



## Chapter 2: Energy Efficiency in Home and Farm Buildings

The least expensive, quickest, and easiest way to save money on your farm is by using energy efficiency. Farms can become more energy efficient in a variety of ways, from demand side management programs—such as replacing incandescent light bulbs with fluorescent lights—to installing distributive generation technologies like CHP. None of these efficiency improvements will decrease energy demands by themselves. However, the synergies created by implementing a variable mix of efficiency improvements can work together to reduce a farm’s energy demand substantially.

When a farmer decides to make plans for new buildings or make renovations to current buildings, efficiency should always be an important consideration. The following efficient building principles should be used to help guide farmers with their decisions, keeping in mind there is no single solution that applies in every instance:<sup>4</sup>

- Minimize operating energy.
- Incorporate renewable energy wherever possible.
- Optimize material use with the fewest, best materials.
- Design for local conditions; build with local materials.
- Conserve resources in design, construction, and operation.

### Lighting

Lighting presents one of the biggest opportunities for savings, both in the home and on the farm. According to researchers from the American Council for an Energy Efficient Economy (ACEEE), lighting amounts to 1 percent of the total known energy budget of the farm.<sup>5</sup> In addition, it is estimated that, through the adoption of a combination of lighting measures in and outside of farm buildings and residence, such measures will produce a savings estimate of between 40 and 70 percent.<sup>6</sup> Lighting measures come in various forms, including compact fluorescent light bulbs, high intensity discharge retrofits, occupancy sensors, day lighting controls, and timer controls.<sup>7</sup>

It is important to remember that these measures described as on-farm lighting includes residential lighting, as well as larger-scale lighting in barns, and area lighting for the farm yard.<sup>8</sup>

### Simple Tips for Everyday Farm Living and Working

Some important common sense measures that are often forgotten, but that should always be in practice, include simply remembering to turn the lights off, or using appropriate lighting based on the type of task. Also, remember to draw the shades on farm-buildings, or install shades on farm buildings to keep heat from penetrating indoors during summer months or escaping during winter months. Another strategy to consider when building a new farm building is to orient it strategically in a direction to get the most benefits of light from the sun.<sup>9</sup> By incorporating these techniques into your operation, you make your assets inherently more valuable because they can do the same amount of work with lower energy costs.<sup>10</sup> The U.S. Department of Energy (DOE) provides great advice to farmers to lower their energy costs through more efficient lighting techniques both indoors and outdoors.<sup>11</sup>

### Indoor vs Outdoor Lighting

Here are some basic things to think about for achieving energy-efficient outdoor lighting:

- Security and utility lighting does not need to be bright to be effective.
- Use fluorescent, high-intensity discharge, or low-pressure sodium lights unless incandescent lights are automatically controlled to be on for just a few minutes each day.
- Consider incandescent flood lights with combined photosensors and motion sensors in the place of other security lighting options.
- Use photosensors with fluorescent, high-intensity discharge, or low-pressure sodium lights.

- Make sure outdoor light fixtures have reflectors, deflectors, or covers to ensure more efficient use of the light source and help reduce light pollution.
- Use timers and other controls to turn decorative lighting on and off.
- Use outdoor solar lighting where and if applicable.<sup>12</sup>

## Lighting the Barn

Replacing all of the incandescent lights in the barn with energy efficient fluorescent lights can save up to 75 percent on the costs of energy for lighting. Moreover, the use of motion sensors, instead of timers, can be even more effective in lighting areas when you need them. Another important efficiency tactic is to design your lighting so that it only illuminates the area that you will be working in. For example, there is no need to light up your entire barn when you are only doing something on the work bench. Energy-efficient lighting in these applications, however, must be carefully tested and designed for adequacy.

### Compact Fluorescent Lighting

One of the easiest ways to increase energy efficiency is to replace the old incandescent light bulbs that might be currently used and install compact fluorescent light bulbs (often referred to as CFLs).<sup>14</sup> CFLs can be installed in regular incandescent fixtures, and they consume less than one-third as much electricity as incandescent lamps.<sup>15</sup> For instance, a farmer can expect savings of almost \$60 over the life of a 100-watt equivalent CFL. Replacing a 100-watt incandescent bulb with an equivalent 25-watt CFL can save a farm \$2 per lamp each month in energy costs, assuming a 100-watt bulb is used for ten hours per day at \$0.085 kilowatt hours (kWh). Thus, replacing ten 100-watt bulbs can save \$20 a month.<sup>16</sup> CFLs are most applicable in low moisture, low dust environments such as utility rooms, office spaces, machine sheds and residences.<sup>17</sup> They can also be used in feed rooms and animal housing if you install fixtures that are approved for use in wet locations.<sup>18</sup> However, you should consider many factors when selecting the appropriate CFL for your farm needs. Again, it is important to choose the appropriate lamp based on the type of lighting activity. Some other factors to consider are whether the lamp will be used indoors versus outdoors, as floodlighting versus decorative, where there is moisture potential, in cool or warm temperatures, and whether the lamp will be enclosed.<sup>19</sup>

Finally, most utilities offer their customers discounts on or even provide free CFLs. Check your utility bill or contact your local utility for more information about your utility's incentive programs.

### High Intensity Discharge Retrofits

High-intensity discharge (HID) lamps provide the highest effi-

ciency and longest service life of any lighting type.<sup>20</sup> They can save 75 to 90 percent of lighting energy when they replace incandescent lamps. Because of the intense light they produce at a high efficiency, HID lamps are commonly used for outdoor lighting and in large indoor arenas. Since the lamps take awhile to establish, they are most suitable for applications where they stay on for hours at a time. They are not suitable for use with motion detectors.<sup>21</sup>

### Occupancy Sensors

Sensors turn lights on only when they are needed, but are more precise than timers as they respond to actual conditions. Ultrasonic motion sensors turn lights on and off in response to movement. Infrared sensors turn lights on and off in response to body heat; and photosensors turn lights on and off when ambient light levels fall below or rise above certain levels. There also are many solar powered outdoor lights available. These lights have zero operating cost as they store solar energy all day and use it at night. This technology has been proven successful for many years, even in cloudy conditions.<sup>22</sup> Occupancy sensors—indoor lighting controls—detect activity within a certain area. They provide convenience by turning lights on automatically when someone enters a room. They reduce lighting energy use by turning lights off soon after the last occupant has left the room.<sup>23</sup>

Occupancy sensors must be located where they will detect occupants or occupant activity in all parts of the room. There are two types of occupancy sensors: ultrasonic and infrared. Ultrasonic sensors detect sound, while infrared sensors detect heat and motion. In addition to controlling ambient lighting in a room, they are useful for task lighting applications, such as over kitchen counters. In such applications, task lights are turned on by the motion of a person washing dishes, for instance, and automatically turn off a few minutes after the person stops.<sup>24</sup>

### Day Lighting Controls

High-quality day lighting requires a design that eliminates glare and unwanted solar gain, and distributes the light evenly and effectively. Natural daylight actually produces less heat per unit of illumination than electric lights, reducing cooling bills as well as the demand for electricity. Also, windows incorporating spectrally selective glazing and tints, or low-coatings, make day lighting compatible with the cooling and heating requirements of any given climate. If replacing your windows is not an option, you can add films to your existing windows to allow the desired amount of light and heat into and out of your home.<sup>25</sup> Depending on your lighting needs, another alternative to artificial lighting is a lightshelf. Lightshelves are flat surfaces attached to the exteriors of buildings that bounce natural light through windows and deep into the building; they also reduce glare. In addition, light pipes, also known as

solar pipes or tubes, are a simple type of alternative lighting technology and are available for under \$400. These pipes last for years, require no maintenance, have a proven performance, and, of course, use no electricity. Light pipes have been used in homes to funnel light into dark hallways, bathrooms, kitchens, and living spaces with few or no windows.<sup>26</sup> These might also be helpful to include in barns or other farm buildings.

