities for reducing your resource consumption and GHG footprint. The measures described in this guide include both low-cost/no-cost opportunities as well as larger capital projects.

To select the best management practices with the largest opportunity for resource and cost savings, we first considered the relevance of each measure to nursery operations throughout Oregon. We then estimated each practice's potential return on investment (ROI, or the net savings divided by the cost). We then prioritized best management practices by applicability, energy efficiency ROI and GHG mitigation ROI, and were able to establish the practices with the highest potential for nurseries as a group.

To their credit, many nurseries have already implemented a number of best management practices and should be recognized for their commitment to resource efficiency. While we have chosen to draw attention to these particular best practices, there are a multitude of management strategies with good potential for saving money, time, and resources; many additional opportunities are referenced in the "Low-Cost/No-Cost Opportunities" and "Best Management Practices Requiring Upfront Capital" sections of this guide, and there are other options beyond those included here. It is important to note that the practices with the highest potential for some nurseries may not work for others due to the variety of nursery parameters, infrastructure and operations throughout the industry. This guide, therefore, comprises a menu of options to consider implementing, and should serve as a starting point for further investigation. You can find the most up-to-date recommendations and information at www.climatefriendlynurseries.org.

Presentation of Savings Potential

This Best Management Practices Guide was designed to speak to all nurseries throughout Oregon, which comprises a very diverse group of businesses in terms of size, age, type of nursery operations, products sold, and level of efficiency. While the measures included in this guide have the potential to generate savings for all participants, it was necessary to maintain a general level of detail regarding cost and savings potential because the results will be different for each nursery. For example, a large nursery with inefficient lighting will have a much larger cost and concurrent energy savings profile after implementing efficient lighting improvements than a small nursery that has previously upgraded some of their lighting systems.

To give some context for nurseries considering further analysis of the six highlighted measures, we therefore present a general range of cost, savings potential, and payback for two sizes of nurseries—one that is 40 acres, and another that is 400 acres. The actual cost and savings potential for each nursery will invariably be different than any others; our presentation of cost and savings potential here is solely to give nurseries some idea of the size of each opportunity. To additionally offer some guidance regarding all of the opportunities listed in the "Low-Cost/No-Cost Opportunities" and "Best Management Practices Requiring Upfront Capital" sections of this guide, we rate the energy efficiency opportunity, GHG reduction opportunity, and applicability to nursery operations for each measure included in this guide with a "high," "medium," or "low" rating.

Model Nurseries: Potential Savings and Payback

To further demonstrate resource and cost savings potential for the six highlighted best management practices in a way that will be as meaningful as possible for all nurseries utilizing this Guide, we have created a working document that presents two fictitious model nurseries with specific parameters; for each of the six measures, we present costs and savings according to these model scenarios. By providing savings calculations captured by a nursery with a certain set of parameters, nurseries will have the opportunity to gain a general sense of the savings they can derive by implementing each measure at their own facility. The model nurseries can be found at www.climatefriendlynurseries.org.

While these model scenarios are completely fabricated, we used our interaction with CFNP participants and vetted our work with industry experts to ensure that they were realistic and meaningful in nature. We continue to do so in order to present data that is as close as possible to actual nursery operations, and in the spirit of continuous improvement, we welcome your feedback and commentary on our results (please see page 4 at the beginning of this document for contact information).

GHG Inventory Tool

We have also developed a GHG Inventory Tool as part of the CFNP, which enables a nursery to track its energy and resource usage and GHG emissions footprint, and measure reductions over time. Measuring energy and resource usage can present savings opportunities that were not previously apparent. Nurseries can download this tool at www.climatefriendlynurseries.org.

Greenhouse Gases: The Basics

Gases that trap heat in the atmosphere are called greenhouse gases. Some greenhouse gases (such as carbon dioxide, or CO2) occur naturally and are emitted by both natural processes and human activities, while other gases are created and emitted only through human activities. According to the U.S. Environmental Protection Agency (EPA) and the Intergovernmental Panel on Climate Change (IPCC), humans have significantly increased the total amount of greenhouse gases in the atmosphere during the past century by burning fossil fuels such as coal, natural gas, oil and gasoline to employ cars, factories, utilities and appliances and through other activities. The gases emitted from these activities are enhancing the natural greenhouse effect, and likely contributing to an increase in global average temperature and related climate changes.

Greenhouse Gas Reporting

To understand the effect that their operations have on the environment, many companies are tracking their greenhouse gas (GHG) emissions and taking strides to reduce their impact as much as possible. Annual GHG reporting in the U.S. is standardized in the U.S. by The Climate Registry (www.theclimateregistry.org), which determined the best methodology for reporting GHG emissions based on the development of an international framework created by the World Resources Institute and World Business Council for Sustainable Development to standardize GHG accounting.

The process of creating an annual GHG inventory provides companies with information regarding the activities that cause emissions, allowing them to focus on those activities with the largest impact. To assist with this, standard reporting separates GHG emissions into three scopes.

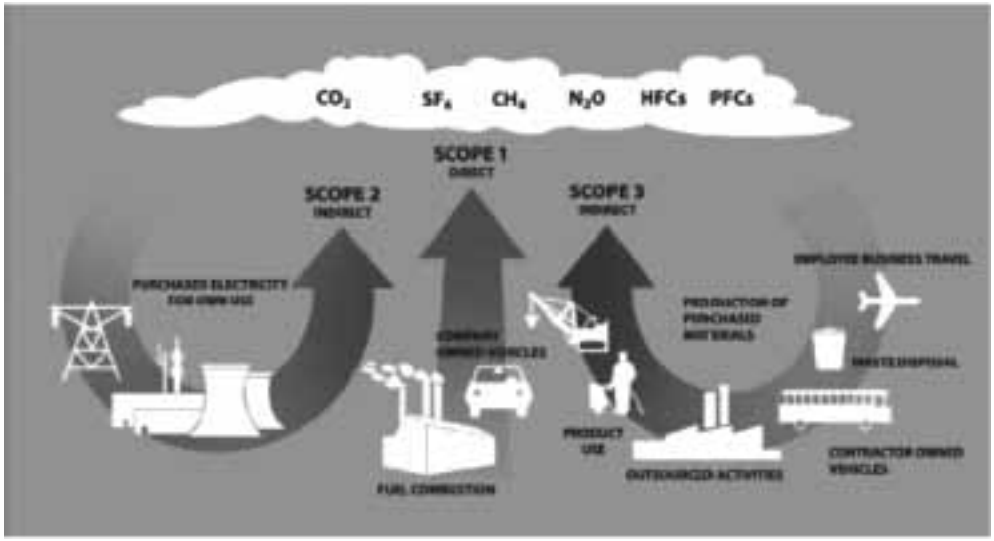


Figure 1: Standard Emission Scopes in GHG Reporting

- Scope 1 emissions are those over which a company has direct control via ownership of activities; this includes emissions from all stationary and mobile equipment.
- Scope 2 emissions are those that a company has indirect control over, based on the amount of power they require to run their business. This category includes all purchased electricity, heat or steam.
- Scope 3 includes the emissions from all activities that are purchased from other companies, and are not generally in the company's direct control. This includes such categories as employee commuting, business travel, fertilizer and pesticide use, plastics and other purchased products, and the transport of goods and services by other companies.

This separation of scope categories is critical to the calculation of any GHG footprint and allows companies to better track GHG emissions and sequestration to their specific origins. Scope 1 and 2 are included in all national and international reporting schemes, as they are the areas that companies directly or indirectly have control over. Scope 3 emissions generally stem from others' business decisions—companies do not have direct control over how purchased products are made, for example—and are therefore considered optional reporting categories. It is important to note, however, that there is often great opportunity for GHG emission reductions in Scope 3 activities, since a decrease in market demand can drive the reduction of manufacturing-related emissions and can promote positive change throughout the supply chain.

GHG Emissions in the Agricultural Industry

Nurseries and covered plant production facilities fall under the agricultural industry for GHG accounting. In the United States, the agriculture industry comprises 7 percent of the national GHG inventory; this figure does not include energy, transport, or inputs manufactured off-farm. Emissions can be broken down into two primary sources: (1) the result of soil management, commercial fertilizer, and manure use on croplands, which are nitrous oxide (N_2O) emissions and approximate two-thirds of agricultural industry emissions; and (2) enteric fermentation (taking place during the digestive process of U.S. livestock) and manure management; these are methane (CH4) emissions and approximate the other one-third of industry emissions.

Below are a list of key highlights regarding the sources and types of greenhouse gases emitted within the agricultural industry.

- Nursery and greenhouse operations fall under the umbrella of agriculture. Emissions in the agricultural industry are almost entirely represented by crop production (70 percent) and livestock production (30 percent).
- The agriculture industry is an anomaly regarding the types of greenhouse gases emitted. Most industries primarily emit CO_2, yet the agriculture industry is the largest emitter of N_2O emissions (emitting 70 percent of the nation's total), and accounts for 25 percent of CH4 emissions in the U.S. Both of these are much more potent GHGs than CO2; CH4 is 21 times the potency of CO2, while N2O is 310 times as impactful.
- On-farm energy use is a minor contributor to agricultural emissions (approximately 2 percent of total emissions) for crop and livestock production. Nurseries may use more energy than the average due to heating and cooling of greenhouses and irrigation needs.

There are five main categories of emissions sources within the U.S. agricultural industry. Two of these, agricultural soil management and agricultural residue burning, are related to nursery production whereas three of the categories are attributable to crop and livestock production only. Please refer to table 1 on the next page for a list of activities that fall within each category.

Category of Agricultural Emissions	% of Total Agricultural Emissions	Methane Emissions	Nitrous Oxide Emissions	Related to Nursery Operations	Contributing Practices
Agricultural Soil Management	67%	Y	Y	**Y**	▸ Fertilization ▸ Irrigation ▸ Drainage ▸ Cultivation and tillage ▸ Application of livestock manure
Enteric Fermentation	21%	Y		N	• Livestock digestive process
Manure Management	10%	Y	Y	N	• Storing animal manure in ponds, tanks, lagoons.
Agricultural Residue Burning	1%	Y	Y	Maybe	• Burning biomass
Rice Cultivation	1%	Y		N	

Table 1: Agricultural GHG Emissions in the United States

Clearly, it is difficult for nurseries to make exact parallels to these categories, as the agricultural industry described covers a breadth of specializations spanning from livestock management to plant production. While the plant nursery industry can glean insights from the largest category, "agricultural soil management," the other categories are more specific to livestock or rice production.

GHG Sequestration and the Agricultural Industry

Because plants take in CO2 as part of their normal "breathing" process, some GHGs emitted by the agricultural industry are negated, or sequestered, by this natural process. In the U.S., the agricultural industry sequesters approximately 44 million metric tons of carbon dioxide equivalents (MTCO2e) annually. However, average emissions from agriculture over the same period are 514 million MTCO2e; therefore, the agricultural industry is still a significant net emitter of GHGs.

