# SUSTAINABLE ENERGY CONSUMPTION AND PRODUCTION (SECP) IN AGRICULTURE

Training Manual

The **overall objective** of SWITCH Africa Green is to support six countries in Africa to achieve sustainable development by engaging in transition towards an inclusive green economy, based on sustainable consumption and production patterns, while generating growth, creating decent jobs and reducing poverty. The objective will be achieved through support to private sector led inclusive green growth.

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# Climate Change

**Climate change** is a serious issue in today's modern world. It is the consequence of increased human activity in the form of hydrocarbon consumption associated with industrialisation and modern agriculture, where the intensive use of hydrocarbons to meet the increasing needs of the world's population leads to the creation of harmful by-products termed 'Greenhouse Gas (GHG) emissions'. **Agriculture, forestry and other land uses** (AFOLU) sector is the **second largest emitter of GHGs** (24%), after the electricity and heat production sector (IPCC, 2014) Agricultural GHG emissions are on the rise; albeit at a slower rate than other human activities (FAO, 2014b). Most of GHS within the AFOLU sector, are produced by crop and livestock production. As a result, enteric fermentation - when methane is produced by livestock during digestion and released via belches – accounts for the largest share of sector's total GHG emissions (refer to Figure 1).

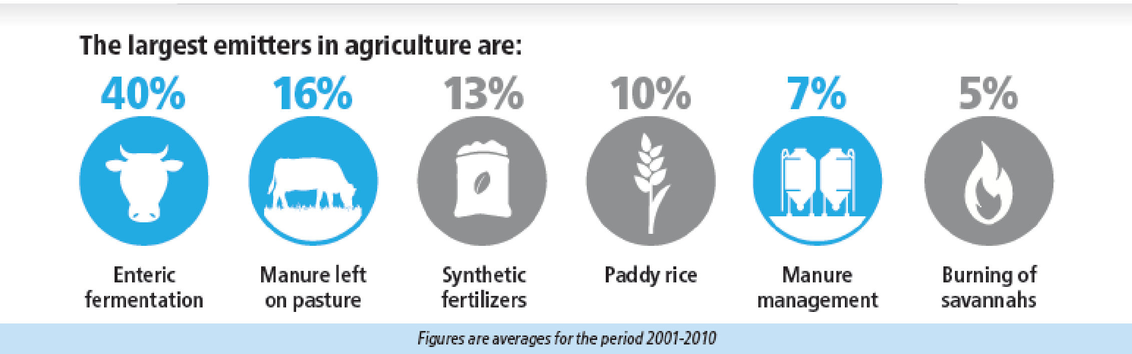


Figure 1: Largest emitters in agriculture (FAO, 2014b)

While agriculture is a prominent contributor to GHGs, it is also **among the most affected sectors by climate change**. Food and water security is compromised as a result of weather changes, drought, and changes in the temperature. All aspects of food security are potentially affected by climate change, including food access, utilisation, and price stability (Porter, et al., 2014). The rural population and the poor are the most vulnerable to these changes and are expected to be the most impacted. Farmers are already adapting to climate change, but greater efforts are required (Vermeulen, 2014).

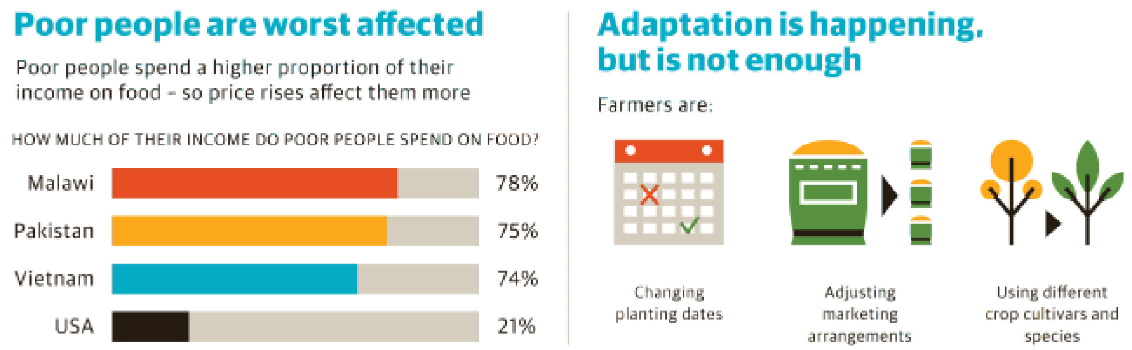


Figure 2: Climate change and food security (Vermeulen, 2014)

# Sustainable Development

Climate issue is a development issue. It affects the development process causing social, political and economic disruptions. At the same time, solutions to climate change need to come from within the development process and specifically through the more sustainable approaches adopted with respect to the use of man-made, natural, and social capitals.

In September 2015, global world leaders have adopted a 2030 Agenda for Sustainable Development that led to the formulation of 17 Goals.

*"Sustainable development is focused on growing the economy and meeting our present needs without compromising the future" (International Institute for Sustainable Development, n.d.)*


Figure 3: The 17 SDG goals

Climate change is already impacting on daily lives of the people, food security, access to water, migration patterns, and peace; thus, jeopardising achievement of the SDGs. Therefore, sustainable development cannot be achieved without mitigation and adaption actions on climate; while at the same time, investments into sustainable development will assist in combating the key drivers of climate change and building climate resilience.

# Sustainability and Agriculture

Sustainability rests on the principle that the needs of the present generation must be met without compromising the ability of future generations to meet their own needs. This in turn demands stewardship of both human and natural resources. The latter has direct linkages with the sustainable use of land for agricultural purposes to produce food for all and provide employment particularly in rural areas.

Sustainable agriculture is farming that is concerned with producing food, fibre and plant and animal products using farming techniques that are environmentally sound, economically viable and protect public health (Conserve Energy Future , 2016). Conventional agriculture is concerned with practices and techniques that are the opposite to sustainable agriculture, thus conventional farming is not sustainable.

