



TRANSFORMING AUSTRALIAN AGRICULTURE WITH **CLEAN ENERGY**

A practical guide to lowering on-farm energy use and carbon emissions



National Farmers'
FEDERATION

CEFC
CLEAN ENERGY FINANCE CORP





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AGRICULTURE AND CLEAN ENERGY

Agriculture is a critical, dynamic and essential part of the Australian community – whether looked at from an economic, environmental or social point of view. That’s why the Clean Energy Finance Corporation (CEFC) and the National Farmers’ Federation (NFF) are proud to bring you this guide *Transforming Australian Agriculture with Clean Energy*.

This guide is about bringing the benefits of one of our newest industries – clean energy – to one of our most established – agriculture. And the benefits are substantial. Clean energy means more efficient energy use, improved productivity and a lower emissions profile for the farm sector.

In the past five years, CEFC has invested more than \$260 million in some 1,100 agriculture projects: from solar PV to energy efficient farm equipment, machinery upgrades and bioenergy solutions to convert agricultural and animal by-products into renewable energy.

This is in addition to a landmark investment in the sustainable cropping fund managed by Macquarie Infrastructure and Real Assets (MIRA). Together with the CSIRO, MIRA and the CEFC are developing new on-farm standards in clean energy to benefit the broader farming sector.

Australian agribusiness has a well-earned reputation for quality produce, innovative production methods and local employment opportunities – whether producing for the domestic market or extending into the highly competitive global market.

The NFF and CEFC, together with the University of Southern Queensland Centre for Agricultural Engineering, have produced this practical guide to help farmers identify opportunities to reduce their energy bills by improving energy efficiency and switching to renewables. The guide identifies many technologies and farming practices that can boost energy efficiency, from variable speed drives and smart controls to upgrading to best-in-class tractors and refrigeration equipment. Solar PV gets cheaper every year and is well suited to on-farm use, and microgrids can help particularly in remote areas or where network connections are expensive.

This guide is not a substitute for an on-farm energy audit, but we trust it will give the agribusiness sector practical insights into the many ways clean energy and energy efficiency can help them manage energy use and improve productivity.

We thank the experts from the University of Southern Queensland for their work in developing this guide and commend it to our innovative agriculture sector.



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EMISSIONS AND THE FARM SECTOR



Energy is one of the Australian agriculture sector's fastest growing costs, with high rates of technological innovation and mechanisation driving growing demand for grid electricity and diesel fuel.

This energy demand contributes to the material levels of farm-based greenhouse gas (GHG) emissions, whether through indirect emissions related to energy consumption, or direct emissions related to animal production, fertiliser use and soil management.

While energy consumption patterns vary across farming enterprises and production systems, there are significant opportunities for farm operations to immediately reduce energy consumption as well as lower energy-related emissions.

Whole-of-farm approaches that incorporate sustainable farm management practices and precision agriculture technologies can reduce fuel and grid electricity demand and improve on-farm energy productivity.

The challenge for the sector is to understand the available options, the scale of the potential investment and the potential emissions.

This practical guide is an important step in understanding the available technologies, approaches and opportunities. It brings together information on proven and emerging technologies and outlines how each can be used to reduce energy consumption and lower emissions for Australia's agricultural sector.

REAPING THE BENEFITS OF CLEANER ENERGY AND LOWER EMISSIONS

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It's about bringing the benefits of one of our newest industries - clean energy - to one of our most established - agriculture. Clean energy means better energy use, better productivity and a better emissions profile for Australia's farm sector.

”

CEFC CEO
IAN LEARMONTH

ECONOMIC POWERHOUSE

\$62B
INDUSTRY

\$49B
EXPORTS

3%
GDP

85,000
FARMING
ENTERPRISES

>250K
JOBS

Source: Australian Bureau of Agricultural and Resource Economics and Sciences 2016-2017



WHERE TO ACT

1

ENERGY
AUDIT

2

ON-FARM ENERGY
PRODUCTION

3

VEHICLES AND
MACHINERY

4

IRRIGATION AND
PUMPING

5

BUILDINGS, HEATING
AND COOLING

6

PRECISION
AGRICULTURE

7

EMERGING
TECHNOLOGIES

INVESTMENT SCALE

51

TECHNOLOGY
SOLUTIONS

10

SOLUTIONS
<\$5K

22

SOLUTIONS
>\$25K

3

SOLUTIONS
>\$100K



CLEAN ENERGY FINANCE IN ACTION

HARVESTING CLEAN ENERGY BENEFITS AT THE GRANGE

The agricultural platform of Macquarie Infrastructure and Real Assets (MIRA) is targeting major clean energy benefits in Australian agriculture, working alongside the CEFC and the CSIRO.

As part of a \$100 million equity investment from the CEFC, MIRA has acquired its first row cropping asset, The Grange, at Dongara south of Geraldton in Western Australia, and is now deploying energy efficiency measures and precision agriculture practices across the 16,500-hectare property.

The key objective is to achieve reduced energy intensity on a per unit of production basis and to deliver improved financial and environmental efficiency.

A key feature of the investment is the establishment of a specialist Energy, Emissions and Efficiency Advisory Committee – 3EAC – drawing on the skills of the CSIRO, MIRA and CEFC. 3EAC will support new on-farm standards in energy efficiency and emissions reduction. It will also develop clean energy models targeted for broader use in the farming sector.