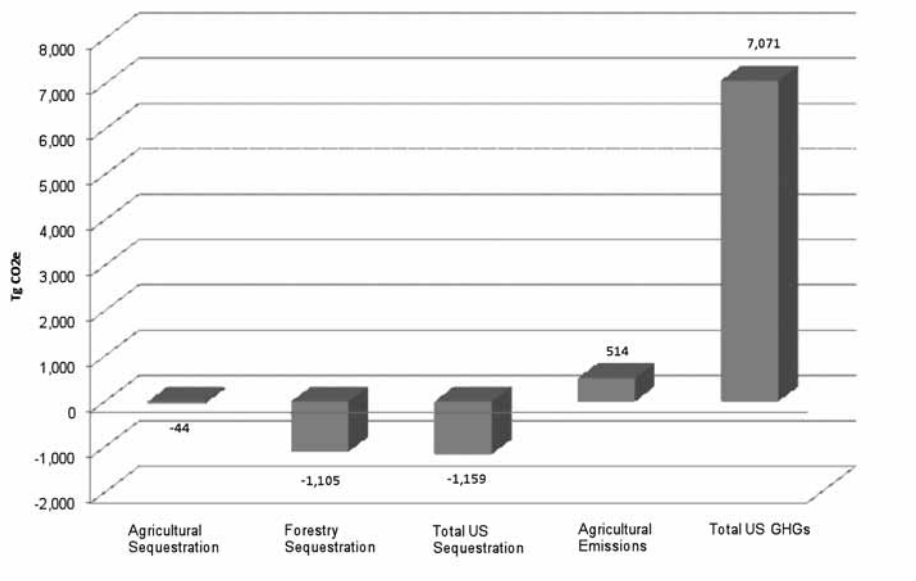


Figure 2: Agriculture and Forestry Net Contribution to GHG Emissions in the U.S., 2003-2007 Average

There are multiple opportunities to enhance carbon sequestration within the agricultural industry. One key area for improvement is soil management, which includes using fertilizer efficiently, building soil organic matter, and increasing on-farm natural vegetation and wetlands. Furthermore, conservation tillage, which reduces soil disturbance and oxidation as well as the release of CO2 from the soil, currently accounts for 40 percent of all agricultural sequestration. A recent study by the U.S. Department of Agriculture and EPA estimates that annual carbon sequestration opportunities in the agricultural industry range from 590 to 990 million MTCO2e per year, which could offset the national annual inventory by between 8 percent and 14 percent. As the Climate Friendly Nurseries Project advances, these topics and related opportunities will be further investigated.

Scope 3 Emissions and the Nursery Sector

Scope 3 emissions are not included as a standard required category in GHG inventories for a few reasons. The ability to collect and accurately account for all Scope 3 emissions is highly challenging and in many cases cost-prohibitive. In addition, counting Scope 3 emissions may lead to potential occurrences of double-counting; if all companies in the world were to complete inventories, Scope 3 emissions would be accounted for by those companies that are directly responsible for them (freight companies, airlines, and fertilizer producers for example).

However, there are many reasons why a company or industry may choose to measure Scope 3 emissions. First, Scope 3 emissions may be a very relevant category, making up the highest percentage source of emissions for the company. Second, Scope 3 emissions may also represent the most significant risk to a company; for example, producers of fertilizers may be impacted by climate legislation and pass on increased costs of compliance to their downstream buyers. The graphs on the next page are from a study of 230 companies (with an even distribution of industries represented) in the S&P 500. Notice how direct operational emissions (Scope 1) and indirect emissions from electricity suppliers (Scope 2) amount to an average of 31 percent of a company's total GHG footprint. The remaining 69 percent of emissions are indirect emissions (Scope 3).

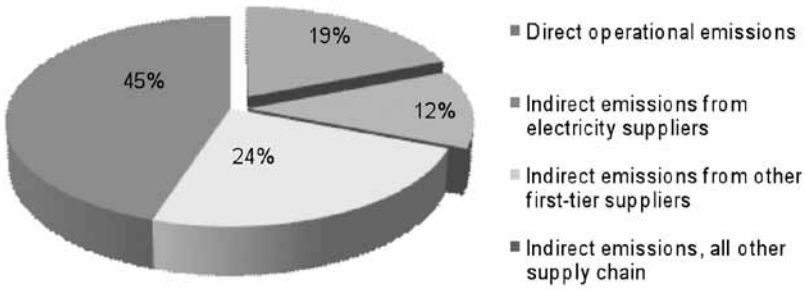


Figure 3: Sample S&P Companies' GHG Emissions by Source

Lastly, by taking Scope 3 emissions in account when considering operational impact, nurseries are likely to identify a significant opportunity for capturing efficiencies and GHG reduction simultaneously, making a significant and real impact in reducing both operational costs as well as overall GHG emissions.

In consideration of Scope 3 emissions for the nursery sector, fertilizer use stands out as one of the most highly impactful categories, as both fertilizer manufacture and use create significant GHG emissions. The International Fertilizer Industry Association (IFA) estimates that the production, distribution, and use of fertilizers contribute between 2 percent and 3 percent of total global GHG emissions. On-farm N2O emissions from nitrogen fertilizer not absorbed by plants is one of the largest GHG emission sources in agriculture.

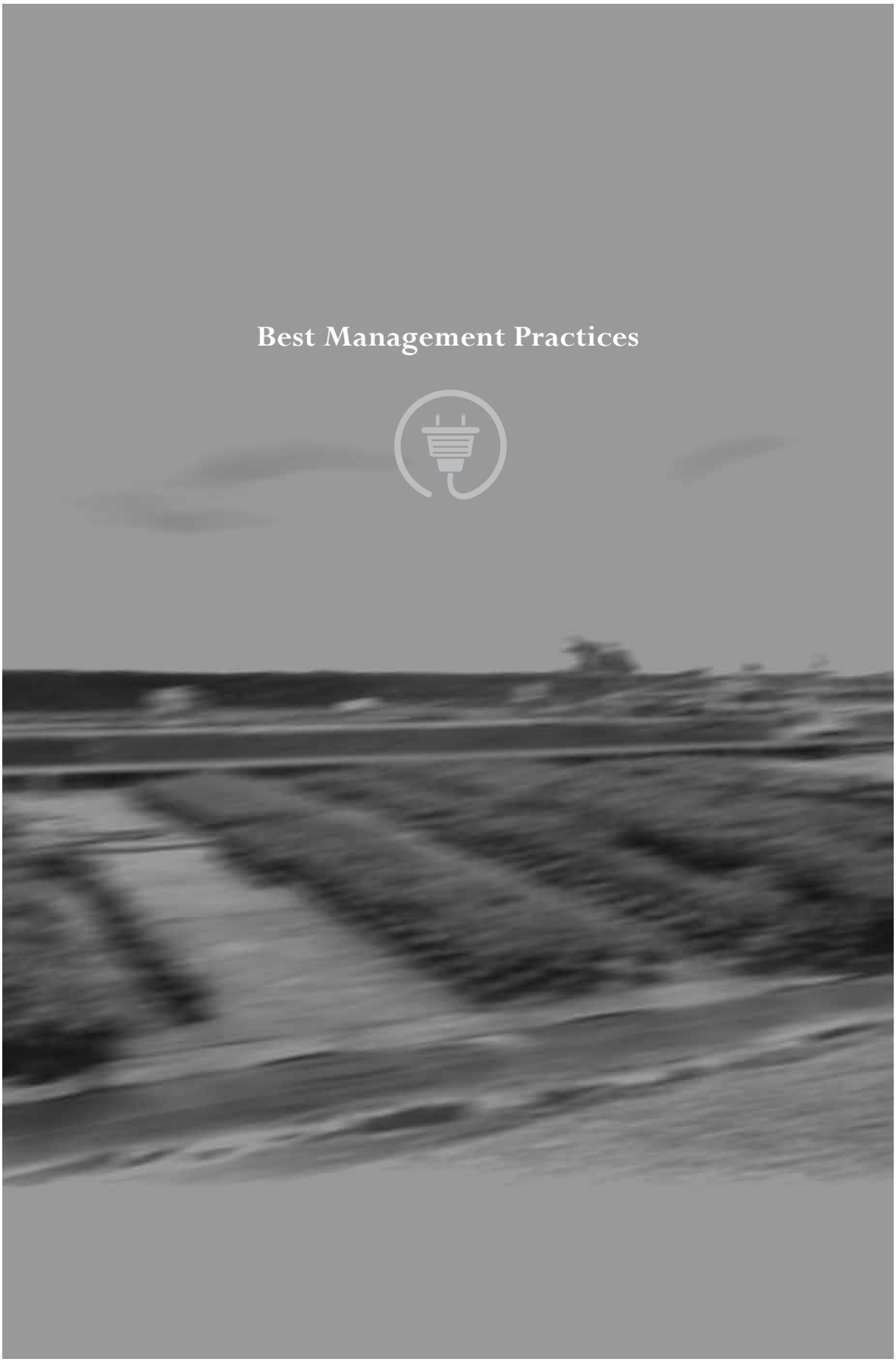
It should be noted that research is still being completed on the exact GHG emissions from the use of fertilizer, as they are dependent on many factors (fertilizer type, amount used and dissemination type, as well as soil and weather conditions, to name a few), making the calculations complex. However, the efficient provision of nutrients to meet plant needs, which may lead to a reduction in fertilizer use, is one of the most important ways for the agricultural industry to reduce GHG emissions.

Table 2 below summarizes common fertilizer types and their associated GHG emission levels from fertilizer production (GHG emissions from fertilizer use are not included in the table below).

Fertilizer Type	Tons of Product	GHG Emissions ($MTCO_2e$)
18-6-8 180	100	78.92
18-6-8 270	100	78.92
12-5-10	100	52.61
19-5-9	100	83.30

Table 2: GHG Emissions from Fertilizer Production

Best Management Practices



1. Lighting and Sensors Retrofit

Description

Lighting retrofits refer to the replacement of old inefficient lighting with proven more efficient alternatives. Occupancy sensors provide energy savings by automatically shutting down lighting applications when rooms or particular areas are vacant. Both lighting retrofits and occupancy sensors usually make financial sense as they require low capital investment but have fast paybacks, and should be examined separately in warehouses, offices, and grow light applications.

Recommended Measures

Complete a Lighting Retrofit

Lighting retrofits tend to be one of the simplest and most direct ways to save energy and see tangible electricity bill savings. An average incandescent bulb lasts one or two years and consumes 66 kWh per year; an average compact fluorescent lamp (CFL), alternatively, lasts six years and consumes 16 kWh per year, bringing an average cost savings of $5 per bulb per year in electricity charges. In addition, maintenance costs are far less for efficient lighting, since bulbs last up to ten times longer, and fixture hardware tends to last an average of twenty years. Likewise, the conversion of any halide lights or T12 fluorescent lamps to T5 or T8 lamps will capture substantial electricity savings.

Install Occupancy Sensors

The installation of motion sensors, or occupancy sensors, is also strongly recommended. Motion sensors have integrated adjustable timers that automatically turn off the light fixture when no motion is detected. Since this feature is integrated into each fixture, the light in occupied areas will remain lit, while those in unoccupied portions of the same space will turn themselves off – automatically saving energy. Burn time is generally reduced by approximately 25 percent when utilizing occupancy sensors.

Additional Benefits and Considerations

Performing lighting retrofits provide multiple benefits. First, in many cases the quality of lighting improves. Second, the lifetime of more efficient bulbs is typically much longer (7 to10 times) than that of inefficient lighting; this extended lifetime allows for reduced maintanence and labor costs. Third, lighting retrofit analysis can also examine possibilities to reduce, or “delamp,” the number of lighting fixtures employed, further reducing lighting load and quickening the payback for a lighting retrofit.

Occupancy sensors require thoughtful consideration of the most appropriate application. For example, occupancy sensors in high-bay applications may not trigger the device when required as the sensors are located at a great distance from typical motion. Also, installing an occupancy sensor with the sensitivity at its highest setting may cause the device to turn on for the benefit of cats and other animals. In general, sensors with light sensitivity (those able to detect when incoming natural light is sufficient) and located in facilities or areas with intermittent activity are ideal.

Incentives Available

Energy Trust of Oregon (ETO) has the following incentives available for common lighting fixtures and controls.

Measure	Incentive $ Range
T-12 to T-8 fluorescent light conversion	$10 to $30 per fixture with ballast
Incandescent to compact fluorescent (CFL)	$2 to $4 per bulb
Occupancy Sensor	$25 to $75 per sensor
Metal Halide lighting (<175 watts)	$40 per fixture

Please refer to www.climatefriendlynurseries.org for more detailed information regarding ETO as well as incentives from the following entities.

- Bonneville Power Administration (BPA)
- US Department of Agriculture Rural Energy for America Program (REAP)
- State of Oregon's Business Energy Tax Credit (BETC).