***"Reaching the SDG targets simply will not be possible without a strong and sustainable agricultural sector" (Farming First , n.d.).***

Food and agriculture are key to achieving the entire set of SDGs, as rural development and investment in agriculture can assist in ending poverty and hunger, and bring about sustainable development. Furthermore, due to the contribution of agriculture towards GHGs emissions, it has a major role to play in combating climate change. (FAO, 2016).

***"More than any other sector, agriculture is the common thread which holds the 17 SDGs together" (Farming First , n.d.)***


Almost eighty percent of the world's extreme poor live in rural areas, where agriculture is the main source of food security, employment, and income. Agriculture is also the single largest employer in the world. Therefore, growth in agriculture can be twice as effective in reducing poverty than any other sector in low-income and agrarian economies.


One in nine people in the world still suffer from hunger. The adoption of climate-smart agricultural innovations and techniques could lead to greater crop yields, improve energy and water efficiency of farm operations; thus, reducing food insecurity in vulnerable regions to help end hunger.


Educating farmers can allow them to access knowledge, skills, tools, and inputs they need. This in turn can lead to greater productivities and increase in agricultural yields.


Unequal access and use of resources resulted in women producing less than their male counterparts. Achieving gender equality in agriculture could lead to an increase of 2.5-4% of output in developing countries, which in turn reduce hunger.


Approximately seventy percent of all water abstractions are used for crops and livestock. Global water demand is set to increase by 50% by 2030, and to sustain population grow and ensure food security, agriculture will need more water than what will be available to meet food production needs.


Energy has a key enabling role in achieving food security and better nutrition. Energy prices influence food prices. Modern food systems, though, are heavily dependent on fossil fuels and will need to decouple from this dependence in order to deliver more food with less and cleaner energy.


Growth in agriculture can stimulate economic growth and reduce poverty by half in low-income economies.


A third of food produced is lost or wasted every year. To feed the world sustainably, producers need to grow more food while reducing negative environmental impacts. At the same time, consumers must be encouraged to shift to nutritious and safe diets with a lower environmental footprint.


Agriculture has a major role to play in responding to climate change. While temperature rises pose a real threat to global food production, investments in all sectors of agriculture can simultaneously support climate change adaptation and mitigation while improving rural people's livelihoods.


Forests make vital contributions to biodiversity and act as source of food, medicine and fuel for more than a billion people. The loss of habitats and forests for additional cultivation can be prevented by improving farmland efficiency, it will also meet the worlds consumption demands.

Adopted from FAO, 2015 and Farming First , n.d.

# Food, Water, and Energy

***"Water, energy and food are essential for human well-being, poverty reduction, and sustainable development" (FAO, 2014a).***

Food, water and energy systems are interconnected - actions in one system impact one or both of the other systems (WWAP, 2014; UN Water, 2014):

- **Water** is required to produce, transport and use all forms of energy to some degree. It is also an input for producing agricultural goods in the fields and along the entire agro-food supply chain.
- **Energy** is required to extract, produce, and distribute water, as well as to produce food: to pump water from groundwater or surface water sources, to power tractors and irrigation machinery, and to process and transport agricultural goods.
- **Agriculture** is currently the biggest user of water at the global level, accounting for 70% of total water withdrawal. The food production and supply chain accounts for about 30% of total global energy consumption.

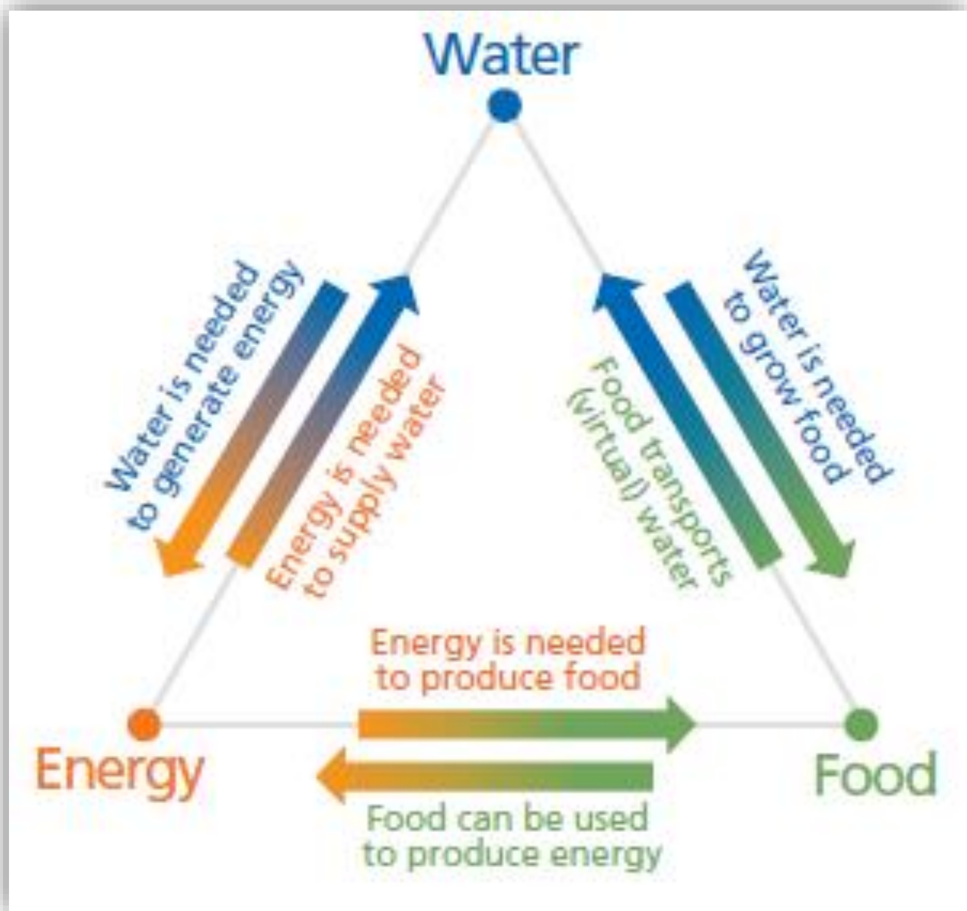


Figure 2: The Energy-Food-Nexus (UN Water , 2013)

# Transitioning to sustainable agriculture

**Conventional agricultural practices** are no longer considered to be acceptable as they ignore preservation of environmental health and biodiversity, contradicting sustainable development principles. A need for more environmentally-friendly and climate-smart agricultural practices has emerged, leading to the promotion of **sustainable agriculture**.