Day lighting has been found to be particularly cost-effective in dairy farming. The animals respond favorably to a rigid schedule of continuous light followed by a number of hours of continuous darkness.<sup>27</sup> The benefits of such practice mean farmers can save money while increasing milk production. Some tips and cost benefits include:

- Converting from eight foot T12 to T8 fluorescent lights will save approximately 400 kWh, or \$40 per year, per fixture! Install 25 fixtures and save \$1,000 per year.
- Install pulse start metal halide fixtures instead of mercury vapor fixtures. Each pulse start metal halide fixture puts out roughly twice as much light as the same wattage mercury vapor lamp. This means you can use fewer fixtures and save energy.
- Use a 150 watt pulse start metal halide lamp in place of a 250 watt mercury vapor lamp. You will get more light, save 736 kWh each year and save \$74 per year per fixture. Install 25 fixtures and save \$1,850 per year.
- Installing pulse start metal halide versus a standard fixture results in approximately 360 kWh savings, or \$36 per year per fixture! Install 20 fixtures and save \$720 per year.<sup>28</sup>

### Timer Controls

Lighting controls such as dimmers, timers, and sensors ensure that lights are turned on when they are needed; they can also adjust light output to the desired luminosity. These controls can save a lot of energy if used properly.<sup>29</sup>

- *Dimmers:* Dimmers actually extend the life of the bulb while saving you energy. Compact and tube fluorescents are available in dimmable fixtures.
- *Timers:* Timers save energy simply by turning lights on and off at pre-designated times.

Simple timers are not often used alone for outdoor lighting because the timer may have to be reset often with the seasonal variation in the length of night. However, they can be used effectively in combinations with other controls. For example, the best combination for aesthetic (decorative) lighting may be a photosensor that turns lights on in the evening and a timer that turns the lights off at a certain hour of the

night (e.g., 11 P.M.).<sup>30</sup> For indoor lighting, timers are sometimes used to give unoccupied houses a lived in look. However, they are an ineffective control for an occupied home because they do not respond to changes in occupant behavior, like occupancy sensors.<sup>31</sup>

## Space Conditioning: Heating Ventilation Air Conditioning, Insulation, Weatherizing, and Air Leaks

### The Building Envelope

The term “building envelope” refers to your farm buildings’ walls, roof, windows, and foundation, which shield your living space or farm building from the elements.<sup>32</sup> Making sure that the building envelopes of the farm are as energy efficient as possible is a must on the modern farm. Because of the diverse climatic regions that the agricultural sector covers and the varying requirement of different operations, heating and cooling systems, different efficiency strategies performed on the building envelope will apply. For instance, hog and pig, poultry, and greenhouse farm-types have large cooling and heating loads.<sup>33</sup> Thus, these types of farms might want to consider focusing on space conditioning as their first priority in attaining more energy efficiency. Accordingly, because the workshop area has different purposes than your home, an unheated storage building, or a barn, different building envelope efficiency strategies will apply. The three main areas where efficiency improvements can be made to the envelope of your farm buildings, including the home, are in insulation, heating and cooling systems, and weatherizing.

### Heating Ventilation Air Conditioning

Although there is little agricultural-specific information available for heating and cooling measures and their energy savings, they are well known in others sectors to be areas of large potential savings.<sup>34</sup> Based on Heating Ventilation Air Conditioning (HVAC) energy savings from the residential and commercial sectors, the combination of a variety of heating and cooling measures estimates savings at 30 percent.<sup>35</sup> Because of the diverse climatic regions that the agricultural sector covers and the varying requirements of different operations, heating and cooling systems should be researched based on the unique characteristics of the farm’s location, the type of farm building, the type of use of the farm building, etc.

HVAC systems account for 40 to 60 percent of the energy used in U.S. commercial and residential buildings. Proven technologies and design concepts, along with energy efficient HVAC technologies, now allow these services to be provided with significant energy savings and lower lifecycle costs. Useful guidelines are available for evaluating the relative efficiency of many appliances and of equipment like furnaces. One standard

is the Energy Star certification. In addition to selecting the most energy efficient heating and cooling system, by burning bio-mass on the farm to heat the barn or home, planting trees around your home to provide shade during summer months and act as insulation during the winter months, or by wrapping your water heater(s), you can dramatically reduce your energy costs. The use of all of these smaller improvements can quickly add up to large energy savings.<sup>36</sup>

### Radiant Heating

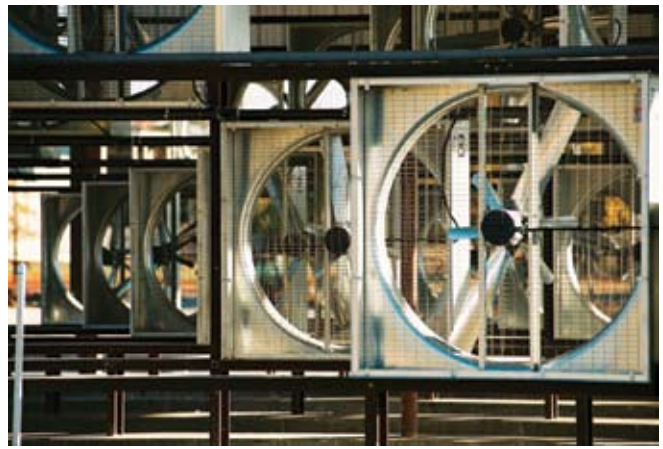
Instead of warming air and then circulating it throughout your work area using ducts and vents, a radiant heating system can be embedded under your work shop floor. The installation of electric heat coils or warm water pipes under the entire floor can evenly distribute low-temperature heat. Radiant heating systems generally require more up front expense than other heating sources, but they also offer several advantages.<sup>37</sup> For example, radiant heating systems are very efficient at low shop temperatures because the radiation heat warms the surfaces it strikes, providing comfortable equipment and surface temperatures.<sup>38</sup> Also, radiant heat sources lower heat loss when large entry-doors are opened since it is not the air in the work shop that is doing the heating, but the workshop itself.<sup>39</sup> Finally, radiant heating systems can provide about the same comfort level as forced air heaters at a 10 degree Fahrenheit lower shop temperature.<sup>40</sup> This means lower energy use by you, and increased savings on your energy bills!

### Energy Efficient Fans

High volume, low speed fans are an efficient way to move large amounts of air and make less noise than standard low volume fans. Generally, try to install fans that have an efficiency rating of 20 cubic feet per minute, per watt used. Furthermore, check to make sure that your fans are clean. Dirt and grime can lower fan efficiency by 20 percent or more. Finally, when the fan is operating, open a door or window slightly (preferably one across the room from the fan) in order to supply fresh air.<sup>41</sup> Particularly, in the summer, provide a cross-flow of air to cool the work space by opening both the endwall and sidewall doors.<sup>42</sup> These simple practices can increase the fan's effectiveness and allows you to run the fan less, which ultimately saves you money on your energy bill.<sup>43</sup>

Some of the most important parameters and selection tips to keep in mind when determining the size and number of fans required for ventilation of the operation include:<sup>44</sup>

- Generally, larger diameter fans will be more efficient than smaller fans.
- Fans with a discharge cone will be more efficient than those without.
- Motor efficiency will affect energy use and the motor's speed can affect efficiency and noise levels.



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- Fan blade tip speeds greater than 4,500 feet per minute will create excessive noise levels. To keep noise levels low, fan revolutions per minute (rpm) should be less than 720, 480, 360 and 320 rpm for fan sizes of 24", 36", 48", and 54", respectively.
- Machete or straight and teardrop blade designs are more efficient and accumulate less dust than cloverleaf shaped fan blades.
- The clearance between the fan blade and the housing will affect efficiency and the static pressure at which the fan is capable of operating. Large clearances will allow air to leak back past the fan blade and housing. If the entrance of the housing to the blade is smooth and rounded, it will reduce the turbulence and drag of the air as it enters the fan blade air foil.