Recommended Tools

- Oregon State University Energy Efficiency Center eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Building_Day_Lighting
- Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Lighting Retrofit and Occupancy Sensor Installation		
	40 Acre Nursery	**400 Acre Nursery**
Cost (After Incentives)	$1,000	$4,900
Annual Savings	$520	$3,800
Payback	~1.9 years	~1.3 years

Next Steps: Lighting Retrofits and Occupancy Sensors

- Transition T12 lighting to T8 lighting in all warehouse facilities. This retrofit creates the most energy savings and the fastest payback.
- Replace all incandescent lights with CFLs. The labor budget for installing and maintaining CFLs is significantly lower than other retrofit options; the transition can be performed by staff.
- Examine possibilities to "delamp" wherever possible; remove lamps if the current level of lighting is not required. With the transition from T12 to T8 lighting, it is common to reduce the number of lamps being used, as T-8s offer greater illumination than T12s do.
- Retrofit warehouse lighting with occupancy sensors. This is the best opportunity for capturing savings at a nursery, as the estimated annual operating hours are reduced from 2,600 hours to 2,000 hours.
- Low-cost but lower energy savings are available with the installation of occupancy sensors in office areas.

Blooming Nursery, Inc.: the 'Easiest Sustainable Project on their Docket' – Lighting Retrofits and Controls

By Whitney Rideout, Oregon Association of Nurseries

Blooming Nursery

Go to Blooming Nursery, Inc. in Cornelius, Oregon and you'll find yourself immersed in a culture thriving on progressive and sustainable practices. You'll find everything from LiveRoof® modular green roof system and solar thermal panels to restored riparian areas and container recycling programs; very alluring and cutting edge stuff. But in this case study we're going to focus on lighting retrofits. Why? Simple. This series of studies is intended to help nurseries get started on sustainable practices in a challenging economy. Lighting retrofits provide a very simple and profitable project with a short payback period. In other words, this is: 'Sustainability on Training Wheels' and it can start contributing savings to boost your bottom-line sooner than you might think. Moreover, Blooming Nursery has done a brilliant job with their lighting retrofits, so if you're looking for a way to get started on a sustainability effort - here is your blueprint on a silver (and green) platter.

Blooming Nursery, Inc. (Blooming) is a wholesale nursery that provides more than 1,800 perennials, flowering shrubs, herbs, ground covers and ornamental grasses. They offer finished containers marketed under the Blooming Advantage name as well as plugs, potted liners and bare root divisions. They cultivate most of their plants in a state-of-the-art 40,000 square foot propagation greenhouse, which can then be moved into heated greenhouses totaling 60,000 sq ft, or to 150,000 sq ft of cool greenhouses and cold frames. They also maintain over 45 acres of growing fields to support their bare root offerings.

Michael Wisshack, General Manager for Blooming, was kind enough to showcase all the sustainability projects they have underway, including energy efficiency items. When Blooming decided to increase their energy efficiency, they began by replacing inefficient boilers with high efficiency condensing boilers and installing heat retention curtains in propagation areas. Lighting seemed a natural next step, and they dug into the project with an intelligence and thoroughness that made short work of it and actually wound up getting most of it paid for by government incentives and grants; more on that in a moment.

[Wisshack] “Lighting was actually the simplest of the actions we implemented in that timeframe. Energy Trust of Oregon (ETO) performed an onsite-audit for free, and wrote up a detailed lighting analysis - it was very impressive and enlightening to see the kind of money we were leaving on the table due to our legacy lighting systems.” The ETO analysis described Blooming’s energy use, suggested retrofits, and included a full ROI analysis which detailed estimated payback of the retrofits, including the amount of work that could be funded through ETO incentives and Business Energy Tax Credits. (BETC)

[Wisshack] “79 percent of the project was paid for by available incentives, which of course was wonderful as this took the ROI payback timeframe down to a year.”

Recommendations by ETO included:

Blooming retrofitted lighting in their barn, offices, shop and lunch room.

- Replacing existing T12 lights with T8 lights: T12 lamps are the very common 1 ½” diameter fluorescent tube lamps. T8 lamps are 1” diameter and also fluorescent tube, but use less electricity and produce more light than T12 lamps. Blooming replaced 40 T12 fixtures.
- Replacing Metal Halide lights with T8 lights. Metal halide lamps are common in high-bay applications such as warehouses or barns. Blooming replaced 13 metal halide lamps with 6-bulb T8 fixtures, cutting electricity use in half in those areas.
- Installing lighting controls: installation of occupancy sensors to ensure lights are turned off. Occupancy sensors were installed on individual fixtures. This allows some lights in a room to be on while others can remain off if that area is not occupied. Occupancy sensors can increase electric savings by 25 percent or more.

[Wisshack] “ETO made this project very easy because they did the analysis and even provided a list of contractors to make the retrofits. Scheduling the contractors to change the fixtures was the most difficult part of this project that we had to manage, but it wasn’t really burdensome as the contractors were very flexible and did most of the work during off times to help alleviate the stress and inconvenience on staff and better facilitate our production demand.”

[Wisshack] “What can I say - it was just a great experience. No training was needed, our lighting is better, and our electricity bills are lower. We now save almost $2,200 per year in electricity and offset 11 tons of CO2. So, it’s good business, and it also feels good to know that we’re fundamentally better stewards of the resources we use to do our jobs and serve our customers. The project was simple and the payback (after incentives) of one year makes it something every nursery operation should investigate.”

2. Variable Frequency Drives (VFDs)

Description

Variable Frequency Drives (VFD) enable irrigation pump systems to work only at the rate necessary in order to complete the job for which they are responsible. Installing a VFD on a system reduces the rotational speed of the motor, which then decreases the speed of the pump, allowing it to consume exactly the amount of power required for use. Installing VFDs will capture substantial energy savings (20 to 50 percent). For information about water savings benefits, see the case study on Eshraghi Nursery that follows.

Recommended Measure

Install VFDs on all Relevant Irrigation Pumps

Whether or not the installation of a VFD is operationally and financially appropriate depends upon the following conditions: if the irrigation pump is required to operate with varying flow and pressure needs; if the pump must operate at varying well depths; and if the pump is oversized for the required task. If any three of these factors are present, then the installation of a VFD should make both financial and operational sense.

Additional Benefits and Considerations

There a multitude of operational benefits to a VFD that will tangibly reduce maintenance costs, including:

- Soft-start up
- Auto restart
- Remote starting
- Even pressure

Incentives Available

Please refer to www.climatefriendlynurseries.org for detailed information regarding incentives from the following entities that apply to VFD installation:

- Energy Trust of Oregon (ETO)
- Bonneville Power Administration (BPA)
- US Department of Agriculture Rural Energy for America Program (REAP)
- State of Oregon's Business Energy Tax Credit (BETC)

Recommended Tools

- The U.S. Department of Agriculture, Natural Resources Conservation Service's Energy Estimator: ipat.sc.egov.usda.gov/
- Oregon State University Energy Efficiency Center: eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Low_Pressure_Irrigation

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

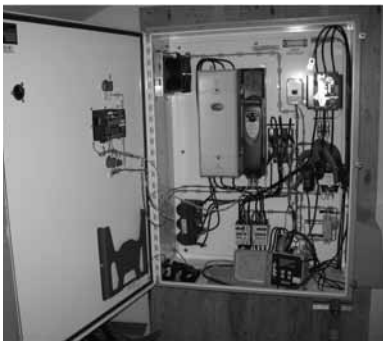
VFD Irrigation Pump Installations		
	40 Acre Nursery	400 Acre Nursery
Cost (After Incentives)	$5,000	$20,500
Annual Savings	$750	$8,700
Payback	~6.6 years	~2.3 years

Next Steps: Variable Frequency Drives

- Assess whether a VFD makes sense for your system (varying flow, pressure, and well depth; oversized for application).
- Compile an inventory (make, model, HP, application) of irrigation pumps. Investigate with ETO if your pumps are eligible for substantial incentives.

Eshraghi Nurseries LLC Found Energy, Water and Cost Savings by Installing VFDs on Their Well Pumps

By Allison Hensey, Oregon Environmental Council



Eshraghi Nursery

You wouldn't keep your car in fifth gear to drive around town – you'd shift to a lower gear so that your motor isn't working any harder than it has to. Variable Frequency Drives (VFDs) are the same principle – they allow a motor to shift to a lower gear, and only work as hard as needed to do the job. This means saving energy, energy costs, and greenhouse gas emissions associated with energy use. When you install a VFD on an irrigation pump, it also enables you to match water volume to plant needs, rather than being stuck with one speed for watering - high, which benefits plant health and saves precious water resources.

Eshraghi Nurseries LLC is a family-owned wholesale grower in the beautiful Willamette Valley specializing in Japanese maples, grafted conifers and woody ornamental nursery stock. They're celebrating their 20th anniversary this year.

Eshraghi draws irrigation water for their nursery from ponds, wells and the Tualatin River. In early summer 2010, Eshraghi installed its third VFD on a 50-horsepower well irrigation pump. Eshraghi will receive one-third of its $8,000 capital investment in a VFD back through a tax credit next year, as well as incentive funds for half of the upfront cost from Energy Trust of Oregon. With these funds, Eshraghi believes that its up-front investment will pay back within approximately 8 months based on an anticipated 50 percent annual energy savings from the VFD. The nursery estimates that it also spent an additional $5,000 in time and labor for system design.

Additional benefits from the VFD include being able to match water use to water needs, which benefits plant health and growth and saves water. Avoiding future pump maintenance issues is also an anticipated benefit of the VFD, as it will allow multiple low volume uses of water without risking pump blowout.

Chris Lee, Farm Manager with Eshraghi Nurseries LLC, said that there was a fine-tuning period for a few months with the second VFD pump they installed, but the computer technician from Hillsboro Pump was very responsive in helping them calibrate it to meet their needs, and now it's working perfectly. Nurseries should also know that there is an override on VFDs that allows manual operation should it be needed. Lastly, Chris recommends that nurseries install VFDs when they are not irrigating as VFD installations can take irrigation off-line for several days.

3. Irrigation Efficiency Measures

Description

Clearly, plant irrigation is a significant component of nursery operations in terms of employee hours, resource consumption, and operational cost. In the agricultural industry, an average of 30 percent to 50 percent of all energy consumed is used by irrigation systems. This percentage may be lower for nurseries, given energy use for heating and cooling greenhouses; however, the energy required for irrigation is still significant within the nursery industry. Configuring irrigation systems in a manner that ensures proper care for nursery products while limiting wasteful use of water and energy will lead to financial savings, potentially offer better care to plants than less efficient systems do, and will also reduce GHG emissions related to energy use and from the application of fertilizers. Due to the variability of product, type and configuration and size of nursery operations, irrigation requirements for nurseries vary considerably throughout the industry. All irrigation systems, however, will benefit from attention to a number of factors that affect system efficiency:

- **Irrigation System Design.** The irrigation system should be designed to ensure the pump produces proper feet of head within a given pump efficiency, compensates for changes in elevation, has appropriate pressure critical points or nozzles, and is broken to adequate number of zones with manageable flow rates. The system should also be designed to ensure the appropriate level of interception and application efficiency.
- **Application Rate and Uniformity**. It is recommended that all nurseries calculate application rates for specific zones, and that they periodically assess application rates and irrigation uniformity using strategically placed catch-cans.
- **Irrigation Scheduling.** Irrigation management of nursery crops grown in containers can be difficult to assess because of the numerous factors that are challenging to account for on a day-to-day basis including weather, substrate, crop water use, crop canopy architecture, irrigation type, precipitation rate, irrigation distribution, and irrigation efficiency. While it is a valid approach to choose a coarse substrate that will allow for overwatering without affecting plant health, excessive watering will negatively impact operational costs relating to water, energy to run pumps, and applied nutrients that get washed away before being absorbed by the plants. It is therefore recommended that nurseries utilize leaching fraction calculations as well as individual crop water use and relative crop evapotranspiration guidelines to effectively schedule crop irrigation.

For additional information regarding these measures, including the calculations that can be used to derive system efficiencies, please see “Irrigation Efficiency for Containerized Crops in the Willamette Valley,” at www.climatefriendlynurseries.org.

Recommended Measures

Schedule Irrigation

Irrigation scheduling is a relatively low-cost measure that, as a rule of thumb, can reduce water consumption by 30 percent. Importantly, reducing water consumption leads to a reduction in the energy used to pump from ponds and wells as well as energy required to pump water for recycling and treatment.

Install Drip Irrigation System

Conversion to drip irrigation will drastically reduce the amount of water required for crops. However, the upfront capital cost of drip irrigation systems is significant and other benefits aside from reduced energy and water consumption need to be assessed.