## *Conventional agriculture*

Is a highly resource- and energy-intensive agricultural system, developed to maximise on potential yields, but at a major cost to the environment. High yields are achieved through the extensive use of chemical fertilisers and pesticides, genetically modified organisms, intensive irrigation and tillage systems. Since the environment is not a major priority in conventional agriculture, there is often an over-reliance on fossil fuels in the production process as well as a significant generation of waste products. As a result, conventional agricultural systems are often associated with high GHG emissions.

- Industrialisation towards optimal yield production performance
- Priority on capital and financial returns
- Extensive use of synthetic chemical fertilisers, pesticides, and herbicides
- Uses genetically modified seeds and hybrid breeds
- Intensive water irrigation systems
- Intensive tillage
- Confined and concentrated animal feeding operations
- Reliance on non-renewable energy sources

## *Sustainable agriculture*

Takes a completely different approach to the one utilised in conventional agriculture. Sustainable agriculture recognises the environment and natural resources as the foundation of economic activity. Sustainable agricultural systems also rely more on the use of biofuels and renewable energy sources, as well as the incorporation of zero-waste agricultural practices. As a result, the GHG emission profile of sustainable agriculture tends to be relatively low, especially when compared to that of conventional agriculture.

- Integration of nature and man in the process of land and resources management
- Capital retention and resource assets conservation
- Use of crop rotation, animal and plant manures as fertilisers, biological and ecological weed, fungi, nematodes and pest control
- Efficient water retention
- Minimum, reduced, or no tillage
- Free-range feeding practices
- Reliance on biofuels or renewables

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# Combating and adapting to climate change in agriculture

Climate change is one of the pressing challenges the agricultural sector is faced with as it has a negative impact on productivity and yields of crop and animal sub-sectors. Conventional agricultural practices also contribute to climate change with 17% of GHG emissions from agricultural activities, and 7-14% from land use changes (OECD , 2015 ). The shift towards sustainable agricultural practices and climate-smart agriculture must be done to mitigate and adapt to the impacts of climate change. This can be done through behavioural changes, changes in operational practices, and the adoption of more energy efficient systems and renewable energy technologies.

The pursuit of land usage solutions in combination with energy efficiency and renewable energy technologies is necessary to combat climate change (Scherr & Sthapit, 2009 ).


Minimum use of nitrogen fertilizers as well as other fertilizers in the soil will reduce the CO2 emissions; thus, mitigating the impacts of climate change.


Implementation of water management practices such as improved water-efficient irrigation will improve water security.


Investment in renewable energy and energy efficient technologies will reduce the use of diesel and fossil fuel usage contributing to climate change.

# Energy efficiency technologies and practices

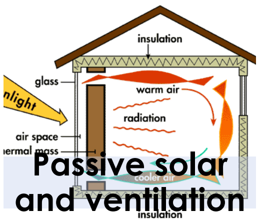
The use of energy efficient technologies and practices can assist in the transition to sustainable agriculture, while reducing agriculture's contribution to climate change. They range from behavioural changes, which are free, and systems which run efficiently, all assisting in reducing electricity of fossil fuel usages and costs.

A Variable Speed Drive (VSD) is an equipment that acts as a regulator on a motor. The device is used as an energy efficient mechanism to reduce the energy used through the regulation of the speed on the motor.


Energy efficient lighting is the use of less energy to provide the same service.


Machinery and equipment that consumes less energy than standard equipment. Motors use less energy, run cooler and last longer.

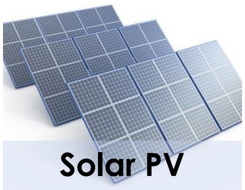

Making use of the sun's energy for heating and cooling purposes.



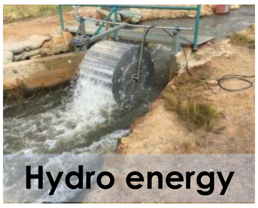

Necessary actions for retaining or restoring equipment, machine, or system to extend the life.

## Renewable energy technologies

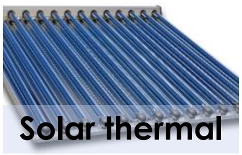
Once energy efficient technologies and practices have been adopted, natural resources should be utilised and investment should be made in renewable energy technologies to reduce electricity usage and costs.




Solar PV panels use an electronic process to convert solar energy into electricity




The utilisation of water from streams or rivers that run through a turbine and are used for energy generation




Solar thermal technologies harness solar energy for the thermal use such as cooling or heating


Bioenergy is renewable energy generally made available from energy derived from a wide variety of material of plant, vegetable, animal, and household origin.


Wind flows are transformed into rotational movements in which the rotational force can be used for mechanical energy or as energy for a generator.


A combination of different energy system`s used.

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# What have you learned?

**How does climate change affect our lives?**

**How does climate change affect agriculture?**

**What is sustainable development?**

**How do sustainable development and climate change link?**

**What is conventional agriculture?**

**What is sustainable agriculture?**

**Why do we need to transform agricultural practices to sustainable and climate-smart agriculture?**

**What are the major areas where we need to focus on when transforming to sustainable agriculture?**

**What technologies and practices can be considered?**

# Agriculture and energy inputs

The agricultural sector is heavily reliant on the supply of direct and indirect energy, e.g. fuels and electricity (Bundschuh & Chen, 2014). As a result, the agricultural sector is often susceptible to exogenous shocks such as energy prices and energy availability, making energy an important production input within the sector. Higher and unstable energy prices can hinder the profitability of agriculture; hence the need for the agriculture sector to find ways to become more energy independent (CRS, 2004).

Energy usage, and subsequently energy intensity of agricultural sub-sectors differs.