### Maintaining the Heating System

When fuel costs are high, it is easy to overlook the value of maintenance. However, a problem in the heating system simply adds to these costs. Change the filter regularly and have the system serviced to make sure it is operating efficiently. In addition, keep a record of all services performed.<sup>45</sup>

### Greenhouses

Greenhouse heating costs can have a major effect on the livelihood of greenhouse growers. In order to reduce these energy costs, and increase the viability of your greenhouse farm, consider the following ten tips when heating the space:<sup>46</sup>

1. *Infrared (IR) plus anti-condensation treated films*  
IR film should be installed to the inside of the greenhouse with a standard film on the outside. This duo reduces space heating energy use by 10 to 20 percent without condensation problems, and the costs are quite low—typically as little as an additional 2 cents per square foot or about \$60 for a 30 foot by 96 foot greenhouse. This puts payback at less than one heating season in certain climates, even if you only heat your greenhouse for a few months of the year.

## 2. *Insulated side walls*

With a bench system energy savings can be achieved by insulating side walls, end walls and perimeter with one inch or two inch foam insulation board. Insulation should be dug in 12 to 24 inch deep and can extend up to plant height. The foam should have a protective cover such as aluminum foil to prevent ultraviolet deterioration and reduce fire hazards. Spray-on foam on framed walls are another good option, but also need to be protected. If foam is placed on the inside of the greenhouse, make sure it's topped with a reflective coating aimed toward the inside. This will reflect direct solar radiation back to the crop canopy and aid in plant growth. Energy savings can be substantial: just two inches of foam insulation around the knee wall of a 28 by 100 foot greenhouse will save about 400 gallons of fuel oil, 610 gallons of propane or 558 therms of natural gas annually if your greenhouse is heated throughout the year.

## 3. *Night curtains*

Greenhouses tend to peak in energy use during the night: research indicates that a greenhouse uses 80 percent or more of its heating energy after dark. Consequently, greenhouse owners should focus on limiting nighttime heat loss whenever possible, and one excellent way is with a movable insulated curtain. There are several types of curtain materials: porous curtains cut heat loss by about 20 to 30 percent when closed, can be used for shade in the summer, and allow water to drain through. Non-porous aluminized materials provide shading in summer and heat retention in winter by up to 70 percent, but hold water which can cause the curtain system to fail from the water weight. Semi-porous aluminized materials do the best job of cutting heat loss—up to 65 percent when closed—provide summer shade and drainage of condensation.

### INFILTRATION LOSSES

## 4. *Close the gaps*

Holes, cracks and gaps in the greenhouse result in unwanted leaks. A 36 inch entrance door with an 1/8 inch wide crack around it will allow about 500 cubic feet per minute of infiltration requiring about 25,000 British Thermal Units (BTU) per hour of additional heat. At \$2.40 per gallon of propane, the cost is about \$0.60 per hour.

## 5. *Poly film coverings on glass houses*

Double poly cover can reduce heat losses by up to 50 percent, but can also reduce light levels by as much as 18 percent, and might require mechanical ventilation to control humidity and replace carbon dioxide. Weigh the

trade-offs and determine which options make the most sense for your greenhouse.

## 6. *Wind breaks*

If your greenhouse is located in an open, windy area, a wind break in the path of the prevailing winter wind will help to reduce infiltration losses. A permanent wind break can be created with four or five rows of deciduous and evergreen trees planted four-to six mature tree heights upwind of the greenhouse. Plant a mix of tree species to guard against losing the entire windbreak from disease or insects.

### HEATING SYSTEMS

## 7. *Thermostats*

Clean thermostats regularly—a dirty thermostat will not read temperature correctly—and calibrate them annually to ensure accuracy.

## 8. *Furnace checkup*

Furnaces and unit heaters should be serviced and tested yearly by a professional. This helps to ensure furnace safety and energy efficiency, and the increased efficiency will easily pay for the cost of the inspection and tune-up. A 2 percent increase in efficiency will save an estimated 179 gallons of fuel oil, 259 gallons of propane or 250 therms of natural gas per year for a 30 by 96 foot greenhouse that is used year round. Replace older deteriorating unit heaters, or gravity-vented unit heaters, with either power-vented unit heaters or with 90 percent efficiency condensing type unit heaters. The power-vented unit heater will pay for itself in 36 days versus purchasing a gravity-vented unit heater, while a high efficiency condensing unit heater could provide a simple payback of approximately two years. There are particular maintenance tips to be aware of depending on whether gas burners or oil burners are used and for chimneys.

## 9. *Central heating systems*

Each uninsulated linear foot of two-inch heating supply pipe will lose an estimated \$4 worth of heat during the winter. Eliminate this waste and expense by properly insulating the heating pipes and air ducts in headhouses and boiler rooms. Insulation is simple to install and usually has a payback of less than two years. It's also important to have the heating system serviced regularly. This includes changing fuel filters, cleaning nozzles, checking valves and controls, checking and aligning belts, lubricating bearings, testing combustion efficiency and removing soot from inside the firebox. Soot removal is especially critical. For instance, just an 1/8 inch of soot can increase fuel consumption by 10 percent or more.

#### 10. *Bottom heating*

Move heating pipes and air distribution systems from overhead to either under bench, on floor or in floor, and you can save 20 to 25 percent in heating costs and have the added bonus of faster plant growth.

## Insulation

Insulation is the first line of defense for heated or cooled buildings. Insulation increases the resistance of the building to heat flow, helping to keep heated or cooled air from escaping.<sup>47</sup> Determining adequate insulation depends on several factors: what kind and how much insulation is currently installed, the geographic location of the farm, the benefit of adding more insulation, where the insulation is installed, and, how it is installed.<sup>48</sup> In addition, building envelopes on the farm have different functions, which should be factored into insulation choices. Also, the fire resistance of the insulation material should be considered. The most common types of building insulation today are fiberglass, cellulose, or petroleum-based foam, though many specialty types of insulation are commercially available, including cementitious foam, straw and mineral fiber.<sup>49</sup> Several building-energy calculators are available for farmers to use in order to help them make the best insulation decisions.<sup>50</sup> Once basic levels of insulation have been achieved in the walls, roof, and floor, the farmer should focus on preventing energy loss in other parts of the building such as weatherizing and air leaks around windows and doors.<sup>51</sup>

### Farm Shop

Normally a work shop does not need to be kept at the same temperature as a home. In warm-weather climates, moderate amounts of insulation in the ceiling, roof, and walls surrounding the workshop can go a long way toward providing some heat relief in the summer and reducing condensation in the winter.<sup>52</sup> However, in cold-weather climates where the farm shop is heated, the building envelope should be well insulated, including the foundation, sidewalls and ceiling to avoid running heaters longer than needed.<sup>53</sup> An important tip is that insulating the ceiling takes 15 percent less insulation and gives 15 percent better heat loss protection than insulating the roof area.<sup>54</sup> Regardless, the farm shop should always be insulated, with foam or fiber-glass insulation applied to the sidewall, foundation, and ceiling.