Additional Benefits and Considerations

While irrigation scheduling is typically a low-cost measure, there are times where more costly investments for sensors and subscriptions to a scheduling service may be most appropriate for your operations. Also, irrigation scheduling can increase staff cost and time, especially at the beginning when new schedule systems are being learned.

Drip irrigation has multiple benefits and water to name a few:

- Reduced use of fertilizer
- More precision in the application of water
- The ability to fertigate/chemigate
- Reduced soil erosion
- Reduced labor costs

Incentives Available

Energy Trust of Oregon has the following incentives available for common fixtures and controls:

Measure	Incentive Range
Irrigation System Conversion	Up to 40% of energy savings by converting to drip irrigation; up to 50% energy savings by converting to a linear/pivot irrigation system
Sprinklers, Nozzles, and Gaskets	$1 to $3 per part for linear and pivot improvements; $.25 to $8 per part for wheel and hand-line improvements

Please refer to www.climatefriendlynurseries.org for more detailed information regarding incentives from the following entities:

- Bonneville Power Administration (BPA)
- US Department of Agriculture Rural Energy for America Program (REAP)
- State of Oregon's Business Energy Tax Credit (BETC)
- Oregon Department of Agriculture (ODA)

Recommended Tools

- Oregon State University Energy Efficiency Center: eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Efficient_Irrigation

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Overhead Irrigation Scheduling		
	40 Acre Nursery	**400 Acre Nursery**
Cost (After Incentives)	$400	$2,800
Annual Savings	$760	$7,000
Payback	~7 months	~5 months

Next Steps: Irrigation Efficiency

- Determine irrigation uniformity and whether irrigation system maintenance or altering system design is warranted to move uniformity into acceptable ranges.
- Identify current interception efficiency of overhead irrigated plants and consider spacing method and/or conversion to drip irrigation to maximize effective water use.
- Determine leaching fraction or application efficiency to see the effect of crop water use, substrate, container size, crop growth stage, and canopy architecture.
- If not currently scheduling irrigation, begin to use one of the given tools described in "Irrigation Efficiency for Containerized Crops in the Willamette Valley," at www.climatefriendlynurseries.org to begin improving irrigation scheduling. If already using the given tools, talk to allied suppliers about new technology that can further enhance irrigation scheduling.

J Frank Schmidt & Son Co.: Using Drip Irrigation to Save Money and Resources

A variety of filtration technologies are employed to remove contaminants unique to each water source. [Doane] "Our largest filter station is connected to a central pond that holds water from a well. Water is pumped from the pond, treated for algae by injecting a low concentration of chlorine, mechanically scrubbed to remove particulates, and then finally distributed to mainline at rates that can reach 2,000 gallons a minute at peak flow."

By Whitney Rideout, Oregon Association of Nurseries

Water, labor and energy all play a role in nursery irrigation. J Frank Schmidt & Son Co. (JFS) took progressive measures to install underground drip irrigation at two of their farms, and by so doing, harvest savings and time benefits. The installation of drip irrigation offered an additional opportunity - drip fertigation – which reduced another costly input and diminished the chance for fertilizer to leach out of their farm and into water systems.

When I stopped by the JFS Canby, OR site one very rainy day in May 2010 to talk to Sam Doane, Production Horticulturist, I thought it would take an hour to talk about the system, a few minutes to take pictures and then back on the road. Like many systems in a large organization it turned out to have more depth than I anticipated. This case study is far from comprehensive; establishing reliable and trusted drip irrigation and fertigation took many years, diligence, research and patience, and the farm is still working on system improvements. This is an introduction with more in-depth information following in future case studies.

PART 1: Underground Drip Irrigation

Water, labor and energy all play a role in nursery irrigation, but it was the second variable – labor – that compelled JFS to proceed with an underground drip irrigation project. JFS had already used many techniques to mitigate irrigation costs: comprehensive schedules and field methods like soil monitoring to water on an as-needed basis, and installing a more efficient and effective system was the next logical step. In 2000 when Sam Doane was transferred from JFS's farm in Independence to manage the farm in Canby, the minimum wage was rising and Oregon was already above the national average. (In 1997 lawmakers increased the federal minimum wage to $5.15/hour; in 2007 this was raised again to $7.25/hour. By comparison, in 1997 Oregon's minimum wage was $5.50/hour and by 2007 Oregon's minimum wage had risen to $7.80/hour, [Doane] "We were paying a lot of overtime for workers to move irrigation pipe and finding a way to mitigate this rising expense was a key priority. Above-ground irrigation is incredibly labor intensive, we were often operating from 5 am to 9 pm."

Doane looked into underground drip irrigation and created a labor savings analysis that captivated JFS owners. [Doane] "The ROI (return on investment) for the infrastructure costs was two years: three workers could do the work that a crew of up to sixteen did before, and there was a 30 percent reduction in water use at the

end of the third year when the system was fully fleshed out."

With this type of ROI analysis Doane received permission to start a pilot project at the Canby, OR facility – a 1,200-acre bare-root shade and flowering tree farm. The project was implemented over a five year period. All of the mainline and filtration systems were installed in the first and second years. With each planting cycle JFS converted more acreage to drip irrigation until the entire farm was done.

Installation of the system was only the beginning of this project. The next step was to develop an irrigation schedule which would take into account soil type, root patterns, crop type, desired water cycle and age of plant. [Doane] "We started out using soil moisture-sensing technology, and in conjunction with this completed a two-year study with Rich Regan at Oregon State University to develop crop coefficients applicable to our diverse group of crops." The crop coefficients help refine data from the AgriMet stations; a subset of an overall satellite network of automatic agricultural weather stations which provides information for near-real-time management of water operations in the Pacific Northwest.

"The fields look different with drip irrigation - they are dry."

Any nursery operation considering drip irrigation needs to expect adjustments to expectations and operations. [Doane] "The fields look different with drip irrigation - they are dry. This was a major adjustment for everyone in the operation as we were used to seeing wet soil, and with that, came knowledge that the plants had enough water for the near future. When we installed the first 220 acres we think we actually used more water than before. The overhead system was limited by hours in the day, pump flow, and the amount of handline that we had available. The new drip irrigation system made completing our irrigation schedule an easy task, and because we were still building system confidence we ran the drip irrigation until we saw water on the surface. After reviewing many soil moisture charts we discovered that this was applying more water than is necessary and it defeated one of our goals – to reduce water use." JFS had been using gypsum blocks for decades to help schedule irrigation. With the change to drip irrigation, new irrigation feedback mechanisms needed to be implemented to ensure this task was completed accurately and effectively. JFS first used electrical sensors that uploaded data to a PC and provided instant feedback – 24/7. The instant feedback helped support the management team's contention that they were applying enough water. The monitoring device they elected to use after gaining a few years of watering confidence was the portable 'Diviner,' which can be taken to all access points at the facility; JFS transitioned from 24/7 monitoring to measuring soil moisture content at a point in time three times a week. [Doane] "That level of information – three data points a week - took time to get comfortable with. Nursery owners and managers need to experiment with different feedback devices and levels of detail that allow them to run their operations effectively."

This case study is very brief in relation to the effort that went into creating a system that delivers drip irrigation accurately and consistently. Before any operation considers drip irrigation there are some items to consider:

1. Hire an experienced engineer. Pay an expert to complete an analysis of the entire system. Everything from mainlines to filtration to flow and pressure, otherwise you could build a system that will not work the way it's intended. The goals are to save water, increase uniformity and efficiency, and make irrigation less burdensome – poorly designed systems won't help you achieve these goals.
2. Management commitment. The managers at JFS were excited about the prospect to reduce labor costs, however, without their forward thinking and commitment to the long-term profitability of the operation this project would have failed. There are many adjustments required for this type of change and management needs to buy in 100percent.
3. Confidence comes with time and experience. There will be many hurdles when installing and perfecting a system like this. If you are going to use a soil moisture monitoring system, make sure you have a staff member who can interpret and evaluate complex graphs and data that come with the system, and someone familiar with the irrigation requirements of your crops. Simple, non-technical solutions are available for evaluating soil moisture as well; these can be a good option during the learning process.
4. Fit the project with the property. JFS doesn't plan to use underground drip irrigation at their Monmouth farm because they've experienced problems with voles in the past. (Voles and other rodents can chew into drip systems, resulting in wasted water and excessive maintenance costs). Also, there are some crops which need the evaporative cooling of overhead watering (ash trees for example), so these types of crops may not be best suited for "drip only" irrigation.

By fertilizing and watering at the same time, JFS reduced overall fertilizer use by 30 percent. The ROI on this project and system infrastructure was less than a year.

[Doane] "The end product has been worth the effort; our operational efficiency has increased through reduced labor costs and water use, we are able to work and cultivate in a field while irrigating, and we have reduced weed growth by limiting surface water. Our owners are happy and we are taking steps to ensure our competitive advantage and future success."

PART 2: Reduced Fertigation Through Drip Irrigation

World fertilizer prices started rising in 2002 and reached historic rate increases in 2008. During the 12 months ending in April 2008, nitrogen prices increased 32 percent, phosphate prices 93 percent, and potash prices 100 percent. This price surge in 2008 was due to strong domestic and global demand for fertilizers, increased energy and freight prices, higher demand for grain-fed meat in emerging countries and low fertilizer inventories.

Rising fertilizer prices and changing perceptions about plant fertilizer needs compelled JFS to look into new and more efficient fertilizer application opportunities. [Doane] "We had already moved from broadcast to band application to reduce fertilizer use, but we couldn't water in granu-

lar fertilizer with drip irrigation. Injecting fertilizer, or fertigating, into drip irrigation provided us with an opportunity to utilize the system to deliver fertilizer directly to the root zone. By fertilizing and watering at the same time, we reduced overall fertilizer use by 30 percent. The ROI on this project and system infrastructure was less than a year."

Doane said system set-up and design were pretty simple. [Doane] "We do manifold level injection 2 ½ to 5 acres at a time for our drip irrigation fields. The hardest part of the system was making sure we had the right dilution factor and keep salt levels where we were comfortable. We use a proportional injector to measure the amount of liquid fertilizer we are injecting; to help keep costs low, we installed this as a bypass on the manifold (about 10 percent of the water goes through the injector). We use a simple flow meter and a series of valves to set the flow at our desired level. We wrote an Excel calculator that allows the irrigation crew to input a number of variables, like row length and total flow per manifold, to ensure that injection rates remain at a safe level."

"We've reduced overall fertilizer use by 30 percent which is a win for everyone. Our operational costs are lower and we are responsible for fewer GHG (greenhouse gas) emissions normally attributed to nitrous oxide emissions. If anyone decides to implement a drip irrigation system, this is a natural next step to investigate."

4. Heating, Ventilation, and Air Conditioning (HVAC): Boiler Maintenance

Description

Proper heating, ventilating, and air-conditioning systems (HVAC) are fundamental to maintaining successful nursery operations. These systems account for approximately 40 percent of the electricity used in commercial buildings; ensuring that systems are as efficient as possible and are properly maintained therefore creates a huge opportunity to capture energy and cost savings. Thinking of your heating and cooling system holistically by considering not only the HVAC system itself but also any other component that affects its performance - such as building shell performance and insulation – will increase your savings opportunities in this arena. By implementing energy efficiency measures, nurseries will also achieve higher heating and cooling performance, allowing for better plant propagation in addition to enhanced workability and comfort for nursery employees.

Because HVAC systems come in many sizes and formations, particular efficiency measures and their savings potential will be different for each nursery. In central HVAC systems, for example, the firing rate can be reduced, allowing the system to only work as hard as it needs to heat the building appropriately. Nurseries with non-central systems, alternatively, will benefit from insulating greenhouses to ensure that none of the heat created is being lost unnecessarily. Additionally, regardless of the size and type of system you have, putting your HVAC system on a consistent preventative maintenance program will make certain that it is running at the highest performance possible.

Boilers, a major component of any HVAC system, tend to be main contributors of energy consumption for business operations. The illustration identifies key areas where energy is lost in a "typical" boiler system [1].