Crop production involves almost equal use of energy directly and indirectly. Fuels and electricity are the most common forms of direct energy consumption.
Fertiliser products contribute the most towards indirect energy usage in crop production.


Greenhouse-grown products are highly energy-intensive.
Generally, half of the energy consumed along the horticultural value chain is spent during agricultural activities; retail and wholesale activities account for about 1/3 of all energy consumed along the horticultural value chain.


Energy usage in animal and animal products production varies significantly. In pig farming and milk production, most of energy is spent directly and includes consumption of fuel and electricity.
In beef meat production, most of energy used is associated with indirect energy usage, which is spent on producing feed for animals and raising young animals.

# Reducing energy usage within agriculture

Transitioning to sustainable agriculture is a long-term process, which requires an interim transformational solution to facilitate the transitioning process. A step-by-step methodical approach needs to be adapted to reduce energy costs and energy usage within the agricultural value change.

**STEP 1: ENERGY AUDIT**

Understand energy needs and usage

**STEP 2: REDUCE ENERGY CONSUMPTION**

Opportunities to identify and implement energy efficient practices

**STEP 3: ADOPT RENEWABLE ENERGY TECHNOLOGIES**

Substitutions for fossil fuel, diesel and gas

# Step 1: Energy audits

An energy audit is an important tool or method of finding potential for energy efficiency measures and for assessing their financial viability (Powering Agriculture, 2016a).

**1. Review of energy use**
Helps understand energy usage/waste

**2. Site assessment**
Alternatives to reduce energy loss

**3. Energy and cost analysis**
Cost-benefit analysis for best energy-efficient solutions

**4. Audit report**
Solutions to improve performance

Figure 4: Energy audit process

### *Who can you approach?*

NCPC
NATIONAL CLEANER PRODUCTION CENTRE
SOUTH AFRICA

The NCPC conducts subsidised energy assessments to identify energy savings based on usage, and provide recommendations for energy saving options.
Tel: +27 (0) 12 841 3772
e-mail: ncpc@csir.co.za

Eskom

Eskom's Energy Advisory Services offer advice to business in the agricultural sector on a wide range of energy efficiency measures and interventions.
Tel: +27 (0) 8600 37566
E-mail: AdvisoryService@eskom.co.za

# Case Study: Energy Audits in the Kenyan Flower Industry (Powering Agriculture, 2016a)


## Findings

The energy audit revealed the following in regards to electrical energy demand:

- water pumping for irrigation (67%) constituted the largest share
- refrigeration requires (13%)
- greenhouses require (11%)
- lighting requires (9%)
- Thermal demand appears when hot water is used to warm seedling beds for better cultivation

## Recommendations

Based on the energy audit conducted, several energy efficient measures were suggested:

- high-efficiency motors and pumps
- LED lighting
- better cold curtains
- variable speed drives
- instituting an energy management system

# Step 2: Adoption of energy efficient technologies and solutions

The International Energy Agency (IEA) describes energy efficiency as the world's first fuel (Powering Agriculture, 2016a). Once an energy audit is completed, before any additional energy generation activities/investments are considered, it is imperative to first and foremost, make sure that the systems in place are energy efficient.


Figure 4: Recommended energy efficient technologies and behavioural practices

Cost-cutting is important for every farmer, reducing electricity bills through energy efficiency is one of the easiest and cheapest ways to cut costs.

## Some practices do not cost a thing but save you money!

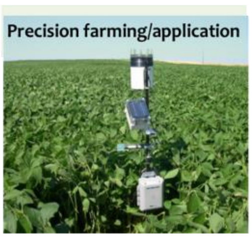
# Fertilisers


The use of cover crops and manures as a soil protection measure to reduce the use of inorganic fertilisers.


Dead plants contain nitrogen that can be reused as fertiliser for soil and other plants.


Composting makes use of decomposed organic waste and can be used as a fertiliser for soil.


Integrated pest management is a sustainable eco-friendly system to managing pests. In crop production, healthier crops which use less fertiliser will reduce pests.




Precision farming allows for control over the application of fertilizers, preventing excess fertilizer being used.

# Irrigation and fertigation


The efficiency of a pump is determined by how well it can convert energy. An example of an energy efficient pump is a pump which has a variable speed drive installed. A variable speed drive regulates the speed of an electric motor; on a pump, it uses electricity efficiently by regulating the motor speed to save energy.


Utilising natural water pressure that is created by gravity, storing it in holding tanks then feeding it through a drip irrigation tube to water plants (Drip Depot, 2016 ).


The controlling or sustaining of a controlled object.


Efficient irrigation systems such as drip irrigation systems only use water and nutrients for the plant without irrigating unplanted grounds unnecessarily through slow application of water to the root area of the plant only (TriEst Irrigation , 2016). Lowering the water pressure and lowering the fertiliser use for nutrients saves electricity.


If an irrigation system is not regularly maintained and faults are not repaired, energy is wasted as the systems do not work efficiently.

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# Lighting


Making the most of natural daylight in horticulture and animal and animal product production and minimizing the use of lighting is an energy efficient solution that will not cost anything.


Conventional incandescent light bulbs have a higher voltage, consume more electricity and have a short lifespan. LED's/CFL's/T5F/florescent/induction lamps run at a much lower voltage, consume less electricity and have an extended lifespan saving on the cost of frequently replacing bulbs.


Efficient atomisation of lighting such as timers, sensors and motion detectors can save electricity. The implementation of these energy efficient solutions allows for lighting to only come on when needed, therefore power is not wasted.


Dimmable ballasts allow for the light level to be controlled between 1-100%. They are controlled through a timeclock, photo sensors and occupancy sensors and the combination of the dimmable ballasts with these reduce the electricity.


Moisture resistant lamp fixtures is an energy efficient measure to prevent water damage occurring on lamps.


Cleaning dust of reflective surfaces ensures natural daylight is utilised and not blocked. It is a behavioural change which results in energy efficiency.

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## Efficient atomisation and dimmables


Timers

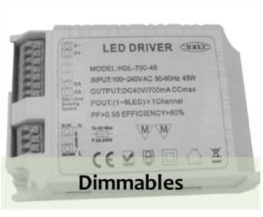
Can be used on a water heater to ensure the water is at the right temperature, only when needed and allows control over the temperature.