Another suggestion is that the typical heated farm shop should have sidewalls insulated to a level of R=13 and a ceiling insulated to R=20.<sup>55</sup> “R” or “R-value” is a measure of a material’s resistance to heat transfer by conduction (the transfer of heat through a solid object, from its warmer side to its cooler side), with the higher “R” levels corresponding to better insulating properties and, consequently, more resistance to heat flow.<sup>56</sup>

For safety reasons, always make sure to cover insulation material with a fire-resistant lining on sidewall.<sup>57</sup> Finally, insulating the perimeter of the building foundation is recommended in heated shops to make the floor warmer around work benches and more comfortable for winter use.<sup>58</sup>

### Livestock and Other Farm Buildings

When it comes to livestock structures, conserving energy means doing those things that reduce or eliminate wasted heat during winter and excessive heat build-up during summer. The most effective conservation measure is proper insulation.<sup>59</sup> Of the many advantages to insulating livestock buildings, including a lower heating bill, you might be surprised to know that proper insulation increases meat, milk, or egg production. Insulation also provides better general animal health and more comfortable working conditions.<sup>60</sup> It has been estimated that, with high and rising fuel costs, an insulation investment with a 20 to 30 year useful life can pay for itself in 2 to 3 years, depending on the building’s present condition and intended use!<sup>61</sup>

Adding insulation (R-19 or 6 inches for walls and floors, R-38 or 12 inches in attics) is an important step to make, if current insulation is not sufficient.<sup>62</sup> In addition, increasing attic insulation from R-19 to R-38 reduces heat loss through the attic by up to 50 percent.<sup>63</sup>

### Farm Residence (Home)

A significant amount of information is available to consumers regarding home insulation. It is well known that proper insulation of the home not only lowers your energy bills, but also increases the comfort of the living space. The DOE provides helpful tips to consumers when either choosing insulation for a new home, or updating the insulation in an existing home.<sup>64</sup> The folks at the DOE recommend consumers hire a qualified home energy auditor to determine the specifics. However, they guide consumers through the process if they choose to complete the process on their own.<sup>65</sup> Also, an energy auditor can be used to determine the efficiency of other buildings throughout the farm. Finally, in order to improve the effectiveness of the insulation, it is important to reduce air leakages as much as possible. In order to learn how to detect air leaks in the home, and to determine the amount of ventilation needed. The easiest way to repair air leaks is through caulking and weatherstripping. It is estimated that these two simple air sealing techniques will pay for themselves in energy savings within one year.<sup>66</sup>

## Weatherizing and Airleaks

Whether in farm buildings, or in homes, air leaks are a major cause of heat loss. Windows, doors, and roofs are primary culprits. The total amount saved varies, but older structures usually realize the most savings. Caulking and weatherstrip-

ping around windows and doors can reduce heat loss up to 37 percent in those areas. Some older buildings may need to be modified if heat losses are great.<sup>67</sup>

## Water Heating Systems

One final step a farmer should take to create the most energy efficient building envelope is an evaluation of their water heating systems. This should be done both for the home and other farm buildings. Like HVAC measures, there is very little data available for agriculture-specific water heating end uses and savings. Accordingly, available data in the residential and commercial sectors indicate a potential savings of approximately 20 percent in the agriculture sector.<sup>68</sup>

One unique option to consider is to include a solar water-heating system on the farm. These systems range from the simple and homemade to the complex and expensive. Generally, they serve to preheat water before it reaches a conventional water heater, minimizing the energy that the water heater then uses to boost the water to its final temperature.<sup>69</sup> For seasonally occupied or warm-climate agricultural buildings, even a simple solar water heater may bring the water to full temperature without supplementary heating which produces energy savings at minimal cost!<sup>70</sup> The DOE offers farmers several tools to evaluate their water heating systems in order to determine the feasibility of more energy efficient systems.<sup>71</sup>

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4. For more information, see Efficient Agricultural Buildings: an Overview, available at: <http://www.attra.ncat.org>.
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## Chapter 3: Energy Efficiency and Farm Equipment

Research has concluded that on-farm energy end-uses providing farmers with the largest savings potential include: motors, lighting (with irrigation being the largest motor application), and onsite transportation (including fuel use decisions).<sup>72</sup> While particular efficiency measures might be more useful to some farms because of their unique characteristics, such as the needs of a farm-type or region, much of the following research is generally applicable to all farms, no matter their location or farm-type. Also remember that the farm's residence, or "home building envelope," contributes to energy expenses, and should be included in any energy efficiency evaluation. Larger farms are certain to implement these techniques, which make it critical that smaller farms also consider them in order to remain competitive and sustainable. In addition, with more consumers focused on buying locally grown products that have been farmed with "green" practices, smaller farms have the benefit of marketing their crops and products as being produced with these energy efficient techniques. Again, the sections below outline the measures that provide farms with

the most potential for savings, or that give you "the most bang for your buck."

### Motors

As noted above, motors are one of the largest energy users on the farm. In fact, motor end-uses account for 18 percent of known and categorized energy uses on the farm at a national level.<sup>73</sup> Accordingly, they also present one of the greatest opportunities for cost savings on the farm. It is estimated that the adoption of a combination of general and application-specific measures on the farm will produce a savings of approximately 30 percent.<sup>74</sup> According to ACEEE researchers, the highest potential savings can come from pumps, fans, blowers and compressors.<sup>75</sup> Specifically, efficiency measures in the motors of pump applications are anticipated to produce a 34 percent savings.<sup>76</sup> Motor measures used to improve the energy efficiency of your farm will come from either a change in process on your farm, change in technology, or through motor replacement. Below you will find tips and suggestions about what to consider when implementing motor efficiency techniques on your farm. Further, financial benefits from implementing these changes will also be discussed.

### Irrigation Pumps

Irrigation presents a large energy- and money-saving potential in the agriculture sector. Possible irrigation energy savings are estimated at \$436 million nationally, and represent 29 percent of the total potential motor savings.<sup>77</sup> Motor energy use is the primary use of energy for all farm-types that use irrigation because of the energy it takes to pump water to and through the system.<sup>78</sup> It is important to note that the benefits of increasing energy efficiency in irrigation are not solely (or even primarily)



Photograph © Mary R. Vogt, MourageFile.

energy related.<sup>79</sup> Much of the benefit stems from the water-savings that result from improving irrigation efficiency.<sup>80</sup>

## Irrigation Energy-Saving Tips

There are several common sense guidelines a farmer can follow to improve irrigation efficiency on the farm. First, it is important to keep irrigation engines and motors serviced and well-tuned.<sup>81</sup> Second, make sure electric motors, switches, and control panels are clean and free of dirt, insects, or bird nests. These factors add to an inefficient motor.<sup>82</sup> Third, check connections to ensure they are tight, and lubricate moving parts that require it.<sup>83</sup> For example, to avoid sprinkler system inefficiency, inspect the system regularly, and make minor repairs such as stopping leaks, replacing worn nozzles, and trimming the impeller, as necessary.<sup>84</sup> Fourth, to prevent over-watering consider using an irrigation scheduling method that times irrigation watering for more efficient fuel and water use. Such methods include starting irrigation before soils are completely dry and using larger amounts of water on fewer acres per irrigation to move water through fields quicker and more efficiently.<sup>85</sup> Also, address watering methods to avoid patchy water distribution and inadequate pressure.<sup>86</sup> Either of these problems will make it impossible to maintain correct soil moisture levels, leading to crop stress, reduced yields, waste water, runoff, soil erosion, and many other problems.<sup>87</sup> Implementing all, or even one, of these techniques is guaranteed to combat these irrigation inefficiencies and save you money through lower energy bills!

Addressing equipment and management efficiency together is critical to creating the most energy efficient irrigation system on the farm. In addition to these common sense tips, there are more specific measures a farmer can take to address equipment inefficiencies and irrigation management inefficiencies. For instance, there are publications that describe recommended irrigation system installations, explain how utilities charge their irrigation customers for electricity and describe common causes of wasted energy, as well as common energy-saving hardware improvements. Also, there are do-it-yourself methods to estimate the efficiency of electrically powered irrigation systems.<sup>88</sup> In addition, see your irrigation dealer or an extension agent to find information on the following:

- What is the net water application rate for my irrigation system?
- How do I calculate the number of hours the system should be operated?
- What are different methods to measure flowing water in an open channel or pipeline?



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- What are possible suggestions for irrigating with limited water supplies?<sup>89</sup>

Finally, all farms should be encouraged to find publications explaining how to maintain irrigation pumps, motors, and engines for peak efficiency, including descriptions and diagrams of recommended installations, checklists for maintenance tasks, and a troubleshooting guide.<sup>90</sup>

## Diary Farming

Dairy farm-types are another candidate for motor energy efficiency programs due to their large use of pumps on the farm.<sup>91</sup> In Vermont, Wisconsin, and other states where dairy is the primary farm-type, upgrading motors can have a significant impact on the energy efficiency of the farm and provide significant savings.<sup>92</sup> In fact, in states where dairy farming is dominant, programs have been established to help farmers achieve more energy efficient pumping on the farm.