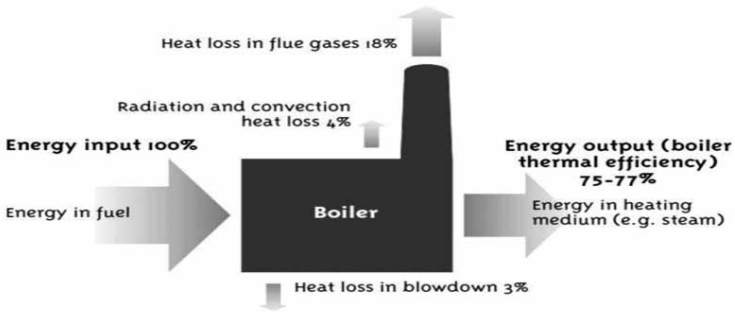


Figure 4: Energy Loss in a Typical Boiler System

[1] Source: Natural Resources Canada, 2001.

While each boiler system is unique and requires a specific onsite audit to accurately identify operating efficiency, we can at least begin to identify the most significant areas for improvements. Fortunately, there are a number of low-cost/no-cost opportunities that nurseries can take advantage of to maintain a boiler's condition and efficient use of energy. The following measures have the potential to save nurseries substantial operational costs with only small upfront capital requirements.

Recommended Measures

Tune Boiler

The first recommended measure with potential for significant energy savings and fast payback is to have the boiler tuned so that an appropriate mix of fuel and oxygen are in the system, which reduces the amount of oxygen required for combustion to a safe and practical level. Most systems are set for too much oxygen to be in the system, because the consequences from too little oxygen can be quite serious. However, if a professional hypothetically deems that the system should be operating at a level of 4

percent surplus oxygen, rather than the current 7 percent, then a boiler tune is a cost-effective path to energy savings. Importantly, each 1 percent of unnecessary oxygen in a system can lead to a 2.5 percent reduction in efficiency (leading to a 2.5 percent increase in fuel input and cost). If a boiler tune eliminates 3 percent surplus oxygen, therefore, you could conceivably see a reduction of 7.5 percent in fuel costs.

Clean Boiler System

Proper maintenance of a boiler should include routine cleaning of both the fire and water side of the system. Each millimeter of fouling or scale can lead to a 2percent reduction in system efficiency.

Additional benefits and considerations

These low-cost measures have fast paybacks and have the ability to significantly reduce energy use. In addition to these measures there are numerous other maintenance, retrofit, and replacement options that can lead to greater energy savings and system performance.

Incentives Available

Incentives are typically available for retrofits and/or replacement of inefficient HVAC systems and boilers with more efficient units. Some of these include:

- State of Oregon's Business Energy Tax Credit (BETC). Please refer to www.climatefriendlynurseries.org for more detailed information.
- Energy Trust of Oregon has the following incentives available for upgrades to more efficient HVAC systems.

Measure	Minimum Efficiency Criteria	Incentive $ Range
HVAC unit heater (non-condensing with electric ignition)	86% annual fuel utilization efficiency (AFUE)	$1.50/kBtu/hr
Warm-air condensing furnace (<225,000 kBtu)	91% AFUE	$3/kBtu/hr
Direct fired radiant heating	N/A	$6.50/kBtu/hr

Recommended Tools

- Oregon State University Energy Efficiency Center: eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Boiler_Fan_VSD

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Boiler Maintenance		
	40 Acre Nursery	**400 Acre Nursery**
Cost (Boiler Tune and Maintenance)	$600	$2,000
Annual Savings	$275	$2,900
Payback	~2.2 years	~ 8 months

Next Steps: Boiler Maintenance

- Contact your HVAC technician to schedule both routine maintenance and an examination of equipment for retrofit or replacement options.
- Complete all low-cost/no-cost opportunities that will reduce heating needs (for example, sealing air leaks can have an impressive return on a minimal investment of time and materials).

5. Greenhouse Insulation

Description

In addition to improvements in boiler efficiency, significant energy reductions are available by appropriately insulating greenhouses. The first step is to seal all air leaks in greenhouses. Once that measure is complete, more substantial investments should be considered. The most prominent examples are installation of thermal blankets or shade curtains. These curtains dramatically reduce the amount of heat that evaporates overnight. Combining thermal blankets with the insulation of unused greenhouse ends will form a solid foundation for an energy-efficient greenhouse.

Recommended Measures

Install Thermal Blankets

Thermal blankets are the most comprehensive solution for preventing heat loss. Savings from thermal blankets range from 20 percent to 50 percent. The typical cost for thermal blankets is approximately $1.00 to $2.50 per square foot.

Insulate Greenhouse Sidewalls and Unused Ends

Insulation with a high R-value should be used to insulate greenhouse sidewalls (typically 3 feet in height). In addition, there may be additional opportunities to insulate greenhouse ends and reduce energy costs if one they are unused.

Additional Benefits and Considerations

An important consideration before implementation is whether the insulation of sidewalls will have a negative impact on greenhouse translucence. In addition, if the area is already covered by a thermal blanket, then insulating the walls may not cause substantial enough additional savings to be worth the cost.

Incentives Available

Energy Trust of Oregon has the following incentives available for upgrades to more efficient greenhouse materials.

Measure	Incentive $ Range
Infrared (IR) polyethylene greenhouse cover	$.02 per square foot of material purchased
Thermal curtain	$.09 per square foot

Recommended Tools

- Oregon State University Energy Efficiency Center eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Insulate_Greenhouse
- US Department of Agriculture- Virtual Grower www.ars.usda.gov/Research/docs.htm?docid=19961

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

It is important to note that nurseries can insulate greenhouses slowly over time. To simplify the results, the numbers below assume that the nurseries implement the recommended insulation measures all at once.

Greenhouse Insulation		
	40 Acre Nursery	**400 Acre Nursery**
Cost (After Incentives)	$3,600	$61,425
Annual Savings	$600	$10,800
Payback	~6 years	~ 5.7 years

Next Steps: Greenhouse Insulation

- A simple but very important measure is to seal all air leaks.
- Re-glaze when needed with triply polycarbonate.
- Consider wind barriers (for example, rows of evergreen trees) which can reduce outside air infiltration.

Northwoods Nursery/One Green World: Simple

Greenhouse Insulation for Fuel and Cost Savings

By Allison Hensey, Oregon Environmental Council

Growing up, when the weather turned cold, instead of turning up the thermostat at home my Dad would tell me to put on a sweater. Greenhouse insulation is the same concept. Like most nurseries, Northwoods Nursery in Molalla uses propane to heat their greenhouses, making recent increases in propane costs a challenge. Northwoods Nursery decided to put a sweater on their greenhouses to keep the temperature comfortable for their plants, rather than pay higher energy costs.

Saving on propane costs can be as simple as sealing cracks and adding weather-stripping in a greenhouse as a first step. "One of our employees has been locating gaps in the greenhouses and sealing them to prevent heat loss," says Laura O'Leary, Sustainability Director for Northwoods Nursery.

The next step for the nursery was replacing single poly sheeting on all greenhouses with double poly sheeting, using more efficient IR film on some. Double poly sheeting creates an air gap and helps to prevent heat loss. Northwoods has also replaced single end walls in their greenhouses with double or triple end walls. "We found a double end wall product with a higher R-value and lower U-value than the triple wall poly, plus it was cheaper," says O'Leary.

Northwoods employees installing insulation.

Northwoods isn't sure yet how much energy these measures will save, because the same large propane tank feeds greenhouses with better insulation and without, making tracking propane savings difficult. However, O'Leary says the nursery will be able to quantify cost savings after a side-by-side trial this year comparing energy use in a greenhouse with double wall poly covering the house against energy use in a single poly greenhouse. The nursery expects a fairly quick payback for their investment through a combination of a state tax credit and propane cost savings. They received a 35 percent tax credit through the state Business Energy Tax Credit program, which they sold to a third party as a pass-through tax credit.

The good news is that Northwoods has already heard anecdotal evidence that they're saving energy and propane costs from the greenhouse insulation – their propane supplier recently complained that their tanks didn't need nearly as much fuel to top off the tanks this trip as in the past. That's the kind of complaint we'd like to hear more often.

6. Reuse and Recycling of All Wastes

Description

While creating some waste through normal business operations is often unavoidable, nurseries will capture savings by following the longstanding environmental mantra: reduce, reuse, recycle. Nurseries that rethink how they do business and decrease the amount of solid and liquid waste - whether it is soil, plastic pots, or water - leaving the facility will inevitably decrease overhead costs in the process.

- **Reduce.** The less you purchase, the less you ultimately have to throw away. This is a critical first stage to waste reduction that often gets overshadowed by the later steps. While the purchase of some items is a requirement for operational continuity, nurseries can achieve savings by looking for ways to decrease their need for those items that end up in the waste stream. Consider all waste streams and ask yourself: Do we need this product or resource to do good business? Is it possible to rethink the way we do our jobs that will allow us to purchase less and save resources? Can you request decreased packaging on any purchased products?
- **Reuse.** There are many opportunities to reuse products and resources that nurseries purchase. Provided that a cleaning system can be instituted, soil and containers can both be reused at a very high rate. By reusing as many purchased products as possible, you will reduce your operational costs while limiting the indirect emissions being created during the products' manufacture.
- **Recycle.** For those products that can only be used once, recycle or compost as much as you can. Plant clippings can be either taken offsite by haulers and composted with yard debris, or can be composted onsite to be used to fertilize plants if sterilized. Standard recyclables (cardboard, metal and most plastics) can be hauled offsite and recycled. Likewise, containers and other non-standard plastics can be recycled through Agri-plas, a company that specifically caters to nurseries; in many regions, they will come directly to your nursery to pick up containers and other plastics and haul them away to recycle.

Recommended Measure

Install an Onsite Container Cleaning Center

An on-site cleaning center allows for the reuse for the majority of nursery containers in such a way that simultaneously reduces labor costs. While the upfront capital investment required can be challenging (in the following case study of Heritage Seedlings this included the purchase of a steamer, site foundation, and a used refrigerated truck), the payback can be relatively quick (~1 year) depending upon your baseline consumption and turnover of containers. The combination of reduced cost for new containers, reduced container waste disposal fees, and reduced labor costs associated with weeding is a cost-effective sustainability trifecta!

Additional Benefits and Considerations

The implementation of a cleaning system reduces the overall number of weeds to contend with, and allows employees to spend their time with other tasks. Please see the following Heritage Seedlings case study for multiple insights into the additional benefits of implementing this type of system.

Recommended Tools

- Oregon Department of Agriculture, The Grower Assisted Inspection Program (GAIP) oregon.gov/ODA/PLANT/NURSERY/gaip.shtml#Additional_Information

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Container Cleaning Center	
	400 Acre Nursery
Cost	$8,000
Annual Savings	$6,000
Payback	~ 1.5 years

A 40-acre nursery is not represented here, as this measure has a very long payback for nurseries of this size. Alternative benefits such as those described here and in the following case study, however, may drive smaller nurseries to decide to implement a cleaning center despite this.

Next Steps: Waste Reuse and Recycling

- Recycle all unusable pots and worn polyfilm from greenhouse covers.
- Before investing in a sterilization system for the reuse of containers, begin by documenting all monthly expenses related to the purchase and disposal of containers. This will enable you to realistically estimate savings and measure payback prior to implementation.
- Consider installing an onsite container cleaning center.

Heritage Seedlings, Inc. Saves Money and Labor by Steam Treating Containers and Soil

(Top) Heritage Seedlings, Inc. Stayton, Oregon facility

(Bottom) Weed-free propagation trays fill the greenhouses

By Whitney Rideout, Oregon Association of Nurseries

No one likes weeding. It's a back killer - and for nursery owners it's a huge outlay of time and money.

Heritage Seedlings, Inc. (Heritage) took progressive steps to nip weeds in the proverbial bud by steam cleaning and reusing both plastic containers and soil. In so doing, they reduced their carbon footprint and saved money from two elements of COGS (cost of goods sold): production materials and general labor. This is their story.

Heritage is a wholesale propagator of unique deciduous woody plants and Willamette Valley natives and perennials. Located in both Salem and Stayton Oregon, Heritage operates seven acres of greenhouses, 15 acres of cold frames, and 240 acres of field-grown liner production.