A TECHNOLOGY-
DRIVEN
**WHOLE-OF-FARM
APPROACH**
WILL DELIVER
INCREASED
PRODUCTIVITY WITH
**IMPROVED ENERGY
EFFICIENCY**



ENERGY SAVINGS FLOW FOR IRRIGATOR

Queensland cotton and chickpea producer Don Baartz transformed the energy demands of on-farm irrigation systems thanks to an investment in solar PV.

A 25kW purpose-built solar power system is supporting an 18kW bore pump at the Darling Downs property. The system runs the pump from about 8am until 4pm daily, with grid power demands largely limited to off-peak periods.

The system cost was \$37,600, after accounting for Solar Renewable Energy Certificates. The investment is offering multiple benefits to the farm. In addition to lower greenhouse gas emissions, annual electricity costs have fallen by \$8,000, with the project offering a further \$5,000 per year in potential income when surplus power is exported to the grid.

The project was financed through the NAB Energy Efficient Bonus program, which uses CEFC finance to offer a 0.7 per cent discount on finance for eligible clean energy investments.



REFRIGERATION UPGRADE CHILLS ENERGY USE

Nightingale Bros cut energy costs by almost 40 per cent by upgrading refrigeration equipment at its Wandiligong plant in Victoria, converting to an ammonia water-cooled central plant with smart controls.

Nightingale Bros produces apples, chestnuts and persimmons over 420 hectares of land in Victoria and New South Wales. With refrigeration responsible for up to 85 per cent of total energy consumption in cold storage businesses, improvements to the technical elements of modern refrigeration systems have the potential to reduce energy consumption by 15 to 40 per cent.

An energy audit by refrigeration specialist MINUS40 identified substantial energy and carbon benefits for the business, using proven technologies to improve its cold storage facilities.

Nightingale Bros drew on discounted CEFC finance available through the CBA Energy Efficient Financing Program to carry out the \$1.2 million upgrade.



USING THIS GUIDE

Information in this guide is presented in a concise 'dashboard' format, providing guidance of a general nature. It presents clean energy options in seven distinct categories, with many applicable to all types of farming operations. Multiple factors influence energy demand at the individual farm level, just as equipment pricing and

installations costs can vary depending on location and availability. Potential investment ranges are considered, from below \$5,000 to more than \$100,000. Cost-effectiveness should be assessed on a case by case basis, with likely payback periods varying depending on the nature and scale of the investment.

UNDERSTANDING THE SCALE OF INVESTMENT

INVESTMENT RANGE

	\$ 0 - \$5,000	\$\$ \$5,000 - \$25,000	\$\$\$ \$25,000 - \$100,000	\$\$\$\$ > \$100,000
APPLICATION AREAS		 <p>Energy Production</p>	 <p>Energy Storage</p>	 <p>Light Vehicles</p>
 <p>Trucks</p>	 <p>Tractors</p>	 <p>Farm Machinery</p>	 <p>Pumps</p>	
 <p>Heating</p>	 <p>Cooling</p>	 <p>Packing</p>	 <p>Buildings</p>	

AGRICULTURE AND THE CLEAN ENERGY TRANSFORMATION: WHERE TO ACT

1	Conduct an Energy Audit Energy audits are an important first step to getting a better understanding of current energy use and helping prioritise energy-related investment decisions.
2	Generate Your Own Energy The farm sector is ideally suited to produce renewable energy and alternative fuels, including solar PV, small-scale wind and bioenergy, and to benefit from on-site energy storage solutions.
3	Upgrade Vehicles and Machinery Clean energy solutions for tractors, ancillary equipment and vehicle upgrades are easily applied and can have relatively low capital expenditure. These technologies are particularly suited to cropping systems, with most savings coming from reduced fuel use and increased operational efficiency.
4	Improve Irrigation and Pumping Energy efficient irrigation and water management practices can improve water use through the use of a range of technologies, including variable speed drives and solar-powered pumping.
5	Consider Buildings, Heating and Cooling On farm building assets, processing technologies and heating and cooling equipment can be energy intensive, impacting energy costs farm-wide. New technologies and energy efficient equipment upgrades offer practical solutions.
6	Benefit from Precision Agriculture Precision agriculture offers opportunities for improved energy efficiency and productivity, including technologies that calculate the optimal quantity, timing and location of farming inputs, reducing energy use and fertiliser application.
7	Consider Emerging Technologies Future farm energy savings, from sensing to robotics and the use of autonomous vehicles.

1 CONDUCT AN ENERGY AUDIT



ON-FARM ENERGY ASSESSMENT



Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

On-farm energy assessments identify where energy can be saved and whether investment in new technologies or practices can be beneficial. Energy assessments must be conducted by a professional. On-farm energy assessments consider energy use across electricity, gas and diesel and identify opportunities to make energy savings, improve output per unit of energy and switch to renewable energy.

TALK TO YOUR ENERGY RETAILER



Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Retail electricity tariffs can be complex, and it is not always straightforward to determine whether you are on the best tariff or benefiting from all available discounts. By talking with your energy retailer about your bill and how you use energy, you may be able to change tariffs or shift your energy use to different times of day to achieve savings.

Some electricity suppliers offer tools and information to help agricultural producers use energy more efficiently.

2 GENERATE YOUR OWN ENERGY



SOLAR PV

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

The cost of solar PV has declined significantly in recent years. The most common solar PV applications in agriculture are rooftop solar installations, diesel plus solar hybrid power generation sets, freestanding small-scale solar, and larger scale solar systems for irrigation. Farms with large roof surfaces with direct sunlight or large areas of unused land are well suited to solar PV systems.