For most dairy farms, the best way to improve energy efficiency is through the refrigeration system's design, operation and maintenance. However, the farmer should address refrigeration system efficiency measures in a logical, step-by-step manner.<sup>93</sup> If a farmer is planning a major expansion or renovation of his dairy farm refrigeration system, it may make sense to install multiple energy saving measures. These measures, in order of priority, include:<sup>94</sup>

1. Refrigeration Heat Recovery (RHR) units
2. Scroll compressors
3. Plate/Pre-coolers
4. Variable speed milk pumps

These measures can reduce refrigeration related energy costs substantially and maintain, or even improve, milk quality. They reduce refrigeration requirements and/or capture

waste heat and use this excess heat energy to pre-heat water. However, before installing one or more of these measures, you might want to consult with farm refrigeration experts, because you may inadvertently increase your energy usage. For example, installing an RHR unit and a pre-cooler may cause an increase in energy consumption if all factors are not considered when designing the new system. Experts can also help you avoid damage to equipment or equipment failures. This factor is of greatest concern for farms with 120 cows or fewer, but all farms can benefit from expert advice before proceeding.<sup>95</sup> Even if a major refrigeration overhaul is not expected, there are still some specific measures the farmer can take to improve the efficiency of the system that are addressed below.

### Use Variable Speed Vacuum Pumps for Milking

The vacuum pump used for milking not only must operate for long hours during the day, but it tends to use a lot of energy. Standard pumps with single speed drives operate at a constant speed of seven to ten cubic feet per minute (CFM), per milking unit. On the other hand, by installing a variable speed drive on the pumping system, the pump speed can be lowered to two CFM per milking unit, yet additional power remains available if needed. The variable speed drive unit alters the vacuum power so that no more energy is needed than necessary, and the controllers on the pump are sensitive enough to prevent injury and milk back flow. The variable speed units, with corresponding controllers can lower the energy costs of a dairy vacuum system by half.<sup>96</sup>

### Dairy Farming: Use a Water Cooled Plate Cooler

Plate coolers, also known as plate heat exchangers, use well or spring water to lower the temperature of milk as it flows from the milking system to the collection tank. Using a plate cooler can speed the cooling process so that the milk is at a lower temperature, reducing the milk temperature by an extra thirty to forty degrees. This means that the compressor does not have to expend as much energy as it would otherwise.

## Machinery

The use of machinery and on-site transportation dominates energy end-use on the farm. Whether tilling the fields with the tractor, moving crops with a fork-lift, or through utilization of the combine or hay baler, the average farmer spends twelve percent of their total identified energy budget fueling machines and on-farm vehicles to perform these tasks.<sup>97</sup> Important to note, however, is that this statistic is formulated knowing that there is an enormous amount of unavailable information with regard to national energy use in agriculture. The actual expen-



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ditures are likely to be much higher, which means the resulting savings will also increase.

Since the tractor is one of the most utilized and essential tools of farms across America, it is no surprise then that the tractor is the machine that presents the largest savings potential.<sup>98</sup> In addition, diesel energy use is predominant in farm machinery, including the tractor, which presents the largest opportunity for savings nationwide.<sup>99</sup> Commercially available technology upgrades (combustion engines only) and changes in practices on the farm result in potential savings from machinery and on-site transportation.<sup>100</sup> For example, certain changes in farming techniques reduce diesel fuel use as well as energy production costs to the farmer.<sup>101</sup> Changing farm practices to increase efficiency can vary from small adjustments in behavior such as adjustments in crop planning to larger-scale modifications such as converting to no-till farming, which can reduce diesel fuel use.<sup>102</sup>

## Fuel

Because of the high use of machinery and on-site transportation on the farm, it is no surprise that fuel energy use is one of the most important ways to improve the energy efficiency of your farm. Researchers have found that gasoline and diesel are by far the fuels most used in the sector, making up seventy-five percent of agriculture fuel use all together.<sup>103</sup> Diesel use dominates because of the high use of diesel fuel in product transport.<sup>104</sup> Fuel expense savings is of primary importance to any farmer, especially to smaller farmers who need to do more with less. Fuel consumption varies widely due to variations in tractor efficiency, soil moisture conditions, crop yields, and other factors.<sup>105</sup> Here are ten ways a farmer can increase fuel efficiency of the farm:<sup>106</sup>

1. Reduce the number of trips associated with spring seed-bed preparation. With today's modern planter units, crop residue does not create the problems it used to with seed placement and depth control. For most field situations,

- one tillage trip over the field in the spring should provide adequate leveling of the soil and seedbed preparation.
2. Change to a no-till planting system where field conditions permit. This is especially true for soybeans, as no-till soybeans are an easy and proven way to maximize yields without doing any tillage.
  3. Reduce the depth of tillage associated with seedbed preparation if you are using a mulch-till or reduced-till system. In most cases, spring seedbed preparation should be performed no deeper than three to four inches. This will reduce the power and fuel requirements needed.
  4. Combine trips across the field may also reduce fuel usage. Producers using 28 percent UAN solutions may be able to mix their pre-plant or pre-emergence herbicides with their fertilizer and apply with one trip over the field. Be sure to check with your ag-supplier regarding chemical compatibility of the herbicides and fertilizer products before mixing these together.
  5. Custom apply either or both herbicides and fertilizer this spring. Although an application charge will be charged by the commercial company, they may be able to do it more cost and fuel-efficiently than an individual producer.
  6. Use post-emergence herbicides for annual grass and broad-leaf weed control. By applying the post-emergence herbicides after the crops and the weeds emerge, producers know the crop's seedling plant population and the infestation of weed species present. In some cases, producers may only need to do "spot" treatments of either the broadleaf or grass herbicide in the field. Also, by waiting until after the crop and weeds emerge for treatment, weed control is usually improved.
  7. Avoid unnecessary use of the cultivator for weed control unless weed populations cannot be controlled with herbicides.
  8. Match field equipment to the appropriate sized tractor. If excess tractor horsepower is used for the job, fuel efficiency declines dramatically. Conversely, if a small horse-powered tractor is used and the tractor becomes overloaded for the job, fuel efficiency also suffers. In many situations, research studies show that a large front-wheel assist tractor or four-wheel drive tractor may actually provide the best fuel efficiency if it is appropriately sized to a large field cultivator or other tillage implement. A good rule of thumb is to usually select the smallest and lightest tractor for the job that needs to be done to enhance fuel efficiency and reduce soil compaction.
  9. Perform general tractor maintenance before going into the fields this spring. Take time to properly clean air and fuel systems including replacement of filters. Also be

sure to properly lubricate tractors and equipment as this will result in enhanced fuel efficiency and equipment operation when you get to the fields this spring.

10. Examine use of the pick-up truck and trips to town. According to research studies, for many farms, one of the largest users of fuel involves the pick-up truck. Without a doubt, the pick-up truck is an essential component of the entire farming operation. However, where possible, combine trips for equipment, seed, chemicals, and to arrange for other agri-business services. Also, using the telephone or the home computer may reduce a number of unnecessary trips to town.

Below is an outline of some additional practical ideas on what to do to save on fuel and increase farm efficiency:

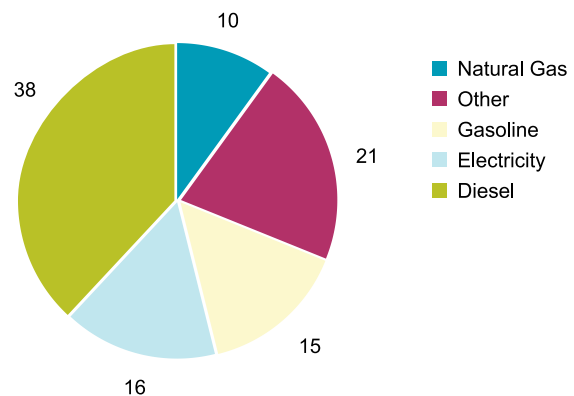


FIGURE FOUR: Total national energy use by fuel type.