Heritage has reused its containers for years, but their decision to begin steam treating containers and planting media came from their participation in the Oregon Department of Agriculture 'GAIP' program (Grower Assisted Inspection Program). "Weeding takes a tremendous amount of resources that could otherwise be used to propagate or fill orders" said Heritage Manager Eric Hammond. "We were able to deal with the critical control points surrounding disease and container re-use, but we couldn't justify the huge labor bill for weeding. I clearly remember the 'profit-driven' pressure to produce clean liners crashing into the 'real-world' fact that we had rings of weed seedlings around the container sides before the tree seedlings had emerged. It was just... an impossible situation. Ethically we felt really good about our decision to re-use our containers in a 'reduce, recycle, re-use' sense, but in doing that - we compounded the weed problem year after year. We needed a solution that could help us maintain our high level of product quality, save a realistic amount of money, and continue to stay comfortable from a 'We're doing the right thing here' standpoint - in other words - sustainability."

The solution Heritage implemented was to hot water bath their small thin-walled plastic containers and steam treat their large thick-walled plastic containers and re-cycled potting soil.

Container Cleaning

Heritage Seedlings created two different stations to clean their plastic containers; one for small thin-walled containers and one for large thick-walled containers. The small thin-walled containers are treated in a hot water bath cooker that owner Mark Krautman bought at auction. The cooker takes a full day to heat up as its capacity is 1,000 gallons, but once it's heated it can clean a half-pallet of trays at a time. "10 minutes at 170 degrees - it works like a dream," said Hammond with a grin like a kid eyeing an ice-cream cone. "We run the cooker for only about a week to clean everything and then we shut it down and give it a rest until we have the need for fresh trays - it's a wonderful solution to a very difficult problem and it's relatively efficient from a labor perspective. While the cooker cleans the trays, employees can tend to other tasks. The trays technically need five minutes at that temperature for killing weed seeds, but we give the trays extra time to ensure they are clean and to give employees enough time to complete other tasks."

(Top) Small thin-walled trays are cleaned in this cooker for ten minutes at 170 degrees

(Bottom) Refrigerated truck with attached steamer used to clean large thick-walled plastic baskets and bulb crates

The cooker is ideal for the small trays, but Heritage found it too labor intensive for thick walled plastic baskets and bulb crates.

[Hammond] "We converted an old refrigerated truck into a steamer to handle the large baskets - same principle as the tray cooker - just bigger. The capital outlay was about $8,500 for the steamer, cement foundation and used refrigerated truck. The return on investment for the big steamer was less than one year; weeding labor is an enormous outlay so it doesn't take long to pay for something that helps you reduce it. Also, weeding isn't exactly the most rewarding work and so our employees spend more time doing the things they enjoy and taking pride in seeing the trees they planted come up. Bottom line, we're spending more time growing the plants we want to grow and less time battling the plants [weeds] we don't want to grow, so it's just all-around good for Heritage and its people."

Soil Cleaning

[Hammond] "We'd been generating a mountain of used potting soil that we wanted to re-use. But we knew there was a horrible weed seed-bank in it. When we enrolled in the GAIP with ODA, we were required to clean the soil to reuse it, and it was like - Well OK, in for a penny, in for a pound - let's figure out how to get this done. So we did, and again, the results have been very positive for us."

Heritage runs steam through pipes at the bottom of a large trailer (see side pictures). The return on this investment was a mere five months:

- The variable cost [fuel + labor] to steam the soil: $15/cubic yard
- Delivered cost of new soil mix: $43/yard.
- Capital outlay for the steam generator and materials: $20,000.
- After only 700 yards of soil use the capital outlay was redeemed and now Heritage saves approximately $28/cubic yard for re-used clean soil

Soil cleaning steam system: trailer and steam generator system

Results Go Beyond Time and Money

When asked if employee buy-in was difficult Hammond responded: "Not at all. Employee buy-in for all three activities was very quick. This solution has a very high: 'Hey we're doing the right thing here' common-sense appeal, and at the same time it allows people to spend more hours of their day doing more rewarding work. So, we saw a very quick return on investment, but more importantly, we are all more satisfied that we're not contributing to waste and pollution, and that we have more time to spend on valuable tasks like transplanting and staking."

The systems used at Heritage didn't happen overnight and there were both trials and errors in fine-tuning their cleaning solution to meet their needs. They recommend not getting hung-up on copying them or anyone else exactly, but rather focusing on the desired end-result and working backward and forward through the operations flow to identify the sources of problems before attempting to solve them.

[Hammond] "Once you really understand the root of your problems and where they impact your people and your costs, you'll be headed down the right path. Recycled container and soil steam treatment have been a big win for us - clearly - but more than that, they've led us to think more progressively about what else we might need to change. It clearly demonstrated to our crews the positive effect of solving the problem at the beginning. Our team is incredible and I'm very proud of them. At this point, I don't think there's anything we couldn't do if we put our minds to it."

Best Management Practice in Development: Nutrient Use Efficiency

The Climate Friendly Nurseries Project and this Best Management Guide will both continue to evolve over the coming years. As these projects advance, so will the investigation into better quantifying sources for emissions and energy use. One important area for further research and analysis in the Northwest is the quantification of GHG emission reductions that are possible from good soil management practices, including plant nutrition and building soil organic matter. Agricultural use of nitrogen fertilizer is one of the most significant contributors to agricultural GHG emissions, and the manufacture of commercial fertilizer is a meaningful source of global GHG emissions. Likewise, agricultural soil management constitutes 67 percent of U.S. agricultural GHG emissions.

While it is known that providing plant nutrition more efficiently and building soil organic matter will reduce GHG emissions, the Northwest does not currently have the research to quantify on-farm nitrous oxide (N2O) emissions from fertilizer use, or the possible GHG reductions from more efficient provision of plant nutrition. However, the general benefits of nutrient use efficiency in terms of reducing costs, GHG emissions and protecting water quality are well established. Therefore, we provide the following best management practice recommendations for field nutrient use efficiency, and encourage nurseries to visit the Climate Friendly Nurseries website (www.climatefriendlynurseries.org) for updates and additions to this best management practice. Oregon State University will publish an Extension publication on the topic Fall 2010, which you'll also find on the Climate Friendly Nurseries website when it becomes available.

It should be noted that although the following considerations focus on nutrient use efficiency in the field, there are important strides that must be made in container fertility and soil management as well. Our hope is that as further research becomes available, our recommendations regarding this best management practice will be equally relevant and useful to all nursery types.

Field Nutrient Use Efficiency

Field nutrient use efficiency is the practice of accurately supplying the amount of nutrients required by a plant. Efficient nutrient application results in less fertilizer applied and less fertilizer waste. Considering the significance of GHG emissions resulting from the application of fertilizers, field nutrient use efficiency has the potential to significantly reduce GHG emissions within the entire nursery industry.

There is little existing data regarding shade tree fertility recommendations. Ornamental tree fertility in the Northern Willamette Valley remains in its infancy, as Oregon State University researchers and extension agents have just begun to investigate nutrient removal, fertilizer timing, and subsequent crop response. Recommendations herein are based on other relevant production guides and current practices of nurseries within the Willamette Valley.

To accurately manage crop fertility one must know soil type and texture, pH, cation exchange capacity, organic matter, and extractable nutrient content. Site-specific soil physiochemical properties are now available online via the Web Soil Survey (WSS, at websoilsurvey.nrcs.usda.gov). In addition, soil needs to be tested regularly to ensure adequate soil fertility and pH with the exception of nitrogen, sulfur and many of the micronutrients.

Nitrogen (N) applications should be applied in spilt applications via band, side-dress or fertigation to the area of the expected root zone during times of growth when nutrient uptake occurs readily. Nitrogen application rate should be reduced proportionally from an acre basis to a smaller application area when banding, side dressing, or fertigating. Growers can make inferences into the efficiency of current nitrogen fertilizer practices by conducting nitrogen soil tests on drier soils in late August or early September. The soil and your production system remain dynamic over time and may require adjustment to ensure optimal fertilization.

Phosphorus (P) moves very little in the soil profile; therefore, conventional fertilizers such as superphosphates, ammonium phosphates, or potassium phosphates are commonly top-dressed and incorporated between cropping cycles. If a phosphorus deficiency does occur during production, or one liquid fertilizes then drip irrigation can be used to apply phosphorus to the root area zone at the time of active root growth.

Bray phosphorus soil test method for acidic or neutral soils phosphorus is used to determine the need and quantity of phosphorus between cropping cycles as follows:

Bray P Soil Levels	Apply?	Amount of P_2O_5/A to Apply
0-20 ppm	Yes	100-125 lbs
20-35 ppm	Maybe	60-100 lbs
35+ ppm	No	None

Traditionally, potassium (K) is top-dressed and incorporated as potassium salts between cropping soils since soil potassium does not decrease rapidly during a perennial cropping cycle. Similar to nitrogen, potassium can also be applied very effectively via drip irrigation at times of active root growth. A potassium soil test is used to determine the need and quantity of potassium between cropping cycles as follows:

K Soil Levels	Apply?	Amount of K_2O/A to Apply
0-100 ppm	Yes	150 lbs
100-200 ppm	Maybe	0-150 lbs
200+ ppm	No	None

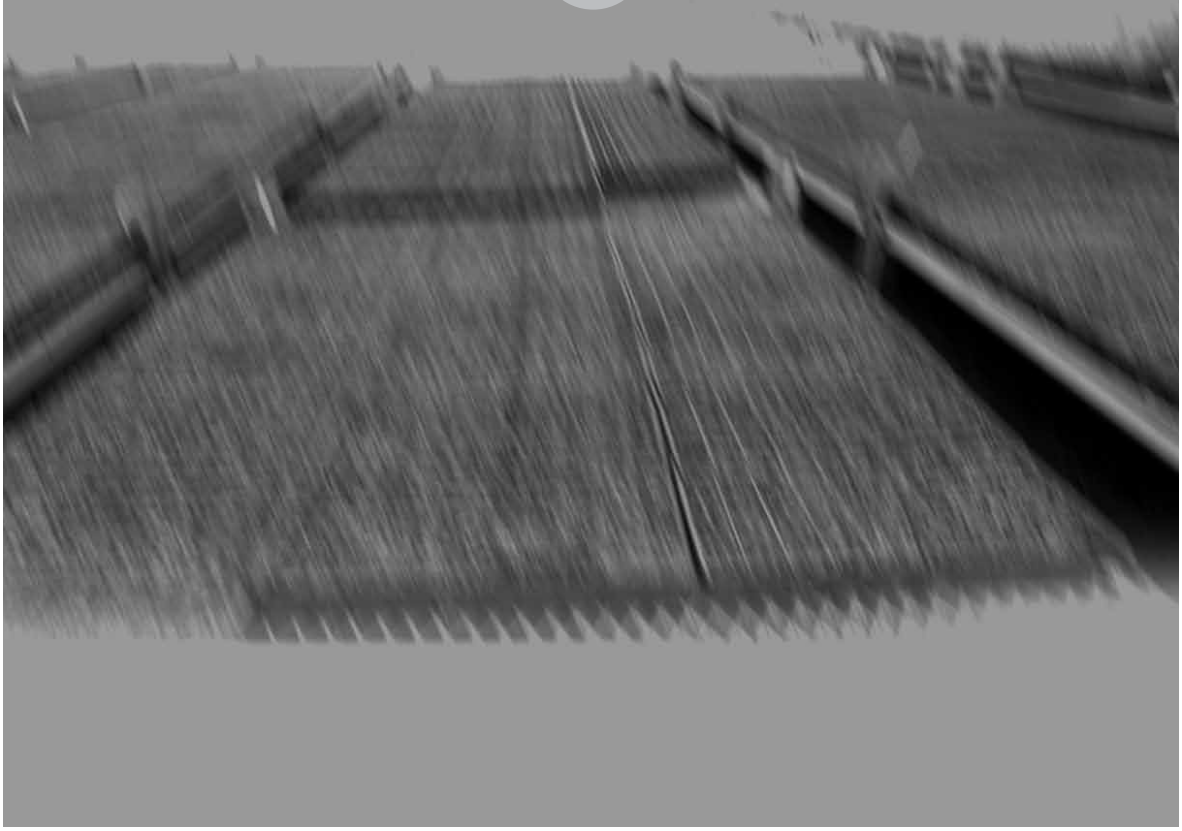
A more robust examination of nursery field nutrient use efficiency, including calcium, magnesium, sulfur and micronutrients is available at www.climatefriendlynurseries.org. In addition, there will be an Oregon State University Extension publication on Field Nutrient Use Efficiency available Fall 2010, which you will also find on the Climate Friendly Nurseries Project website.