Pricing is dependent on system size, mounting system and connection to the network. Output is seasonal and depends on panel orientation and angle. Single or dual-axis tracking can increase output but tracking systems add to the installed cost. Accredited solar installers can advise on appropriate system design.

BATTERIES, FUEL CELLS AND STORAGE

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Benefits

- Reduced GHG emissions

Energy storage can reduce reliance on network electricity by storing the output from renewable energy sources such as solar, wind and bioenergy. Storage can also reduce the need for network connection upgrades and provide cost-effective backup power. Costs for energy storage technologies continue to decline as global battery manufacturing accelerates.

Solar PV with battery storage can be cost-competitive with other energy sources in off-grid applications or where grid connection costs are high.

MICROGRIDS

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Benefits

- Increased resilience
- Reduced GHG emissions

Microgrids are small free-standing power networks. Many microgrids use renewable energy such as solar and wind accompanied by battery storage to supply a group of power users with or without the need for grid connection. On remote farms or where grid connections are costly, a standalone microgrid can cost up to 30 per cent less than a grid connection and deliver a renewable local electricity system.

For a microgrid connected to the main electricity network, costs are up to 50 per cent less, and CO2 emissions can be halved.

SMALL-SCALE WIND TURBINES

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Farms with high electricity needs in windy coastal and upland areas can consider small-scale wind turbines. These can be installed at ground level or mounted on roofs and buildings. Assessing the potential for a wind turbine project involves measuring the wind resource and characteristics.

SMALL-SCALE HYDROELECTRIC POWER

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Hydroelectric systems can be used on farms to generate renewable energy from rivers, permanent creeks and dams. Small-scale hydroelectric systems are suited to farms in mountainous areas or near rivers or permanent creeks with sufficient water flow and elevation drop or 'head'. A run-of-river small hydro system in a permanently flowing creek can produce power continuously.

On-farm hydroelectric systems may be incorporated into irrigation systems to reduce grid electricity demand.

BIODIESEL

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Benefits

- Additional by-products from production
- Fuel replacement
- Reduced GHG emissions

Biodiesel can be used in farm equipment such as tractors, trucks, stationary engines and diesel pumps. Most engines that take diesel can run on biodiesel. Most Australian states have commercial biodiesel production capacity. Biodiesel can also be produced on-site from sources such as crop residues, vegetable oil and animal fats using small processing systems.

Emissions and performance depend on the percentage of biodiesel, with blends varying from five per cent (B5) to 100 per cent biodiesel (B100). The cost of the biodiesel depends on price of the feedstock. Biodiesel carries less energy than petroleum-based diesel, which results in a small engine performance penalty.

CLEAN ENERGY FINANCE IN ACTION: ON-FARM ENERGY PRODUCTION



A produce farmer in Stanthorpe, Queensland installed a roof-mounted solar PV system which provides 38 per cent of daily electricity use, shaving approximately \$7,500 from the annual power bill.



A produce coolstore in Shepparton, Victoria installed a 100kW solar PV roof-mounted system which, along with other energy efficiency upgrade measures that reduced energy use by 25 per cent.



A 200-hectare winery in Victoria has installed a 100kW solar PV system to provide electricity for up to 20 per cent of its power needs.



A beef producer installed roof-mounted solar PV across multiple sites throughout Queensland, to reduce grid energy demand by around 30 per cent.

BIOETHANOL

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Benefits

- Fuel replacement
- Reduced GHG emissions

Bioethanol can substitute for petrol or diesel in vehicles and farm machinery. In Australia, the majority of bioethanol is produced by commercial refineries, largely using feedstock from the sugar industry. A reduction of 49-55 per cent in GHG emissions can be achieved by using bioethanol from agricultural waste.

BIOGAS

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Benefits

- Fuel replacement
- Waste management
- Reduced GHG emissions

Biogas is produced on farms through the anaerobic digestion of organic waste using covered lagoons or concrete or steel tanks. The process produces electricity, heat and a residual organic product that can be used as a fertiliser. Cost-effective biogas production generally requires an input volume of at least 25 tonnes per day and will depend on a farm's existing waste management practices.

There is further potential for biomethane to be used in tractors and vehicles or injected in to the natural gas grid.

BIOMASS

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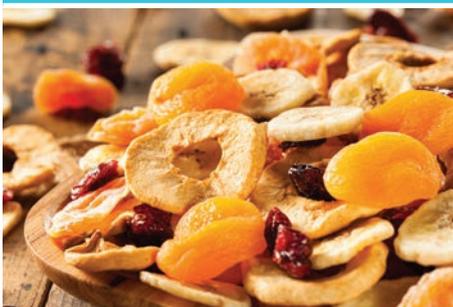
Benefits

- Additional by-products
- Fuel replacement
- Reduced GHG emissions

Biomass can be fired or co-fired in a high-efficiency boiler to produce heat and steam for renewable energy generation. Sustainably sourced biomass material can be derived from residue or waste product from crops, grasses and plantation timber and its processing. Gasification and pyrolysis are advanced combustion processes suited to feedstocks such as rice hulls and macadamia nut shells.

Gasification can improve efficiency and produce additional outputs such as biochar, which can be used to increase soil fertility, water holding capacity and crop productivity.