Sensors

Sensors are used for moisture detection on irrigation systems.


Motion detectors

Motion detectors are used for power control and are only provided when needed.


Dimmables

Dimmables are used for lighting purposes to control the level of light provided.

## Crop drying and other storage


Energy efficient drying

Replace old dryers with energy efficient dryers designed to use less fuel.


Humidity control of dryers

Moisture metres and sensors on dryers should be calibrated, in addition fuel efficiency can be increased through the use of higher drying temperatures within the recommended range (Eskom ).

# Refrigeration and cold storage

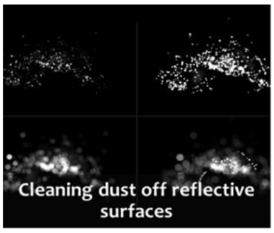

Pre-cooling of produce is the removal of field heat from harvested crops and should be undertaken right after harvesting (Energypedia, 2015).


Thickness of insulation is an important factor to consider in refrigeration and cold storage units as the thermal conductance should not exceed 0. 15 kcal/m2h°C as it then increases energy costs (FAO, n.d.).


Reduce the opening closing of refrigeration and cold storage units to reduce the infiltration of warm air (FAO, n.d.). When warm air seeps into refrigeration and cold storage units, more electricity is needed for the unit to re-cool itself.


Refrigeration and cold storage units should be well maintained to prevent inefficient cooling. Curtains inside the door storage area should be well maintained to prevent warm air travelling inside (FAO, n.d.).


Temperatures should be controlled with a controlled system to ensure compressor cycles are reduced the compressor start up process requires a lot of energy (Saving energy on Refrigeration, n.d.).




Cleaning dust of reflective surfaces ensures cold air flows effectively through the unit.

# Machinery and farm activities


Fuel efficient vehicles and machinery

The use of biodiesel and plant oil to fuel vehicles and machinery reduces the reliance on fossil diesel-fuel.


Efficient automation (efficient drives and motors)

Motors and drives need to be the right size, correctly installed, regularly maintained, sufficiently ventilated and operated properly to ensure electric power is converted efficiently (Beard & Sanford, 2012). Motors should have a load factor of between 65-100% (Beard & Sanford, 2012).


Correct gear throttle and selection

The conservation of fuel can be achieved through operating tractors in higher gears and lower throttle (Chandon & Agra, n.d.).


Proper tyre inflation

Tyres need to be inflated with the correct tyre pressure to ensure they are ballasted properly as insufficient ballasts can cause high fuel consumption due to excessive wheel slip. (Chandon & Agra, n.d.).


Selecting optimum truck size for the load

Tractors should be correctly matched to the required load or operation to decrease the fuel consumed.


Routes should be planned and scheduled so fuel is used efficiently. In addition, servicing of tractors and filling of tanks should be done in the morning to avoid unnecessarily trips that waste fuel.


Regular maintenance is essential, as poorly maintained vehicles could result in higher fuel consumption (Chandon & Agra, n.d.)


Instead of having vehicles idling for long periods, rather turn it off to save fuel.


Light-medium soil conditions allow for reduce tillage, meaning less fuel uses. Avoidance of wet field work will also reduce tillage and fuel used for breaking compaction (Chandon & Agra, n.d.). No till cropping systems prepare the soil without any mechanical disrupting of the soil. It reduces the cost of fuel to run tractors and the carbon emissions released from mechanical equipment.


For small or light loads, a larger tractor that has a higher horse power is inappropriate as it uses more fuel because of the size, if a smaller tractor is an option make that the preference (Chandon & Agra, n.d.).


A variable speed drive runs per the need of the electric motor; it adjusts the speed in accordance with the required conditions (Beard & Sanford, 2012).

# Hot water applications

Efficient heating systems- e.g. solar water heaters and heat pumps

Electric geysers are an in inefficient means of heating water as they use electrical resistance to convert electric energy into heat, a costly solution (McKenzi, 2012).
Solar water heaters harness the sun's energy to heat water.
Heat pumps heat water more efficiently than electric geysers, water is heated through the transfer of heat from the air outside (McKenzi, 2012).

On-demand hot water systems

A tankless hot water heating system is one that does not use a water storage tank, the hot water tap is turned on and the cold water is converted into hot water through an electric or gas element, therefore using less standby energy that conventional hot water heating systems with a storage tank (Ahmet, 2011).

Boiler combustion efficiency

Boiler and combustion efficiency balances the amount of air and fuel within the firing range of the burner to ensure no energy is wasted due to the burner switching off, hence the balance of controlled variables (Controls 4 Steam , 2015).


Insulation boilers, hot water tanks & the associated valves & flanges

Insulation of boilers, hot water tanks, valves and flanges prevent heat loss

## Case studies: VSD's

| | |
|---|---|
| *Variable Speed Drives: Reducing energy costs in horticulture (Eskom Integrated Demand Management , 2015)* | Reducing a pump or fan speed by 20% can reduce energy consumption by more than 50%.<br><br>When a motor is started at full voltage without the use of a VSD, it could draw up to 400% of its rated current whilst producing only 50% of its rated torque. |
| *Jomajoco a Lettuce farm in Tarlton (Claassen, 2014)* | Monthly electricity savings equate to R10,000 as a result of the system.<br><br>Installation of the VSD ensured the borehole pump ran at 31A instead of 41A.<br><br>R40, 000 to purchase, the payback period was 4 months. |

## Case studies: Lighting

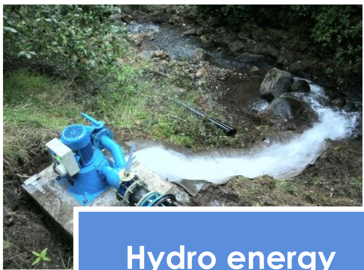
| | |
|---|---|
| *Energy efficient lighting at the Kromme Rivier Poultry Farm in South Africa (Eskom Integrated Demand Management , 2013)* | Reduction in energy usage of 51 226kWh per annum.<br><br>Savings in energy cost of R60 053 per annum.<br><br>Replacement of 256 X 60w incandescent globes with 6W LEDs.<br><br>Replacement 2 X 125W Mercury vapour floodlights with 20W Light LEDs.<br><br>The lighting retrofit costed approximately R70 700. |
| *Belnori Boutique Cheesery and Enaleni Farm* | Less use of Eskom electricity with the LED lights resulting in savings on their electricity bills.<br><br>LED lights have lasted longer.<br><br>LED lights cost between R100-150 each. |

# Step 3: Adopt renewable energy technologies

There is a wide range of well-established renewable energy technologies that can be adopted in agriculture to lessen the over-reliance on fossil fuels and provide adequate electricity generation. Hybrid energy systems, are the most feasible as it harnesses two or more different types of renewable energy technologies to provide electricity.