Low-Cost/ No-Cost Best Management Practices

Best Management Practices Requiring Up front Capital

Available Incentives

Next Steps



Low-Cost/No-Cost Best Management Practices

The following section lists a number of opportunities that require little or no capital to implement. For the most part, these measures do not require external expertise, and can be put into practice by nursery employees. Opportunities are rated based on the energy savings captured for the related upfront costs (energy efficiency return on investment, or EE ROI), the level of GHG emissions mitigation for the cost (GHG return on investment, or GHG ROI), and the relevance to nursery operations throughout the industry (Applicability). Each category is rated as a "high," "medium," or "low" level of opportunity. For further explanation regarding the rating system used in this section, please see the "Guide Methodology" section of this report.

Incentives that apply to each measure are also noted, although many of these measures will be cost-effective opportunities without funding assistance, or they are changes in behavior which require no capital output. Where standard incentives are available, they are listed in the "Incentives" column. Information regarding the following incentive programs, as well as others, is included.

- Energy Trust of Oregon (ETO), www.energytrust.org
- Oregon Business Energy Tax Credit (OR BETC), www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml
- USDA's Renewable Energy for America Program (REAP), www.rurdev.usda.gov/or/reap.htm
- USDA's Environmental Quality Incentives Program (EQIP), www.nrcs.usda.gov/programs/eqip/

Additional information on these incentive programs is included in the "Available Incentives" section of this report.

Lighting Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Switch out incandescent light bulbs for compact fluorescents (CFL)	High	High	High	REAP grants can cover up to 25% (max $250,000) of eligible project costs. See also REAP loan programs. ETO and BETC also offer incentives for this measure.
Install auto-lighting (e.g., timers, motions sensors)	High	High	Medium	ETO offers a number of standard incentives for lighting fixtures and controls. For custom projects and retrofits, ETO can cover up to 35% of approved project costs (not to exceed $0.17 per annual kWh). BETC and REAP also offer incentives for this measure.

Heating and Cooling Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install programmable thermostats (options range from basic models to more sophisticated varieties that offer functions like tracking the weather)	High	High	High	
Limit heat use to offices and buildings, or those parts of greenhouse that require controlled environments	High	High	Medium	ETO offers incentives ranging from $1.50-$6.50 kBtu/hr in for premium efficiency natural gas equipment (e.g., direct fired radiant heating, tankless hot water) as well as a standard incentive of $1,000 for boiler dampers.
Seal cracks/make environmental system airtight	High	High	Medium	
Complete maintenance/operational activities on an ongoing basis (e.g., keeping doors shut, cleaning fans, etc.); applies to cold storage and packing rooms as well as greenhouses	High	High	High	

Refrigeration Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Maintain all systems on a normal basis (e.g., checking for seal health and coolant leaks)	Low	Medium	High	

Irrigation/Fertilizer Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Don't over irrigate, as it leads to fertilizer leaching through container	Medium	High	High	
Pay attention to irrigation timing: (a) study the release curve of the fertilizer you are using and apply accordingly, and (b) analyze application timing requirements and apply only when plants need it	Low	High	High	
Pay attention to nutrient amount: (a) apply recommended rate or tested rate; (b) be familiar with starter package and what you are adding to the container, and (c) liquid feed only when micro-irrigating	Low	High	High	
Monitor herbicide rates and application techniques along with water use to reduce herbicide movement	Low	High	High	
At container nurseries, monitor electrical conductivity (EC) over time so that you know the release of the fertilizer being used and only apply it as needed	Low	High	High	
Maintain all irrigation equipment on a normal basis to ensure the best efficiency	Medium	High	High	

Project Planning Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Look into assistance provided by ETO and EQIP: they offer technical advice and/or funding to help plan efficiency projects, and provide contacts for technicians and contractors	High	High	HIgh	ETO and EQIP (incentives vary)
Complete a measure feasibility study	Low	Low	High	REAP offers grants specifically for feasibility studies which nurseries are generally eligible for
Get free advice! Check for technical assistance available in the area. Encourage local governments and institutions to take advantage of REAP and other programs to develop community-based energy audits for agricultural producers and rural businesses	High	High	High	REAP offers up to 25% of costs for feasibility studies for qualified applicants (max $50,000).

Other Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Initiate educational and/or incentive programs for low-carbon commuting and business travel (air travel for business is often overlooked but has enormous GHG impacts)	Medium	High	Medium	OR BETC offers a tax credit worth up to 35% of program design and implementation.
Recycle used containers through Agri-plas	Low	High	High	
Recycle all general types of waste (paper, plastic, cardboard, glass, etc.)	Medium	Medium	High	

Best Management Practices Requiring Upfront Capital

The following section outlines a number of best management practices that have the potential to reduce operational resource consumption and GHG emissions. Different from those listed in the previous section, the measures included here will require a higher level of upfront capital to be implemented.

Opportunities are rated based on the energy savings captured for the related upfront costs (energy efficiency return on investment, for EE ROI), the level of GHG emissions mitigation for the cost (GHG return on investment, or GHG ROI), and the relevance to nursery operations throughout the industry (Applicability). Each category is rated as a "high," "medium," or "low" level of opportunity. For further explanation regarding the rating system used in this section, please see the "Guide Methodology" section of this report.

Incentives that apply to each opportunity are also noted in the "Incentives" column. Information regarding the following incentive programs, as well as others, is included here.

- Energy Trust of Oregon (ETO), www.energytrust.org
- Oregon Business Energy Tax Credit (OR BETC), www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml
- USDA's Renewable Energy for America Program (REAP), www.rurdev.usda.gov/or/reap.htm
- USDA's Environmental Quality Incentives Program (EQIP), www.nrcs.usda.gov/programs/eqip/

Additional information on these incentive programs is included in the "Available Incentives" section of this report.

Lighting Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install skylights in offices, warehouses, and propagation houses	Medium	Medium	Medium	OR BETC offers a tax credit worth up to 35% of design, materials, and installation.

Heating and Cooling Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Upgrade greenhouse cover	High	High	Medium	OR BETC offers a tax credit worth up to 35% of design, materials, and installation (50% for combined heat and power). ETO and REAP also offer incentives for this measure.
Add diffuser cones to ventilation fans that funnel the air, allowing the motor to work more efficiently	Medium	Medium	Medium	ETO, REAP and BETC offer incentives for this measure.
Convert to more efficient heating systems (condenser boiler systems, radiant heating)	High	High	Medium	REAP grants can cover up to 25% (max $250,000) of eligible project costs. See also REAP loan programs. Priority given to grant asks below $20,000. ETO and BETC also offer incentives for this measure.
Use more efficient fans and motors	High	High	Medium	ETO offers incentives ranging from $10-$2,000 for efficient electric motors, with additional incentives for premium efficiency motors. REAP and BETC also offer incentives for this measure.
Install energy curtains	Medium	Medium	Medium	ETO, REAP and BETC offer incentives for this measure.
Install a combined-heat-and-power system	Medium	Medium	Medium	ETO offers incentives of $120-$300 on efficient air-conditioning units. REAP and BETC also offer incentives for this measure.
Install Variable Speed Drives (VSDs) on cooling systems	High	High	High	ETO offers standard cash incentives of $0.20/sq foot of efficient insulation. Custom incentives are also available. REAP and BETC also offer incentives for this measure.

Irrigation/Fertilizer Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install premium efficiency irrigation pumps	Medium	High	High	Check EQIP Agricultural Water Enhancement Program (RFPs to be announced) for opportunities. ETO, REAP, and BETC also offer incentives for this measure.
Install Variable Frequency Drives (VFDs) for irrigation pumps	Medium	High	High	EQIP Conservation Activity Plan can recuperate up to 75% of costs and loss of income due to program implementation (up to 90% for projects with special environmental significance). ETO offers up to 50% cash back for adding a VFD to a new or existing pump. REAP and BETC also offer incentives for this measure.
Monitor soil moisture, preferably in conjunction with an irrigation system upgrade. This will allow you to only pump and use water when it is needed.	Medium	High	High	ETO, BETC and REAP all offer incentives for this measure.
Convert existing irrigation system to drip or linear/pivot system	Medium	High	High	ETO offers cash incentives ranging from $1-$3 per part for linear and pivot irrigation system improvements, and from $0.25-$8 for wheel and hand-line improvements. BETC, REAP and ODA also offer incentives for this measure.
Use CRF, as it is less likely to run off. If liquid feed is being used, amplify it via micro-irrigation rather than using an overhead irrigation system. If an overhead system is being used, be vigilant about runoff	Low	High	High	
Do not broadcast CRF	Low	High	High	

Refrigeration Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Upgrade to systems that require less GHG-intensive refrigerants (e.g., ammonia systems)	Low	Medium	Medium	

Water/Wastewater Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Manage water drainage system	Low	Low	High	
Use rip rap, grass waterways or sediment traps to assist in managing onsite water	Low	Low	High	Check EQIP Agricultural Water Enhancement Program (RFPs to be announced) for opportunities.
Use constructed/floating wetlands and catch basins to clean water before it enters the containment pond	Low	Low	High	
Create a bed and nursery design to efficiently capture water for reuse	Low	Low	High	

Onsite Energy Production Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install solar panels to create onsite energy	Medium	Medium	Medium	Oregon BETC offers a tax credit worth up to 50% of design, materials, and installation. REAP grants can cover up to 25% (max $500,000) of eligible project costs. See also REAP loan programs. ETO offers $0.50-$1.25/watt produced through solar electric. For PGE customers, this is capped at $500,000-$600,000. For Pacific Power customers, this is capped at $100,000.
Install a solar hot water system to meet nursery heated water needs	Medium	Medium	Low	ETO offers incentives for up to 35% of the project cost (typically 10-15%) associated with commercial solar hot-water.
Install a hydroelectric or hydrokinetic system	Medium	Medium	Low	ETO offers to cover up to 50% of the costs (max $40,000) associated with project development assistance for large-scale wind, biopower, geothermal, and hydroelectric energy projects. They also offer funding to implement and install such projects. These funds are not capped, and are provided for a negotiated share of ongoing energy profits in the form of "green tags."
Install wind microturbines on site	Medium	Medium	Medium	ETO offers incentives of up to $60,000 for small-scale wind power projects.
Install geothermal heat pumps	Medium	Medium	Medium	
Install fuel cells	Low	Low	Medium	

Fleet/Transportation

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Be sure all transportation equipment is tuned on a normal basis	Medium	Medium	Medium	OR BETC offers a tax credit worth up to 35% of costs (Hybrid-electric vehicles DO NOT apply).
Reduce tillage trips over the field	Medium	Medium	High	
Purchase and use more fuel-efficient vehicles for trips that do not require heavy cargo capacity (e.g., electric vehicles like golf carts and plug-in cars, or bicycles)	Medium	Medium	Medium	
Use biofuels in existing vehicles where possible	Medium	Medium	Medium	

Other Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Practice integrated pest management	Low	Medium	High	
Plant cover crops, inter-row crops or plant material in areas of high erosion risk. For bare root nurseries that harvest in the winter, straw mulch can be applied during or post-harvest to reduce the impact on cover crops	Low	Low	High	
Reduce reliance on plastics and materials that need to go to the landfill	Low	Medium	Medium	

Available Incentives

Incentive Database Websites

The following website offers good information regarding available incentives for best management practices:

- Database of State Incentives for Renewables & Efficiency (DSIRE) at www.dsireusa.org/incentives offers a searchable database for federal and state incentives.

There is also great information available at each program's website; many offer searchable databases for the type of project you are looking to fund.