CLEAN ENERGY FINANCE IN ACTION: ON-FARM ENERGY PRODUCTION



A South Australian food producer and distributor purchased a biomass boiler as an alternate heat source to meet its dehydrating requirements and saved more than 60 per cent per year in energy running costs

3 UPGRADE VEHICLES AND MACHINERY



VEHICLE SELECTION

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

Choosing a vehicle that is suited to the task can significantly reduce fuel consumption and related emissions. Factors to consider include fuel type and consumption, as well as 2-wheel, 4-wheel or all-wheel drive functionality.

ENGINE MODIFICATIONS

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

Turbochargers and superchargers increase engine efficiency by compressing air intake, and intercoolers can further improve efficiency by exhaust gas. Engine modifications require professional fitting. Any impact on the vehicle manufacturer warranty should be considered before proceeding.

TYRE SIZE INCREASE

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Benefits

- Reduced energy consumption (fuel)
- Reduced soil compaction (indirect)
- Reduced GHG emissions

Increased tyre diameter increases the tyre footprint, spreading the vehicle's load more evenly to achieve greater traction and less rolling resistance. Change in tyre size will change gearing. Scope to change tyre size will depend on vehicle type, size and manufacturer specifications.

EXHAUST UPGRADE

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

A tuned exhaust reduces energy lost when expelling exhaust gases by removing or reducing the back pressure on the engine. An extractor manifold allows exhaust gases to flow from each cylinder, facilitating optimal flow. Upgrades must be designed and fitted by professionals and require a dynamometer to optimise fuel settings. Any impact on the vehicle manufacturer warranty should be considered before proceeding.

ENGINE CONTROL UNIT MODIFICATIONS

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

Changing the fuel mapping of a vehicle through the engine control unit can improve fuel efficiency. Any impact on the vehicle manufacturer warranty should be considered before proceeding.

AUTOMATIC TYRE INFLATION

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Benefits

- Reduced energy consumption (fuel)
- Reduced soil compaction (indirect)
- Reduced GHG emissions

Automatic tyre inflation systems are an in-cab device that can change tyre pressures. Changing tyre pressure allows tyres to perform optimally in different conditions by reducing wear and maintenance, increasing tractive power in soil and lowering rolling resistance on roads.

AUXILIARY POWER UNIT

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

An auxiliary power unit can power accessories such as fans, refrigerators and air conditioners while a vehicle is moving or stationary. This can reduce the load on the engine and improve fuel efficiency. Considerations include the amount of time the vehicle is idle and potential energy savings will depend on the type of power unit fitted e.g. fuel cell or generator.

NEW EQUIPMENT PURCHASE

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

Ongoing improvements in the energy efficiency of tractors, headers and other farm machinery mean that upgrading to a new or best-in-class model, particularly where it replaces old or inefficient equipment, can deliver significant fuel and cost savings as well as lower emissions. The benefits of upgrading will vary depending on the age and efficiency of the machinery being replaced. Performance test data, which includes fuel consumption, can be used

to assist selection. Best-in-class machines often feature turbocharged engines, continuous or infinitely variable transmission and real-time performance monitoring to provide feedback on performance to the operator. Upgrading ancillary equipment such as planters, seeders, towable sprayers and other trailed equipment can improve efficiency by incorporating variable-rate technology or reducing the number of passes and the implement draft.

TRACTOR BALLAST

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Benefits

- Reduced energy consumption (fuel)
- Reduced soil compaction (indirect)
- Reduced GHG emissions

Tractive efficiency can be improved by correctly ballasting a tractor using weights. Correct ballasting is dependent on individual tractor make and specifications and the particular on-farm application. For additional benefit, ballasting weights can be added or removed for different farm practices.

LOWER ROLLING RESISTANCE TYRES

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

For certain road surfaces and loads, switching to tyres with lower rolling resistance can reduce energy lost through friction, reducing fuel use. This measure is best suited to multiple axle vehicles. For smaller vehicles, the cost of the low resistance tyres may offset the fuel savings.

TRAINING AND ADAPTIVE DRIVING

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Benefits

- Reduced energy consumption (fuel)
- Reduced GHG emissions

Driver training can achieve fuel and time savings while maintaining safe practices. Evidence indicates that an operator who has received training achieves higher efficiency than an untrained operator.

CLEAN ENERGY FINANCE IN ACTION: VEHICLES AND MACHINERY



A new windrower helped a family business in Ballarat, Victoria reduce diesel consumption by about 25 per cent, cut carbon emissions and improve energy productivity. The windrower saves 2 to 2.5 litres of diesel per hectare.



A beef producer in Western Australia upgraded to a low emissions utility vehicle for their on-farm transport requirements. This new vehicle has considerably less combined tailpipe CO2 emissions than their existing vehicle, at 169g/km.



A Victorian-based specialty tree nursery purchased an Australian-designed multi pot filler and conveyors with integrated electric controls and a variable speed drive, reducing energy bills by almost 80 per cent.

4 IMPROVE IRRIGATION AND PUMPING



WATER USE EFFICIENCY

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Benefits

- Reduced energy consumption (fuel and electricity) via reduced pumping
- Reduced GHG emissions

Improvements in energy and water efficiency start with understanding where irrigation water losses occur and avoiding unnecessary pumping. Measurement tools such as flowmeters, infield sensors and soil moisture probes are used to match the amount of water applied to the field with the crop water requirements and soil water holding capacity.