### Upgrading Diesel Engines or Converting from Gasoline or Electric

One smart way to improve the fuel efficiency of the vehicles or machinery on your farm is to replace any gasoline engines used on the farm with a diesel engine. Even better would be replacing old diesel engines with newer ones that contain more advanced technology. Only fifteen percent of the gasoline you put into the tank is used to move the vehicle or equipment. The rest of the energy is lost to engine and driveline inefficiencies or idling. Therefore, the potential to improve fuel efficiency with advanced technologies is enormous.<sup>107</sup>

Diesel engines are more powerful and fuel-efficient than similar-sized gasoline engines (about 30 to 35 percent more fuel efficient). Plus, today's diesel vehicles are much improved over diesels of the past.<sup>108</sup> Today's diesel engines must meet the same emissions standards as gasoline vehicles. Advances in engine technologies, ultra-low sulfur diesel fuel, and improved exhaust treatment have made this possible. Further

improvements are made by combining an upgraded engine that advances in emission control technologies with “clean” diesel fuels, such as ultra-low sulfur diesel<sup>109</sup> and biodiesel created on your farm. Using this technology reduces hazardous air pollutants.<sup>110</sup> Energy efficient engine and transmission technologies are continuously improving.

The purchase price (initial cost) of an electric motor has been estimated to be only 1 to 2 percent of the total operating cost over the lifetime of the motor.<sup>111</sup> Because the purchase price is so insignificant, the farmer’s first step in investigating energy savings by purchasing a new electric motor, or upgrading a current electric motor should be to determine how much it costs (energy) to operate current motors on their farm.

## Gear up and Throttle Down

Running your tractor at the proper RPM is essential to fuel efficiency. In all cases consult the guidelines issued with the tractor. You should make sure that you don’t overload the engine. However, if you are hauling hay bales or pulling a rake, consider reducing the engine RPM by “gearing up and throttling down.”

## Tires

Tires should always be inflated to the proper pressure. Over-inflated tires decrease traction, create ruts in soft soil and can deteriorate sidewall tread. Also, be careful to not overload your tires. Overloading can cause pre-mature tire wear, increased soil compaction and increased fuel consumption resulting from increased rolling resistance. A University of California Study demonstrated that correctly inflated tire pressure required twenty percent less fuel than those tires that were under- or over-inflated.<sup>112</sup> Always check your equipment owner’s manual or consult your local tire distributor for the proper inflation information.

## Maintenance

Make sure to perform general maintenance on your farm equipment, especially before and after harvest season. Properly lubricated tractors and equipment will result in better fuel efficiency.<sup>113</sup> Also, be sure to change the filters in the air and fuel systems.<sup>114</sup> Finally, use appropriate equipment ballast to keep wheels from slipping and using more fuel.<sup>114</sup> Ensuring



### “Plymouth, New Hampshire: Small Farmers Benefit from Efficiency in Marketing Towards Reducing Fuel Costs”

The Plymouth Area Renewable Energy Initiative (PAREI) is a local organization in Plymouth, New Hampshire, begun to encourage energy conservation, energy efficiency practices and to promote the use of renewable energy. This group collaborated with local agricultural interests, including D-Acre Organic Farm and Educational Homestead, to organize a program to streamline the process by which local goods could get to local consumers.

The problem was that local small farmers invested all of their energy into cultivating and harvesting their crops—leaving them little time to get their crops to market, other than the weekly or bi-weekly farmers market. On the other hand, local restaurants, consumers and markets did not have the time or gas money to attend all of the local farmers’ markets to find everything they needed. When PAREI learned of the marketing problems, it organized to seek out government funds from the United States Department of Agriculture—Rural Development Agency for a \$3,445 Rural Business Enterprise Grant to begin Local Foods Plymouth.

Local Foods Plymouth is an on-line order and purchasing project that promotes food that is grown or produced in the Plymouth, NH area, which includes the town of Plymouth and 21 surrounding towns. The on-line purchasing system allows farmers and businesses to market their products via the net to the local community during any given week. Under the new system, buyers can purchase items online prior to crops being harvested and delivered to the Local Food Plymouth booth at the Plymouth Farmers’ market.

Ultimately, farmers could benefit from the system by saving labor and money by knowing exactly how much pre-bought food to harvest. Furthermore, buyers could now know which crops were in peak season and did not have to shop around for different farmers’ markets to find the produce/meat/flowers/bake goods that they wanted to purchase.<sup>115</sup>



## “Lancaster, Pennsylvania: Tomato Farmer saves time, energy and money with no-till farming”

In Lancaster, Pennsylvania, tomato farmer Steve Groff has been able to reduce soil erosion, increase his harvest, as well as cut down on the need for herbicides and insecticides on his tomato fields.

As Groff says, “Some of my fields have not been tilled in any fashion for about 30 years. The reason I got away from plowing the soil was because I saw too much soil erosion. My soil was washing away when we had rain and, since soil is my number one asset, I want to try to manage it in such a way to keep my soil in place.”

Steve Groff uses no-till farming to save time, fuel and his soil. Steve never exposes the soil by disking or turning it up in any way. He uses a specially designed planter that places the seeds for his tomatoes and other vegetables into the ground amidst the natural stubble and detritus from last year’s harvest.

“We’ve done some testing comparing the conventional versus no-till tomatoes, and on our farm where we’ve got about a 10 percent yield increase. And we’ve been able to consistently get increased yields ever since we’ve been able to do this,” says Groff.<sup>117</sup>

that you follow the proper maintenance schedule will not only increase fuel efficiency, but will extend the life of the tractor.

## Transportation

Minimizing the use of heavy-duty pick up trucks when driving into town can surprisingly save hundreds of dollars a year on gas. Larger trucks and pick ups are important to farm operations, but they should be saved for those tasks that require their power and hauling capacity. Also, remember to use air-conditioning selectively and considering combining trips to town so that one trip can accomplish multiple tasks.

## Conservation Tillage

Conservation tillage (CT) is an agricultural strategy where crops are grown with minimal cultivation of the soil. CT can limit the amount of trips that a farmer needs to take through the field. The more traditional method of tilling to control weeds and break up the soil is replaced with other more efficient and environmentally sound practices. With CT, crops are planted directly into the stubble or plant residue of the prior year’s crop. Weeds are controlled with either herbicides or with cover crops planted in between the rows of the new year’s crop. CT has many advantages besides saving on the amount of fuel that a farmer expands caring for their field, including: an increase in soil organic matter, an elevated soil-water holding capacity and a decrease in soil erosion.<sup>116</sup>

72. Elizabeth Brown and R. Neal Elliott, ii On-Farm Energy Use Characterizations (2005) (note: throughout the reports, the researchers express the extreme conservative nature of the potential savings because of the relatively limited data indicating how energy on the farm is used and further lack of data on savings potentials for particular energy end-uses—where there was no data indicating savings, they assumed that there were no savings available in that end-use.) available at: <http://www.aceee.org>. Insightful data by farm-types that are considered to be a relatively comprehensive representation of all farms across the country (poultry, dairy, greenhouse/nursery, cattle feedlots, oilseed and grain farming, fruit and tree, and hog and pig farms) is also available at: <http://www.aceee.org>.
73. Elizabeth Brown and R. Neal Elliott, Table 2, On-Farm Energy Use Characterizations, American Council for an Energy Efficient Economy 6 (2005).
74. Elizabeth Brown and R. Neal Elliott, Potential Energy Efficiency Savings in the Agricultural Sector, American Council for an Energy Efficient Economy 5 (2005).
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## Chapter 4: Energy Efficiency: Government Programs and Technology

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Energy expenses are normally a significant portion of a farm's budget, accounting for up to 10 percent of total costs.<sup>118</sup> As a result, energy expenditures cost the nation's farmers \$10 billion in energy bills a year.<sup>119</sup> Accordingly, energy ranks sixth out of total production expenses.<sup>120</sup> In addition, profit margins on farms (especially small farms) have continued to shrink, leading to an interest in minimizing expenses.<sup>121</sup> Agriculture has been hit hard by recent energy price increases.<sup>122</sup> Of course, the smallest farms feel these effects the most.