Solar PV

Solar thermal



Hydro energy

Wind energy

Bioenergy

Hybrid energy systems

# Solar PV

Solar PV technologies convert solar energy into electricity (OECD/IEA, 2016) via an electronic process that occurs naturally in certain types of material called semiconductors.

Most PV solar cells are made from either crystalline silicon or thin-film semiconductor material (Solar Energy Industries Association, 2016). There are three types of Solar PV panels, as illustrated below.


Figure 5: Types of solar PV most common panels (My Solar Quotes , 2016)

The generated electricity can be for both grid and off-grid uses (if used in conjunction with batteries) depending on the PV systems incorporated. In other words, PV technologies can be used to power anything from small electronics and up to large-scale commercial uses. It should also be noted that solar PV can be utilised as a standalone technology or as a complementary technology in energy hybrid systems.

Examples of applications in agriculture include:

- PV-driven pumps for irrigation
- Solar PV powered tractors and mowers for traction
- PV powered sprayer for crop spraying
- Solar PV lanterns for pest control
- Solar PV powered greenhouses
- Off-grid solar PV powered cold storage for fresh produce refrigeration
- PV powering of small loads used in agro-enterprises
- PV powered lighting for poultry and livestock
- PV powered pumping for livestock watering
- PV powered electric fencing for grazing management
- PV powered system for poultry hatching
- PV cooling for veterinary uses
- PV powered mechanical ventilation in livestock buildings/storage sheds
- PV powered dairy/meat processing refrigeration and PV powered milking machines

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# Case Studies: Solar PV

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| *De Rustica Oliva Farm* | Installing Solar PV panels on the farm has generated savings of R3,000 a month on their electricity bills.<br><br>The Solar PV panels meet the peak demand times in summer.<br><br>The Solar PV panels costed R450,000 with a payback period of 4-5 years. |
| *Rooibos Ltd. (Colthorpe, 2013)* | Rooibos Ltd. has installed 2088 solar 245W modules on the roof of their storage facilities to generate 875 000 kWh of energy per a year and supplies 40% of the electricity needs.<br><br>SolarWorld guarantees system performance for 25 years, mitigating maintenance and repair costs associated with poorly installed panels. |
| *Olderburg Vineyards* | They generate 73,948 kwh from the unit with 119 panels, Eskom power can generate 95,000 kwh.<br><br>Eskom electricity costed R173, oo0 per an annum, with Solar panels they are now saving on that cost.<br><br>During midday, the Solar panels can accommodate 85% of the electricity demand. |
| *Ceres Fruit Growers (Colthorpe, 2013).* | The large fruit producer invested in 4,060 SW250 polycrystalline panels.<br><br>The Solar technology contributes to 6% of Ceres's annual electricity consumption.<br><br>The Solar technology contributes to 6% of Ceres's annual electricity consumption.<br><br>Reduces the impact of rising electricity tariffs.<br><br>Reduces the carbon footprint of Ceres by over 1,622 tonnes each year for the next 25 years. |
| *Humpheries Boerdery Piggery* | Capacity of electricity in the evenings is 60-70kWh at night.<br><br>Solar PV panels are used to generate electricity for multiple uses on the piggery farm, including irrigation. |

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| *Camphill Village Farm* | Initially the solar plant was a 20kwh plant it now has a capacity of 60kwh.<br><br>Phase 2 of the Solar PV plant allowed for the dairy operations to be completely off-grid through the use of 732 PV modules was installed when the project started.<br><br>In summer, they save R14,000 a month as a result for solar electricity generation.<br><br>R8,000 a month is saved in winter as a result for solar electricity generation.<br><br>Over the next 20 years the anticipated savings on electricity costs are R1.44 million.<br><br>Capacity to produce 28 000 litres of dairy products from the Solar PV plant.<br><br>The anticipated payback period is 5 years for the implementation of the Solar PV panels. |
| *Red Barn Free Range Chickens* | 32 Solar PV panels on the roof of their processing area as a result of the pressure faced from electricity price hikes.<br><br>The Solar PV panels provide electricity to run all of the fridges and provide electricity for the borehole pumps.<br><br>Investing in a battery bank enables Red Barn Free Range Chickens to consume electricity from the panels in peak and off peak times throughout the day and night.<br><br>Long-term savings are 20%-25% savings on their electricity bills as they hope to go completely off grid.<br><br>The payback period is anticipated to be 10 years. |

# Solar thermal

Solar thermal technologies harness solar energy for thermal energy use; i.e. heat or cooling (Powering Agriculture, 2016a). There are different types of solar thermal technologies based on temperature applications, including non-concentrating collectors such as flat plate collectors and evacuated tubes, and concentrating collectors (Powering Agriculture, 2016a).

Figure 6: Flat plate and evacuated tube collectors (Northern Lights Solar, 2016)

Flat plate collectors are used for low temperature applications and examples include solar water heaters, solar air heaters for space heating and drying, etc. Concentrating collectors are used for high temperature applications such as power production, cooking, and drying.