PUMP TESTS

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Ensuring that pumps are operating efficiently is a low-cost way of reducing energy consumption. Tests measure pump discharge and inlet and outlet pressures. Analysis of pump energy consumption is key to optimising energy use in irrigation systems.

SOLAR PUMPING

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Solar pumping can present an opportunity to reduce grid electricity and diesel use, though it is highly dependent on the application. Small solar pumping systems for livestock watering are generally independent of the grid and can be placed in isolated areas where water is available from bores or other sources. Large irrigation pumping systems will typically use solar pumps in combination with diesel or other power sources

IRRIGATION PUMP ALIGNMENT

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Pump and motor alignment, which involves the centring of pumps and motor shafts, reduces energy consumption and costs through a more efficient transfer of power from the motor to the pump.

VARIABLE SPEED DRIVES

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Variable speed drives are commonly used to alter electrical motor speeds on the basis of pressure sensors or flow meters and can reduce electricity consumption by up to 60 per cent. Variable speed drives can be installed and configured to ensure the operating point of the pump matches the system requirements without the need to regulate pressure using a gate valve.

PUMP UPGRADES

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Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced GHG emissions

Pumps use less energy for the same volume and pressure when operating at maximum efficiency. Seek professional assistance to assess pumping needs, measure suction and discharge pressures, water flow rates and diesel and electrical power consumption.

CLEAN ENERGY FINANCE IN ACTION: IRRIGATION AND PUMPING



A potato, onion and carrot producer in Parilla, South Australia cut energy use by about 15 per cent and water and fertiliser use by around 20 per cent after investing in a new irrigation system with variable rate centre pivots to control overwatering



A Western Australian based irrigator has upgraded the pumps that supply water from the onsite dams to their irrigators, including retrofitting variable speed controls to improve the supply capability. This has not only improved on farm water use efficiency, but also provides savings in pumping costs of more than 20 per cent and will assist in prolonging the useful life of the irrigation system.



A cropping farmer in Tasmania installed a 215-metre span lateral move irrigation system with variable speed drive and low-pressure booms, significantly reducing running costs and power usage, while contributing to improved water control.

5 CONSIDER BUILDINGS, HEATING AND COOLING



WASTE HEAT RECOVERY SYSTEM

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Heat generated from the normal operation of equipment can be recovered through heat pumps and thermo-electric and liquid heat exchangers. Waste heat can be used for electricity generation, refrigeration and air conditioning or recycled back into processes such as boilers and heating and cooling plants. Recovering heat reduces energy consumption, lowering energy costs.

SOLAR HOT WATER SYSTEM

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Solar hot water systems are typically placed on a roof, with the unit also serving as a hot water storage device. The type of collector – serpentine, flat plate, evacuated tube or compound parabolic – should be matched to the application. In Australia the average efficiency is around 45 per cent compared with 15 per cent for PV panels.

GROUND SOURCE HEAT PUMPS

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Ground source heating is ideal for buildings that need to be heated or cooled such as farmhouses, greenhouses and poultry sheds. Ground source heat pumps use the ground as a heat source and heat sink. Heat pumps system types include horizontal, which requires more piping but less construction costs; vertical, which requires less piping but has higher construction costs; and

submerged, which has the least amount of piping but requires a water body or access to ground water.

VARIABLE OR FLOATING HEAD PRESSURE REFRIGERATION COMPRESSORS

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Floating head pressure compressors in refrigeration systems deliver higher reliability, less wear, quieter operation and more flexible temperature control. Controlling the head pressure of the compressor allows the compressor speed to be reduced at low loads.

SOLAR THERMAL COOLING AND ICE-MAKING

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Solar cooling uses concentrated solar thermal energy to power a thermally-driven cooling process. A solar cooling system has solar thermal collectors to capture heat from the sun and an absorption cooling machine to convert heat to cooling. Solar thermal cooling systems use renewable energy to make ice, cool air or cool other mediums.

HYDRO COOLING

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Hydro cooling is more efficient than cooling rooms to quickly reduce the temperature of agricultural produce. Water can be showered over the produce or the produce can be immersed in a water bath.

REFRIGERATION MAINTENANCE

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Maintaining refrigeration equipment has a direct effect on energy efficiency. A detailed maintenance schedule allows parts such as filters, seals and refrigerant to be monitored and replaced before refrigeration efficiency is affected. Monitoring temperature set points taking into account refrigeration requirements allows for more efficient operation.

Regular defrosting as part of a maintenance schedule reduces load on the other components, reducing wear and increasing performance. Cleaning condensing coils and fins also contributes to improved performance.

REFRIGERATION UPGRADES

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Upgrading older refrigeration equipment can reduce electricity consumption by up to half. Refrigerant can leak from worn or damaged pipes and worn seals on doors can lower efficiency. Ensuring refrigeration equipment matches the needs of the business and upgrading to refrigeration with heat exchangers can increase efficiency and lower costs.

HVAC EQUIPMENT SELECTION

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Significant energy savings can be realised through optimal selection of heating, ventilation and air conditioning (HVAC) equipment. Systems types may include:

- Variable air volume technology which regulates the volume of air supply depending on the amount of heating or cooling required
- Condensing boilers for hot water, delivering efficiencies more than 90 per cent
- Energy recovery systems that capture energy in exhaust air to pre-warm or cool fresh air entering the system

- Economy cycle options which use 100 per cent outdoor air in cooling mode when ambient conditions are cooler than the return air temperature
 - Reverse cycle heat pumps to eliminate the need for boilers
 - High temperature heat pumps that produce hot water can replace natural gas boilers in many applications, with substantial reductions in GHG emissions where renewable energy is used.
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SMART CONTROLS

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Air quality and temperature sensors optimise the operation of heating, ventilation and air conditioning systems to obtain energy savings and optimal environmental conditions in intensive production facilities. Lighting sensors reduce electricity demand by ensuring lighting levels are better matched to operational needs.