Since operating margins for small farms are typically well under 10 percent, energy costs can have an enormous impact on the economic viability of a farm.<sup>123</sup> Lowering these energy costs can be achieved through the adoption of energy efficiency on the farm. According to a conservative analysis, the potential for energy and cost savings in the agriculture sector is over 34 trillion BTUs and over one billion dollars per year (a more aggressive estimate is 98 trillion BTUs).<sup>124</sup> Energy efficiency is the streamlining of energy use through technology and behavior in a way that minimizes energy use and cost while maximizing productivity.<sup>125</sup>

In the following pages we explore different state and federal programs that are available to farmers to help them take advantage of energy efficiency opportunities on their farms. We also touch on capital intensive technology that farmers could consider in the future.

### Energy Efficiency Programs

Programs for energy efficiency range from and include:

- Simple tax incentives for farmers.
- An energy audit by a utility to explore opportunities for lower energy consumption on the farm.
- Educational programs that seek to promote information education and exchange between farmers.<sup>126</sup>

In the agriculture sector, there are four primary types of energy efficiency programs that have been most effective and provided farmers with the most benefits: audits; demonstrations; financial incentives and education; and tax related programs.<sup>127</sup> Ag energy efficiency programs have been diverse, reflecting the unique needs of the sector both programmatically and technologically.<sup>128</sup> Each region of the U.S. offers unique programs that address the differing and varying needs of the regions and farm types in order to deliver energy or economic savings while meeting the special needs of the agriculture sectors.<sup>129</sup>

### Benefits of Energy Efficiency Programs

A major goal for education programs is to encourage information transfer of appropriate material. There is a lack of information transfer in the agriculture sector due to high sector diversity, both regionally and by farm-type.<sup>130</sup> Education programs raise awareness of the best practices and energy efficiency as a resource for production cost stabilization.<sup>131</sup> The informal ability to lower information transfer barriers contributes to making these programs a success.<sup>132</sup>

### Conclusions

Farm houses and very small farms have energy use profiles akin to the residential sector.<sup>133</sup> Larger farms and their relatively intense energy needs use energy more like the industrial sector. The lighting needs reflect the commercial side of agriculture. In order to be successful, agriculture energy efficiency programs must have the best of each of the other sectors.

Most states now have an efficiency service or an energy efficiency utility that can provide many services to farmers to help them kick-start efficiency practices on their farm and in their homes. These programs help energy consumers capture the greatest energy-saving opportunities available through

the installation and use of efficient construction designs, products and equipment. Businesses can receive incentives to install high efficiency equipment (such as lighting, motors and HVAC systems). Low-income farmers can receive assistance to convert from costly electric heat and hot water systems to lower cost alternatives. Electric consumers can receive instant coupons or mail-in rebates for discounts on energy efficient lighting products and appliances.

## Non-Utility Energy Efficiency Program Administrators

Recently, several states have begun looking for alternative entities to administer energy efficiency programs. This change has partly been driven by restructuring activities and some of the concerns listed above regarding the role of distribution-only utilities in providing energy efficiency services.<sup>134</sup>

Some states (ME, IL, OH, WI and NY) have shifted the responsibility for energy efficiency administration to their respective state government.<sup>135</sup> Oregon has established an independent, non-profit agency, the Energy Trust of Oregon, Inc., to administer the energy efficiency programs there. Vermont established a new entity, the Vermont Energy Efficiency Utility, to act as a regulated energy efficiency utility independent of the state's electric utilities. Vermont solicited competitive bids to select the administrator of its energy efficiency utility, discussed below.

Other states (CT and MA) have explicitly decided to leave the energy efficiency responsibilities with the distribution-only utilities.<sup>136</sup> Massachusetts also allowed towns and cities to establish municipal aggregators to provide generation service to all customers in their boundaries, and to replace the local distribution utility as the provider of energy efficiency programs. To date only one municipal aggregator, the Cape Light Compact covering all of Cape Cod and Martha's Vineyard, has taken advantage of this option.<sup>137</sup>

## Case Study: Efficiency Vermont

Efficiency Vermont is the nation's first statewide provider of energy efficiency services. They are operated by an independent, non-profit organization and offer technical advice, financial assistance and design guidance to help make Vermont homes, farms, schools and businesses more energy efficient. In the process they help customers save energy, reduce electric bills and protect Vermont's environment. Efficiency Vermont provides specific energy efficiency advice to dairy farmers that bring many benefits. By incorporating specific energy efficient methods and equipment into dairy farm operations farmers can lower operating costs, reduce energy bills, improve equipment reliability, improve building comfort and safety, improve milk quality, lower equipment maintenance costs and increase productivity. Efficiency Vermont provides rebates for up to

60 percent of the total installed cost of energy saving equipment and offers 0 percent financing to all Vermont farmers. In 2004, Efficiency Vermont provided \$850,000 in incentives to dairy farmers that invested in energy efficiency technologies which resulted in over \$385,000 in electricity cost savings to those farmers.<sup>138</sup>

## Tax Incentive, Grant, and Loan Programs

Farmers that invest in energy efficiency will reduce their operating costs, conserving cash previously needed to pay for energy. States and the federal government are particularly eager to encourage farmers to invest in renewable and energy efficiency technologies in order to help the nation meet its energy needs and stimulate economic development in rural areas, all while helping to combat the larger issue of global climate change. For these reasons, and the myriad of additional benefits that stem from energy efficient practices, the federal government and many states have programs in place that support investment in energy efficiency. The incentives and programs offered cover a wide range of tax incentives, grants, loans, and rebates. Each state has its own set of programs, so be sure to check your state for details.<sup>139</sup> In addition, states are setting their own policies that reward consumers for their energy efficiency practices.<sup>140</sup> If you don't find information in these two areas, be sure to contact your state energy office or local utility for more information.

## Farm Bill

One federal program that is available to agricultural producers and rural small businesses in eligible rural areas is the Renewable Energy Systems and Energy Efficiency Improvements Program (also known as the United States Department of Agriculture [USDA] Farm Bill Section 9006 Program).<sup>141</sup> This program offers farmers grants that can range from \$1,500 to \$250,000. The program also offers guaranteed loans for 50 percent of eligible project costs up to \$10 million per project. In fiscal year 2007, there are approximately \$11.4 million available in grants and \$176.5 million in guaranteed loans. Projects under \$200,000 total project costs qualify for a simplified application process. For more information, including information on how to apply for grants and/or loans, and who qualifies visit the USDA website.<sup>142</sup> Or, you can contact a Rural Energy Coordinator in your area to assist you with the process.<sup>143</sup>

## Distributed Generation on the Farm

Because efficiency can significantly decrease your farm's energy demands, the farm's need for energy becomes easier to satisfy through distributed generation. Distributive generation (DG) refers to small, modular electricity generators sited close

to customer loads.<sup>144</sup> Defined another way, distributed energy generation allows for the production of energy on a smaller scale, which can occur locally at the homeowner level, closer to demand, is transportable, and allows for its storage. This is in contrast to “centralized” systems where the energy is generated by a remotely located, large-scale power plant and then transmitted down power lines to the consumer.”<sup>145</sup>

Most DG technologies generate smaller amounts of power, ranging from less than one kW to only a few hundred kW of power.<sup>146</sup> This is perfect for small and medium size farms whose power requirements are significantly smaller than a larger farm. In addition, distributed power generation technologies use a variety of fuels, including natural gas, diesel, biomass-derived fuels, fuel oil, propane, hydrogen, sunlight, and wind.<sup>147</sup> By combining the techniques learned from Chapters 3 and 4 into a distributed energy generation technology, the potentials are limitless. DG can be a supplement to the traditional centralized system, to fulfill your farm’s energy demands all together, or even as a resource to sell any surplus power generated by the DG technology back to the utility.<sup>148</sup>

## Benefits of Distributive Generation

The benefits of utilizing distributed generation on the farm are numerous, including residual effects on the entire electricity generating infrastructure. The DOE provides a comprehensive list of these benefits, including:<sup>149</sup>