Within the global agricultural sector, solar thermal technologies are also applied in various practices, with the most common practice being that of solar drying (Powering Agriculture, 2016a). Examples of other applications in agriculture include:

- Solar thermal pumps for irrigation
- Solar thermal heating to warm greenhouses at night
- Solar thermal cooling for field crop and horticultural preservation
- Solar dryer technologies for drying of farm produce and crop curing
- Solar process space heating and cooling technologies for air conditioning livestock shelters and poultry houses
- Solar thermal technologies to produce hot water for milking parlours and other meat processing applications
- Solar dryers for meat drying
- Solar absorption refrigeration and freezers for preserving livestock and poultry products
- Concentrated solar power technologies for electricity generation to power multiple energy demands for farm buildings and other general farm operations
- Solar thermal water heaters for hot water production in farm buildings
- Solar thermal air-conditioners for heating and cooling farm buildings
- Solar cookers for cooking applications
- Solar thermal technologies for water pasteurisation

# Case studies: Solar Thermal

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| *The Sunflower solar thermal pump for irrigation in Kenya (REEEP & FAO , 2014)* | Water yield: 5-20,000 litres/day.<br><br>Pumping depth 0-15m.<br><br>Lifespan: 20 years<br><br>Initial capital costs (2013): USD 400<br><br>Increased income.<br><br>Resilience and food security in the dry season.<br><br>Decreased manual work (compared to manual pumps).<br><br>Decreased long term operating costs (compared to diesel engine pumps). |
| *Klipopmekaar Rooibos Farm* | The power is used to heat water for some of the houses which are installed with solar water heaters.<br><br>Savings on the electricity bill was the biggest benefit Klipopmekaar Farm indicated.<br><br>The payback period is 3-4 years. |
| *The SunChill™ off-grid refrigeration solution for smallholder farmers* | Enables increased field crop and horticulture agricultural productivity by reducing spoilage, especially during the post-harvest handling value chain stage.<br><br>The refrigeration technology, targeted at smallholder farmers, transforms 50°C solar thermal energy into 10°C refrigeration using solid refrigerants and local, non-precision components (Powering Agriculture, 2016a). |
| *Solar water heating in the Costa Rican dairy sector (Ashden , 2015)* | It is estimated that a typical 60-cow dairy uses about 450 kWh per month to heat water, so saves about US$120 per month.<br><br>The 12-monthly loan repayments are around US$112, which is lower than the cost of electricity displaced. Once the loan has been repaid, the farm saves around US$1 400 per year, increasing its profitability typically by 10%. |

# Wind energy

The governing principle of wind energy is based on the transformation of wind flows into rotational movements, force from which can be used either directly for mechanical energy or to drive a generator and produce electricity (Powering Agriculture, 2016a).

There is widespread use of wind systems for mechanical energy applications in agriculture, particularly for water pumping. In Southern Africa alone, an estimated 300 000 wind-driven water pumping systems are in operation (IRENA, 2015).

In order to successfully make use of wind power, the required wind resources (i.e. sufficient wind) need to exist while the appropriate wind harnessing technologies are utilised. Wind turbine technologies used for electricity generation vary in sizes, i.e. micro, small, medium, and large sized wind turbines.

Also, similar to solar technologies, wind power can also be for grid and off-grid connections. Micro-wind turbines, usually for off-grid connections, may be as small as 50W and can generate about 300 kWh/year (FAO & USAID, 2015). On the other hand, small turbines in low wind speed locations (4 m/s-5 m/s) can also generate up to 1 500kWh/year, and save around 0.75t $CO_2$-eq if displacing diesel generation (FAO & USAID, 2015). Also, worth noting is the claim that a small wind turbine of 20kW and 9m rotor diameter could produce about 20MWh per year for use on farms, as well as small agri-food businesses (FAO & USAID, 2015).

However, it is also imperative to note that wind power, by its nature, is variable (or intermittent); therefore, some form of storage or back-up is inevitably required, which can include inter alia (UNIDO, n.d.):

- Connection to an electricity grid system
- Incorporating other electricity producing energy systems, i.e. Hybrid energy systems
- Using storage systems such as batteries or, for mechanical systems, storage via water held in a tank

Examples of applications in agriculture include:

- Windmills are used for pumping water for irrigation
- Watering livestock
- Supplying drinking water to be used on the farm
- Wind powered grain mills for processing grain and animal feeds

## Case studies: Wind energy

*Wind pumps and wind turbines in Kenya (energypedia, 2015)*

Kijito wind pumps come in a range of rotor diameters from 8ft, capable of pumping heads of up to 36.5m, to the larger 24ft diameter wind pumps, which are able to lift water from deep boreholes of 152m.

The wind turbines have charge controllers that enable them to regulate themselves during high wind speeds.

Kijito wind pumps have proved competitive with diesel pumps for small and medium-scale water supply applications, if the wind speed in the least windy month is above 3.5 m/s.

In remote areas, where diesel fuel costs are high, Kijito wind pumps have proven to be economical at even lower wind speeds, as long as the water level is high.

The wind pumps have also proven to be economical in many remote cattle posts where access to small, dispersed water supplies is needed for livestock.

*Kestrel's small wind turbines (Kestrel, 2012)*

Kestrel Wind Turbines, a subsidiary of Eveready (SA), is a South African local manufacturer of small wind turbines. The company's range of wind turbines includes an e160i (600W), e230i (800W), e300i (1kW), e400n (3Kw) and e400nb (3,5kW with brake). Kestrel utilises the following systems, among others, to harness the power of their small wind turbines:

- Stand-alone battery-charging systems (which can also be used to minimise the impact of load shedding)
- Hybrid systems with solar photovoltaic panels or any other power source
- Grid Tie systems (which feeds the renewable electricity onto the national grid)

All these systems can be utilised for various purposes, including agricultural purposes.

# Hydro energy

Hydropower is the most widely used source of renewable energy in the world, mainly due to the high-energy density and low cost and reliability advantages that it has relative to other renewable energy sources (Powering Agriculture, 2016a).

Hydro power plants can also meet the electricity needs of an entire farm or can be targeted to specific applications, depending on the size of the hydro power plant; e.g. (Practical Action , n.d ).