Smart control systems, including software and wireless sub-meters and sensors, have multiple on-farm applications.

BUILDING INSULATION

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Increasing the insulating properties of buildings lowers the amount of cooling or heating required, in turn reducing energy demand. Older farm buildings are often well suited to upgrades to save energy.

Installing roofing insulation, shading and double glazing can significantly reduce energy demands from temperature control.

REFLECTIVE OR WHITE ROOF

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Dark coloured roofing absorbs radiation from the sun, which can lead to significantly higher temperatures in farm buildings and facilities. For farm buildings and facilities with air conditioning, cooling systems and ventilation fans, this can significantly increase energy demand.

Installing light coloured and reflective paints or roofing can lead to significantly lower energy demands by reducing the amount of solar radiation absorbed by the roof.

REDUCING AIR LEAKAGE

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

Preventing air leakage in temperature-controlled facilities is essential to reducing energy demand. Applying foam sealants to gaps and cracks, weather-stripping, adding plastic air barriers and modifying procedures for opening and closing doors, windows and

shed access points can reduce leakage in a cost-effective manner.

LED LIGHTING

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Benefits

- Reduced energy consumption (electricity)
- Reduced GHG emissions

LEDs can replace electric lighting in a broad range of applications. Most LED bulbs can be purchased from a retailer and will fit into existing light fittings. The initial cost premium is offset by the longer lifetime of LED bulbs.

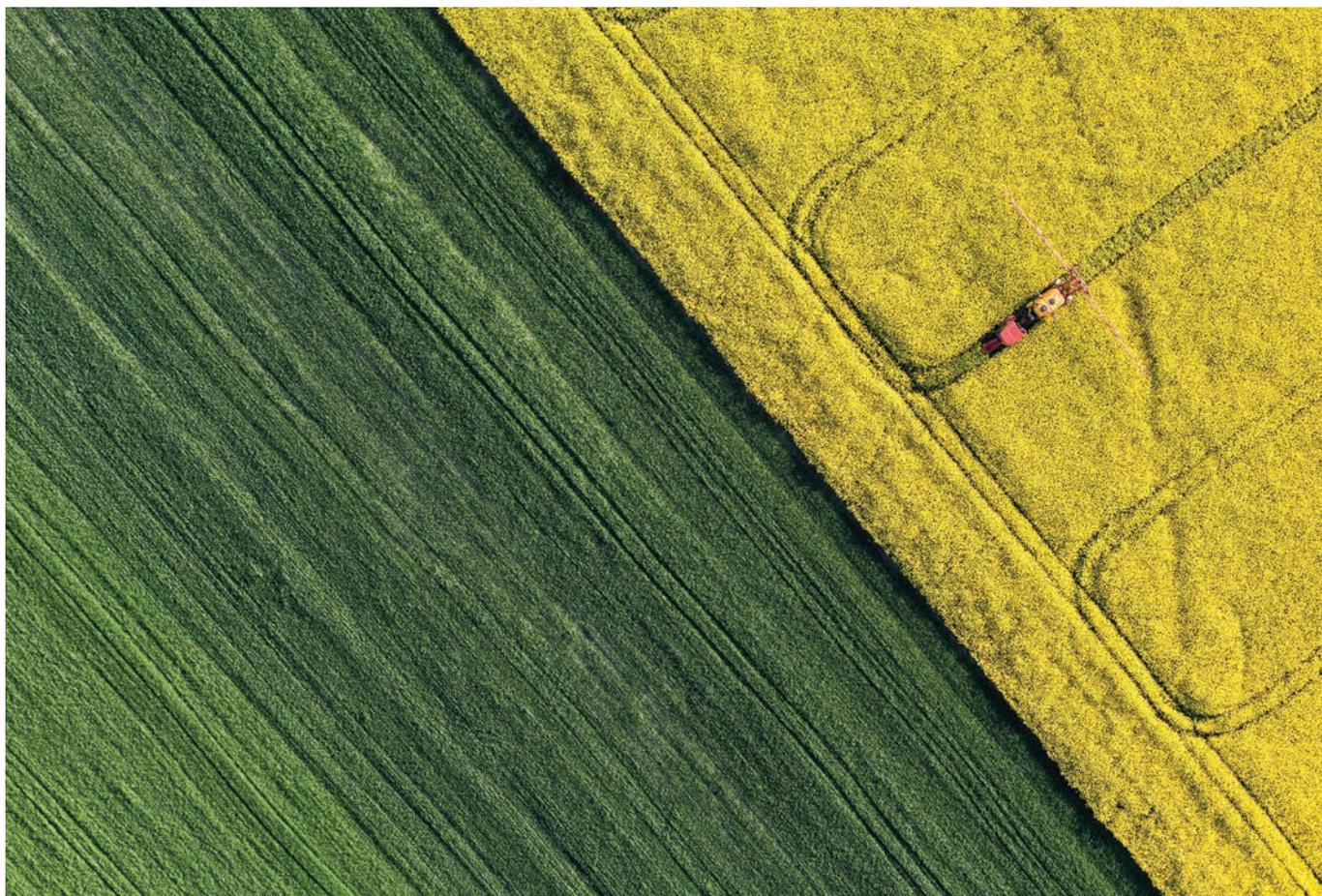
CLEAN ENERGY FINANCE IN ACTION: BUILDINGS, HEATING AND COOLING



A north Queensland vegetable producer upgraded to new cold room storage fitted with semi hermetic compressors and variable speed drive fan motors, achieving a 54 per cent reduction in energy use.