- Energy Trust of Oregon (ETO) at www.energytrust.org offers incentives for commercial, agricultural and industrial customers of any one of the state's investor-owned utilities to increase the energy efficiency of their existing buildings.
- Oregon's Business Energy Tax Credit (OR BETC) at www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml is available for investments in energy conservation, recycling, renewable energy resources, sustainable buildings, and less-polluting transportation fuels.
- The federal Rural Energy for America Program (REAP) at www.rurdev.usda.gov/or/reap.htm offers grants and loan guarantees for energy efficiency improvements and renewable energy systems, as well as grants for energy audits and renewable energy development assistance.
- USDA's Farm Bill Programs at www.nrcs.usda.gov, including Environmental Quality Incentives Program (EQIP) help farmers, ranchers and forest landowners meet environmental challenges on their land through financial, educational and technical assistance.
- Stephanie Page, Renewable Energy Specialist at the Oregon Department of Agriculture, has extensive knowledge about incentive opportunities for Oregon's nurseries. For more information on available incentives than is included in this document, feel free to contact her at spage@oda.state.or.us.
- Additional information on the incentive programs described here is available on the Climate Friendly Nurseries website at www.climatefriendlynurseries.org.

State of Oregon Incentives

Energy Trust of Oregon (ETO)

ETO offers incentives for commercial, agricultural and industrial customers of any one of the state's investor-owned utilities to increase the energy efficiency of their existing buildings. The project site must be located in Oregon, and serviced by Portland General Electric, Pacific Power, NW Natural Gas, or Cascade Natural Gas. The standard incentive program provides specific rebates for the retrofit of such equipment as electric motors, irrigation equipment, lighting, insulation, compressed air and HVAC equipment. Projects must be pre-approved before making any equipment purchases or initiating any work.

Business customers retrofitting existing buildings through measures not covered under the standard incentive program can receive financial assistance from ETO through the custom incentive program. To qualify for a custom incentive, the energy savings must be at least 25 percent of the current energy use for lighting equipment and 10 percent for all other equipment and measures.

State of Oregon's Business Energy Tax Credit (OR BETC)

Oregon's BETC is available for investments in energy conservation, recycling, renewable energy resources, sustainable buildings, and less-polluting transportation fuels. They are administered through the Oregon Department of Energy's Financial Services Division. Any Oregon business may may include in their application all costs directly related to the project including equipment cost, engineering and design fees, materials, supplies and installation costs. All projects must meet the BETC technical requirements to qualify. General retrofit projects for lighting, system efficiency, and building shell are eligible for 35 percent of the total project cost (the incremental cost of the system or equipment that is beyond standard practice).

The credit must be taken in equal portions over five years at 10 percent in the first and second, and 5 percent thereafter. For high efficiency combined heat and power, renewable resource generation, and renewable energy resource equipment manufacturing, the BETC program offers a tax credit worth 50 percent of eligible project costs. The credit for these projects is taken over 5 years at 10 percent per year. Alternatively, if your company cannot utilize the tax credits yourself, they can be sold to another interested party; the discount rate for sold credits varies slightly.

Federal Tax Credits and Treasury Grants

The federal government offers a number of tax credit incentives for businesses. A few of the programs are described below, but businesses are encouraged to view a detailed list of both state- and federal-level programs found online at the Database of State Incentives for Renewables & Efficiency (DSIRE, at www.dsireusa.org/incentives). Applicable tax forms may also be found at DSIRE.

Federal Rural Energy for America Program (REAP)

The federal REAP, enacted as part of the Food, Conservation, and Energy Act of 2008 (H.R. 2419), promotes energy efficiency and renewable energy for agricultural producers and rural small businesses through the use of grants and loan guarantees for energy efficiency improvements and renewable energy systems, as well as grants for energy audits and renewable energy development assistance.

REAP funds are available to agricultural producers and rural small businesses to purchase renewable energy systems, to make energy efficiency improvements, and to conduct relevant feasibility studies. Grants are limited to 25 percent of a proposed project's cost, and the loan guarantees for up to 50 percent (loan guarantees may not exceed $25 million); the remaining 75 percent of the project's cost must come from non-federal sources including loans, investors, or any available state or local grants. The size of the grant awarded can be anywhere from $1,500 to $250,000 for energy efficiency projects; for renewable energy systems, grants of between $2,500 and $500,000 are awarded. No person or entity can receive more than $750,000 from multiple projects.

Farm Bill Programs

The Farm Bill includes both policies and programs that affect all aspects of agriculture including farming, ranching, conservation, food markets, rural America, nutrition and consumers. The Farm Bill's conservation programs help farmers, ranchers and forest landowners meet environmental challenges on their land through financial, educational and technical assistance.

As a component of the Farm Bill, the USDA has established a system to certify third-party providers of technical assistance, such as soil and water conservation districts conservation programs. Additional information regarding the technical assistance available for federal conservation programs can be found at www.techreg.usda.gov. Informational on all Farm Bill programs can be found at www.nrcs.usda.gov.

Environmental Quality Incentive Program (EQIP)

EQIP is one of the largest landowner incentive programs, and offers financial, educational and technical assistance for conservation practices such as reducing fertilizer and pesticide use and irrigation efficiency Administered by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), EQIP pays up to 75 percent of project costs and up to 90 percent for limited resource and beginner farmers. While the program designates 60 percent of program funds (the annual budget for this program is approximately $1 billion) to assist farmers in addressing natural resource issues related to animal agriculture, EQIP funding is also used to underwrite activities on rangeland, cropland and forestland.

Conservation Stewardship Program (CSP)

The Conservation Stewardship Program gives financial assistance to farmers and ranchers in the form of incentive enhancement payments or cost share to conserve and enhance natural resources on working agricultural lands. This program is very broad -- it can address nearly any environmental issue related to land management on any type of farm or ranch in any state. This program is innovative in that it marks the first time a Farm Bill program has rewarded farmers and ranchers who have already established their own high standards for environmental performance; landowners already strip-cropping (which protects soil against erosion and helps keep sediment and farm chemicals out of watersheds), for example, may be eligible for payments. Depending on the resource and the breadth of the program in your agricultural operation, initiatives may be eligible for up to $45,000 annually for terms of 5 to 10 years.

Business Energy Investment Tax Credit

The federal Business Energy Investment Tax Credit is a corporate tax credit for use by the commercial, industrial, and utility sectors. The tax credit covers implementation of renewable technologies including solar water heat, solar space heat, solar thermal electric, solar thermal process heat, photovoltaics, wind, biomass, geothermal electric, fuel cells, geothermal heat pumps, combined heat and power/cogeneration, solar hybrid lighting, and micro turbines. The size of the credit can be worth up to 30 percent for solar, fuel cells (with a maximum of $1,500 per 0.5 kW), and small wind (max $200 per kW).

Renewable Electricity Production Tax Credit

This corporate tax credit is available to commercial and industrial sectors and covers renewable energy implementations relating to landfill gas, wind, biomass, hydroelectric, geothermal electric, municipal solid wastes, hydrokinetic power, anaerobic digestion, small hydroelectric, tidal energy, wave energy, and ocean thermal energy. The tax credit is worth $0.021 per kWh for wind, geothermal, and closed loop biomass, and $0.011 per kWh for other technologies for the first ten years of operation.

Federal Renewable Energy Grants

The U.S. Department of Treasury offers grants that may be awarded for new renewable energy installations in lieu of the Business Energy Investment Tax Credit or the Renewable Electricity Production Tax Credit. It is applicable in commercial, industrial, and agricultural sectors, and covers 30 percent of property that is part of a qualified facility, including fuel cell property (with a maximum of $1,500 per 0.5 kW), solar property, or small wind property (with a maximum of $200 per kW). The grant program additionally funds 10 percent of all other property (with a maximum of 50 MW for combined heat and power). Detailed program information can be found online at www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US53F&re=1&ee=1, and at www.treas.gov/recovery/1603.shtml.

Next Steps

The information provided in this Best Management Practices Guide is high-level in nature; as discussed in the "Methodology" section, the diverse infrastructure configurations of the nurseries using this guide gives rise to the need for additional number-crunching. This guide should therefore be used as a starting point only; nurseries must complete a more detailed quantitative analysis for each potential measure prior to adoption in order to determine its cost effectiveness and savings potential.

Online Tools and Calculators

There are a few options that nursery managers can use to vet the opportunities mentioned in this guide. The first is to utilize the do-it-yourself calculators available online. There are a number of tools available on the Web that allow you to input parameters particular to your nursery and building systems; these will then calculate the estimated capital investment required as well as the expected energy and cost savings from implementation. You can find an extensive list of links to these calculators at www.climatefriendlynurseries.org.

Public online tools tend to be simple and straight-forward to use, and are readily available to anyone looking to examine an efficiency opportunity. However, these tools can also be somewhat limiting: it is difficult to identify the tools' author, and data reliability can be a real concern. Calculations are also generally fairly simplistic in nature, and do not often take all of the complexities of nursery operations into account when deriving savings and payback estimates. The tools listed above should therefore be used as a starting point, and additional analysis should be completed before project implementation.

Onsite Audits

Onsite audits offer an opportunity for nurseries to obtain site-specific information regarding efficiency measure opportunities. Audits come in many shapes and sizes. Depending on the level and depth of analysis you'd like to receive, you may opt to select one of the following types of audits:

- **Walk-through Audit.** These audits are often offered by utilities' efficiency programs for no- or low-cost. The auditor will take a quick tour of your operations and will give general recommendations regarding opportunities they notice that are likely to save money and resources. Because auditors generally do not collect data specific to your equipment and operations, results tend to be fairly generic and high-level in nature.
- **Engineering Audit.** Expert staff (either engineers or resource/energy efficiency experts) will analyze resource usage and consumption patterns and will collect data on your nursery's specific equipment parameters prior to coming on site. They will then tour your facilities with a site or operations manager and will spend a good amount of time becoming familiar with your facilities systems, as well as the human aspect of how resources are consumed. The auditors will then compile recommendations based on your nursery's consumption patterns and. equipment usage; they will suggest specific changes, outlining equipment types and deriving cost and savings estimates based on all of the site-specific information they collected.

- **Investment-grade Audit.** Investment-grade audits are completed by an energy professional or licensed engineer, who will assess your particular site, building systems and business operations to develop the best possible plan of action. The investment-grade audit provides a dynamic model of energy use characteristics of both the existing facility and all energy conservation measures identified; because the recommendations are so in-depth and therefore costly, companies tend to identify one or two measures to focus on. Site analysis is calibrated against actual utility data to provide a realistic baseline, from which operating savings for proposed measures are calculated. The energy professional will also work with nursery personnel to understand both the characteristics of all existing energy-consuming systems as well as any variations in load profile and operating procedures that may occur throughout the year. In some situations, they may elect to install sub-meters to some systems in order to fully understand your nursery's resource consumption profile. The result of an investment-grade audit is a report containing all information required to implement the measures in question.

The cost for audits varies widely. Walk-though audits are the least expensive, but provide the least specific information. Engineering audits are more costly, but will provide enough site-specific information to make an informed decision on whether to proceed with implementation. Completing a professional investment-grade audit is a comprehensive and trustworthy way to capture all of the information necessary to move forward with highly technical projects, and is highly recommended prior to capital investment and project implementation. However, an investment-grade audit is the most expensive option. As a rule of thumb, for expensive investments you will want to pay for the level of information you need in order to make a sound business decision. For less expensive investments or for those with fewer variables to consider, go with a less expensive alternative.

Technical Assistance

In addition to the audits described above, there is extensive technical assistance that can be utilized for best management practice implementation. There are a multitude of contractors and product suppliers with a high level of expertise in the realm of resource efficiency and nursery operations that can assist you throughout the process of vetting and implementing efficiency practices. Many contractors can also help you take advantage of tax credits and other incentives.

There are also some organizations in the area that can assist in project analysis and implementation. Cascade Pacific RC&D (www.cascadepacific.org) and OSU Energy Efficiency Center (eeref.engr.oregonstate.edu) both offer technical assistance for energy efficiency improvements. Joseph Junker, Director of the OSU Energy Efficiency Center, can be contacted directly at junkerj@engr.orst.edu.