- By siting smaller, more fuel-flexible systems near energy consumers, distributed generation avoids transmission and distribution power losses, and provides a choice of energy systems to the utility customer.
- Many distributed power systems produce so little noise or emissions that they can be located inside, or immediately adjacent to, the buildings where the power is needed. This greatly simplifies the problems of bringing power to expanding commercial, residential, and industrial areas.
- Distributed energy systems offer reliability for U.S. businesses and consumers who need dependable, high-quality power to run sensitive digital equipment and can provide alternative, less-expensive power sources during peak price periods. The potential market for providing power during peak price periods is as high as 460 GW, according to a DOE study.
- The potential benefits include avoiding or deferring transmission and distribution (T&D) upgrades; improving power quality; lower T&D line losses; and, given the shorter lead times and the modularity of the technologies involved, reduced risk of costly generation and T&D over-capacity by more closely matching electrical supply to demand.<sup>150</sup>

On the “supply side” of the concept, relevant technologies include small-scale internal combustion engine generator sets, small gas and diesel-fired turbine generators, microturbines, energy storage systems, solar photovoltaics, wind generating turbines, and fuel cells.<sup>151</sup> Incorporating other renewable energy sources at the site provides a doubling of energy effect.

A word of caution, however, that not all DG technologies might be perfect for your farm. DG technologies should be carefully planned, selected and implemented in order to avoid the current shortcomings of the technologies. First, distributive generation technologies have capital costs that are approximately double those of the newest central generation stations.<sup>152</sup> Second, today’s gas-fired distributive generators, such as microturbines, have an efficiency rate that is about half that of a new gas-fired central plant.<sup>153</sup> Third, distributive technologies are small and thus operators must purchase their natural gas as commercial or small industrial customers.<sup>154</sup> Fourth, while newer fuel-based distributive generation options emit conventional pollution at levels that are comparable to those reached by new central stations, their low efficiency levels result in much higher carbon emissions per unit of electricity generated.<sup>155</sup> One efficiency expert concluded that distributive generation technologies will have to dramatically improve their efficiency and reduce their costs if they are to become competitive with power purchased from the grid.<sup>156</sup>

However, with recent developments in the federal and state governments, as well as in private lending institutions, farmers across the country could soon find investing in DG the wiser choice for the long term, than the traditional short term cost of an electric bill; farmers may soon start building solar panels on the roofs of their barns to provide lighting inside the barn, or install a CHP generator fueled by biomass to run their pumps or water their crops.

## Distributed Generation Measures

Distributed generation technologies (called measures here) come in many different forms. Below is a list and description of the most common types that provide the greatest promise to farmers:<sup>157</sup>

### Fuel Cells

Fuel cells produce electricity and heat by combining fuel and oxygen in an electrochemical reaction and can operate on a variety of fuels including natural gas, propane, landfill gas, and hydrogen. Their direct conversion of chemical energy into heat and electrical energy offers quiet operation, low emissions, and high efficiencies. With present technologies, fuel cell electrical efficiencies range from 40 to 60 percent, and their combined electrical and heat efficiencies are over 80 percent, thus providing highly reliable, premium quality power. Presently, the cost

of fuel cells are relatively high at about \$3,000 per kW, but are expected to become considerably lower under mass production.

### Microturbines

Microturbines, also known as small gas turbines, with only one moving part, range in size from 30 kW to several hundred kW, and operate on a variety of fuels including gasoline, diesel, and natural gas. Microturbines are quiet, readily dispatchable, and well suited for commercial and industrial applications. First generation microturbines yield relatively low efficiencies of about 30 percent, but also have moderate capital costs of around \$600/kW. It is anticipated that microturbines that are fueled by natural gas, without cogeneration, will produce electricity for 7 to 10 cents per kWh making microturbines competitive with centrally based utility electricity generation and distributions service in the near term.

### Photovoltaic

Photovoltaic (PV) devices convert direct sunlight into electricity and are modular, lightweight, contain no moving parts (unless tracking devices are used), release no emissions, need no water, and have low operation and maintenance costs. PV panels can be placed on rooftops giving this technology significant siting flexibility. PV installations require relatively large areas to produce significant amounts of power. The most common applications of PV technology to date have been to power small loads in remote, off-grid sites where utility line extension costs are prohibitive. As PV technology becomes more widely used, it is anticipated that resulting mass production will lead to significant price decreases. A number of states provide favorable tax rules for private PV investments.

### Reciprocating Engine/Generator

Reciprocating engine/generator sets run on a variety of fuels, come in sizes from 5 kW to tens of MW with installed costs from \$500/kW to \$1,500/kW. These mass produced sets are supported by established sales and maintenance infrastructures, and are available as residential and commercial cogeneration packages. Drawbacks include relatively high emissions, noise, and maintenance requirements.

### Wind Turbines

Wind turbines have been the subject of recent, ongoing technological advances having increased in efficiency and reliability while simultaneously decreasing in costs. Installation costs for wind turbines range from \$1,000/kW to \$3,000/kW. Adaptations to cold, icing environments has also made progress. While wind turbines have no fuel requirements and zero emissions, they typically produce power at only 30 to 40 per-

cent of their rated capacity and can have site-dependent noise, wildlife habitat, and visual aesthetic concerns.

### Storage Technologies

Storage technologies, the most common being the battery, store energy in chemical or mechanical form and like other storage devices can be used for peak shaving, spinning reserve, outage support, and voltage and transient stability. While not yet viable for storing large amounts of energy, batteries are currently used for uninterruptible power supplies, support for off-grid PV and wind systems, and emergency backup for lighting and controls. Other options include compressed air storage, pumped hydroelectric storage, and more exotic technologies such as flywheels and superconducting rings, both of which remain experimental.

### Combined Heat and Power

A combined heat and power system (called cogeneration) placed on customers' farm promotes local economic development and other investments in the local community. DG resources are most often installed at the distribution level and can be on either side of the meter. They are typically small, ranging from less than one kW to only a few hundred kW. On the supply side, gasoline and diesel fueled reciprocating engines have well-known cost and performance characteristics, while micro-turbines and fuel cells are more novel, but have potential advantages where air quality and power quality requirements are critical. Advancement in the efficiency, reliability, cost and maintainability of advanced technologies may be expected to continue and screening choices should be reviewed frequently.

The DOE provides a detailed analysis of the characteristics, benefits, drawbacks, possible fuel choices, and size of each of these distributed energy generation technologies that might be helpful when making the decision of which to choose to utilize on your farm.<sup>158</sup>

### Financing Distributed Generation

There are a wide range of financing options for distributed energy systems. Distributed energy requires an upfront investment that is recovered through revenues or savings over time. Some of the financing mechanisms include: appropriations, debt (commercial bank loan), mortgage, home equity loan, limited partnership, vendor financing, general obligation bond, revenue bond, lease, energy savings performance contract, utility programs, chauffage (end-use purchase), and grants. Several financial strategies for businesses are also discussed

including: venture capital, informal investors, bank and debt financing, and the stock market.

One example of financing, the home mortgage or home equity loan option, has several advantages to meeting the economics of small-scale of DG. Interest rates on home mortgages are tax deductible, resulting in a lower effective project cost. There are also residential energy efficiency improvement loans of up to \$15,000, with interest rates that are below market interest rates.<sup>159</sup>

Another example is vendor financing, which is common among energy technologies. Vendor financing, where a third party such as a bank is often the actual source of financing, offers an easy, low cost solution, and is an effective way for the supplier to stimulate markets. Large companies may use this type of financing, but it is most suitable for small projects in the \$25,000 to \$400,000 range.<sup>160</sup>

Chauffage is an agreement where the customer purchases the electricity, heating, or cooling of the DG project instead of the actual prime mover itself.<sup>161</sup> This allows the customer not to be burdened with development and ongoing operation of the DG project and the risk of non-performance falls totally on the owner/operator of the equipment.<sup>162</sup>

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