6

BENEFIT FROM PRECISION AGRICULTURE



GPS AUTO-STEER

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**Benefits**

- Reduced energy consumption (fuel)
- Reduced soil compaction (indirect)
- Reduced labour times (indirect)
- Reduced GHG emissions

Auto-steer uses GPS signals to automatically control the tractor in seeding, spraying, fertiliser application and harvesting, reducing overlap of farming operations and leading to substantial fuel savings. Auto-steer also increases labour productivity as it reduces operator fatigue. Some tractors have auto-steer as standard, and there are many aftermarket kits available.

CONTROLLED TRAFFIC FARMING

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**Benefits**

- Reduced energy consumption (fuel)
- Reduced soil compaction (indirect)
- Reduced labour times (indirect)
- Reduced GHG emissions

Controlled traffic farming or 'tramlining' involves setting up predefined tracks that all machinery travels on during seeding, spraying, fertiliser application and harvesting. Tramlining improves efficiency by confining compaction to permanent tramlines and reducing overlap. In addition to these benefits, reduction in fuel consumption is achieved because of greater traction on the tramline and less draft from tillage equipment due to improved soil conditions.

MINIMUM TILLAGE

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Benefits

- Reduced energy consumption (fuel)
- Reduced labour times (indirect)
- Reduced GHG emissions

Minimum tillage practices rely on minimal soil disturbance. Equipment developed for minimum tillage or conservation farming practices reduces the number of passes and focuses on operations which are less energy intensive and require less fuel use. This may include spray equipment and light tillage-based equipment such as disc coulters and narrow tillage points.

FERTILISER APPLICATION USING VARIABLE RATE TECHNOLOGY

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Benefits

- Reduced energy consumption (fuel)
- Reduced chemical use (indirect)
- Reduced GHG emissions

Variable rate technology uses sensors or pre-programmed maps to determine fertiliser application rates. Supporting technologies include variable rate controllers, GPS, yield monitors, crop sensors and soil sensors. Specialist advice from equipment suppliers and industry specialists is recommended to achieve maximum benefit.

PRECISION SPRAYERS

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Benefits

- Reduced energy consumption (fuel)
- Reduced chemical use (indirect)
- Reduced labour times (indirect)
- Reduced GHG emissions

Precision spray systems use sensors to identify vegetation and soil matter using spectral reflectance. These systems complement minimum tillage farming practices and improve the field efficiency of sprayer operations, reducing fuel consumption.

CLEAN ENERGY FINANCE IN ACTION: PRECISION AGRICULTURE



A New South Wales cropping farmer purchased a self-propelled sprayer with sensors and a 36 metre boom, reducing fuel requirements by almost 50 per cent, while also improving on-farm efficiency.

7 CONSIDER EMERGING TECHNOLOGIES



WIRELESS COMMUNICATIONS FOR SMART MONITORING AND CONTROL

From \$



Benefits

- Reduced energy consumption (fuel and electricity)
- Reduced labour times (indirect)
- Reduced GHG emissions

Enabling farmers and businesses to gather more information on crop, equipment and environmental conditions is vital to more efficient farming practices. Long-range wireless communication can control gates, pumps and other equipment remotely over long distances, and sensors or nodes can remotely detect water advance, soil and plant health.

Long-range systems can transmit information over up to 40 kilometres, reducing fuel costs associated with direct monitoring and controls, and improving operational efficiency.

ROBOTICS

From \$



Benefits

- Reduced energy consumption (fuel)
- Reduced labour times (indirect)
- Reduced GHG emissions

Robots are used for many tasks in agriculture such as fruit picking, image capture and processing, weed spraying and phenotyping. Energy savings depend on the application. For example, a solar-powered plant monitoring robot could lead to lower overall energy consumption by reducing fuel use associated with visual inspections.

DRIVERLESS TRACTORS

From \$



Benefits

- Reduced energy consumption (fuel)
- Reduced labour times (indirect)
- Reduced GHG emissions

Driverless tractors are near commercial with many of the enabling elements already available on the latest tractor models. Driverless tractor concepts built by the large tractor manufacturers are based on technologies such as GPS auto-steer, variable rate application, continuously variable transmissions and drive-by-wire functionality.

The potential benefits of driverless tractors include reduced labour costs, increased productivity and equipment utilisation rates, alongside the more precise application of farming inputs.

UNMANNED AERIAL VEHICLES

From \$



Benefits

- Reduced energy consumption (fuel)
- Reduced labour times (indirect)
- Reduced GHG emissions

Unmanned aerial vehicles (UAVs) are used in agriculture for surveillance of farm assets, cropping and livestock, and drone-mounted sensors are able to identify weeds and diseases. Drones can reduce fuel consumption by reducing the need for physical inspections using a vehicle.

CLEAN ENERGY FINANCE IN ACTION: EMERGING TECHNOLOGIES



A dairy farming property in south-west Victoria upgraded to a new robotic dairy milking system, reducing energy use by more than 25 per cent, as well as lowering water consumption.

NAVIGATING THE INVESTMENT OPTIONS

	ADVANTAGES	DISADVANTAGES
<p>Self-financed through cashflows and/or existing debt facilities</p>	<ul style="list-style-type: none"> • Suitable if the investment is smaller, or cashflows are sufficient to support the expenditure • Suitable if the investment doesn't fit into existing debt arrangements • May be simpler to organise • No ongoing repayment costs directly related to the project 	<ul style="list-style-type: none"> • Less capital available for investment in core business activities • Owner retains any installation and operating risk
<p>Equipment and Asset Finance for a specific project or piece of equipment which could be part of broader financing and/or separate unsecured financing</p>	<ul style="list-style-type: none"> • Reduced or no upfront costs for the project • Loans are generally secured against the equipment • Repayments are generally fixed and known in advance and can be tailored to suit cashflows and business seasonality • There are loans specifically tailored for clean energy projects, which generally have lower interest rates and longer finance periods 	<ul style="list-style-type: none"> • Interest rates for unsecured loans or loans secured against equipment only can be higher than general business lending interest rates
<p>Environmental and Building Upgrade Agreement Finance for solar PV and improved energy, water and waste efficiency in existing premises, with finance tied to the property</p>	<ul style="list-style-type: none"> • No upfront costs for the project • Loan repayments made through a local council charge on the land, paid via council rates • Can allow owners to use energy savings to pay back project costs • No mortgage security required. 	<ul style="list-style-type: none"> • Available in selected local council areas in New South Wales, Victoria and South Australia • Limited to existing, non-residential, commercial buildings
<p>Energy Services Agreements (ESAs) An ESA offers a 'turn-key' solution in which the provider finances, constructs, owns and often maintains equipment</p>	<ul style="list-style-type: none"> • Reduced or no upfront costs for the project • Interest charges can have tax advantages • Implementation and operating risks are borne by the ESA provider 	<ul style="list-style-type: none"> • Can potentially be higher cost than other financing options, due to transfer of risks to the ESA provider • 'Bundled' nature of the offering can reduce potential transparency of individual components



ENERGY SAVINGS SCHEMES

The Australian government, State and local governments provide incentives for energy efficiency and fuel switching projects via grants and Energy Savings Schemes. For more information:

Energy Efficiency Council: eec.org.au

National Farmers' Federation: nff.org.au

Department of the Environment and Energy: environment.gov.au

Department of Agriculture and Water Resources: agriculture.gov.au

CEFC FINANCE FOR AGRICULTURE



EQUIPMENT AND ASSET FINANCE

There are a range of programs with banks and other financiers that deliver discounted financing solutions for smaller-scale clean energy investments, including solar PV, water and energy efficiency upgrades, energy efficient farm equipment and machinery and low emissions on-farm vehicles. The programs include:

	NAB Energy Efficient Bonus Program
	Commonwealth Bank Energy Efficient Equipment Finance Program
	Westpac Energy Efficient Financing Program
	ANZ Energy Efficient Asset Finance Program
	Macquarie Leasing Energy Efficient Finance
	RateSetter National Clean Energy Lending Market



BIOENERGY

The CEFC and the Foresight Group are working together to identify and develop opportunities to invest in a range of bioenergy and energy from waste projects, from landfill gas capture and destruction to anaerobic digestion; biomass to energy and the production of biofuels as an alternative to gas or coal-fired generation. Much of this fuel for bioenergy comes from agricultural waste, so agribusinesses are well placed to benefit from this emerging technology.



BUILDING UPGRADES

Environmental or Building Upgrade Agreements give manufacturing, cold storage and many other agricultural related building owners the ability to invest in clean energy improvements via competitive finance with long-term repayments. The finance is offered at a fixed interest rate, with no upfront spend and loan terms of up to 10 years. Energy savings can be used to fund the repayments, which are made via fixed, quarterly council rate payments, allowing the upgrade costs to be offset against the energy savings. For more information visit eurekauf.com.au

ABOUT THIS GUIDE

This guide was prepared for the Clean Energy Finance Corporation by Craig Baillie, Bernadette McCabe, Andrew Hill and Victor Skowronski from the Centre for Agricultural Engineering at the University of Southern Queensland. It also benefited from contributions from Joseph Foley (USQ) and Michael Dennis.



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CLEAN ENERGY FINANCE CORPORATION

The CEFC is responsible for investing \$10 billion in clean energy projects on behalf of the Australian Government. We help lower Australia's carbon emissions by investing in renewable energy, energy efficiency and low emissions technologies. We also support innovative start-up companies through the Clean Energy Innovation Fund. Across our portfolio, we invest to deliver a positive return for taxpayers.

cefc.com.au



National Farmers'
FEDERATION

NATIONAL FARMERS' FEDERATION

The National Farmers' Federation (NFF) is the peak national body representing farmers and, more broadly, agriculture across Australia. It is one of Australia's foremost and respected advocacy organisations. Since its inception in 1979, the NFF has earned a reputation as a leader in the identification, development and achievement of policy outcomes - championing issues affecting farmers and dedicated to the advancement of agriculture. The NFF is dedicated to proactively generating greater understanding and better-informed awareness of farming's modern role, contribution and value to the entire community. One of the keys to the NFF's success has been its commitment to presenting innovative and forward-looking solutions to the issues affecting agriculture, striving to meet current and emerging challenges, and advancing Australia's vital agricultural production base.

nff.org.au