Overall, the requirements for a small hydro power (or simply micro-hydro) scheme for a farm are as follows (Eskom, 2016):

- A permanent water source providing a continuous flow of water, e.g. a stream, waterfall, small dam or large reservoir
- A turbine turned by water acting on the blades of a runner or wheel
- An alternator or generator to generate current
- A rectifier or converter that converts AC to DC for electricity
- Cables to transfer the electricity from the generator to the electricity supply or storage system

Hydropower has been previously utilised to generate mechanical energy to power farm machinery such as grinding mills and water pumps for irrigation.

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# Case studies: Hydro energy

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| *Pico hydropowered agricultural mills in Nepal (REEEP, 2015b)* | The improved water mill can produce between 1-5kW and process more than 50kg of grain per hour, as well as allowing for other uses such as paddy hulling, oil expelling, saw milling and electricity generation.<br><br>Up to 50% increased wheat and grain processing capacity.<br><br>A 70% decrease of agricultural waste.<br><br>A 30% reduction in cost of production.<br><br>Increased income.<br><br>Diversification of processing activities. |
| *Murludi farm in the Western Cape (Kriel, 2015 ).* | Kobus saved over 50% on his electricity bills during the fruit season, this is because his operations are heavily reliant on electricity, particularly the cooling and drying systems which uses 80% of the total electricity usage for the cooling and drying of fruit crops.<br><br>The turbines can meet the demand of up to 124kWh during fruit season and the unit can deliver 29kWh in total.<br><br>Kobus also managed to reduce his Eskom electricity consumption by 22 000kWh in 2015.<br><br>Savings maintenance of his equipment are benefits he has gained.<br><br>In 2013, Kobus's electricity bill was R360,00 because of power outages; when he installed the hydro-electric turbines his electricity bill reduced by half in 2014.<br><br>The payback period is indicated to be five years. |

# Hybrid energy systems

A hybrid energy system is a combination of different (i.e. two or more), but complementary energy supply systems at the same place, which are commonly installed in remote areas that are isolated from the utility grid (El-mohr & Anas, 2014). Examples of hybrid energy systems include the following, amongst others; Solar-wind, Hydro-wind, Hydro-solar, Solar-biomass, Wind-biomass, Solar-wind-biomass, Solar-diesel, Wind-diesel and Solar-wind-diesel.

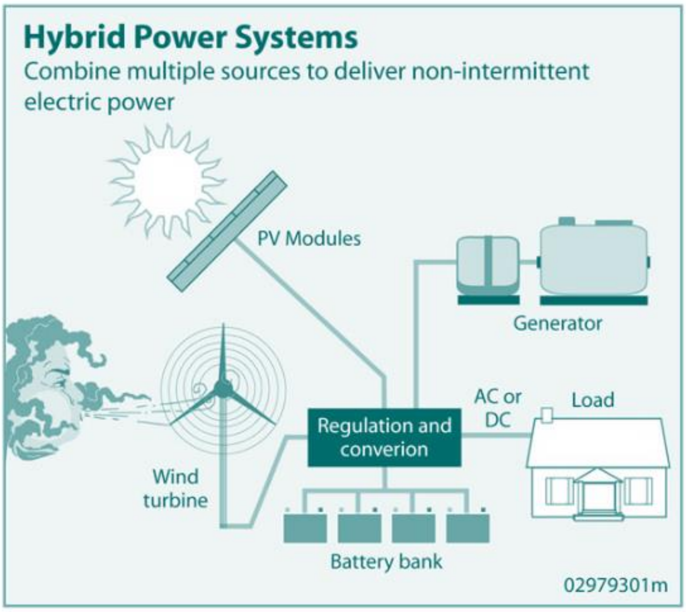


Figure 7: Hybrid system schematic example (Wikipedia, 2016)

Similar to the other renewable energy technologies already covered in earlier sub-sections, hybrid energy systems can also be utilised to support different energy applications in agriculture. They are usually utilised for electricity generation; hence, they reduce the reliance on grid electricity as well as petroleum products such as diesel and petrol that are normally used as fuels in generator sets. For that reason, hybrid energy systems can support any agricultural application dependent on electricity.

Examples of applications in agriculture include:

- Irrigation
- Electric fencing
- Lighting
- Refrigeration
- Drying systems
- Space ventilation systems
- Agro-processing
- Other agricultural application that is dependent on electricity

# Case studies: Hybrid energy systems

*Hybrid wind-solar generation in South Africa (Farmer's Weekly, 2013)*

Luke Bell is a livestock farmer from Molteno in the Eastern Cape. His Boshoffskraal farm is located in a remote place, far away from the nearest Eskom grid. The farmer would need slightly under R1 million to connect to the utility grid. As a result, the farmer has been relying on a mixture of conventional energy sources to meet his farm's energy demands; i.e. a diesel generator for lights, gas for freezing, a wood-fired 'donkey' for hot water, and anthracite stoves for warmth during the bitterly cold winters of the region. The huge costs and effort of running such conventional energy systems however, drew Luke Bell's attention towards renewable energy technologies.

**Considering the windiness and hotness of the Molteno area, the idea of installing a wind-solar hybrid system at Luke's Boshoffskraal farm made some economic sense. Luke installed a Kestrel e300i 1kW wind turbine combined with a 230W solar panel. The hybrid system also includes an electronic inverter (48V 3 000W) and batteries.**

**The whole hybrid-system costed Luke approximately R140 000, payable over five years. The system now provides this Eastern Cape farmer's home and workshops with relatively consistent and sufficient electricity. According to the farmer, the two renewable energy technologies, i.e. wind and solar, tend to compensate each other; for example, considering that the wind might still blow during overcast days when solar systems do not perform as well as during sunny conditions. In 2013, it was reported that Luke was envisaging to install solar geysers in order to minimise his reliance on wood for hot water energy demands.**

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# Bioenergy technologies

Bioenergy, which could include fossil fuels, is generally restricted to only encompass renewable energy sources such as wood and wood residues, agricultural crops and residues, animal fats, and animal and human wastes, which can all yield useful fuels either directly or after some form of conversion (UNIDO, n.d.).

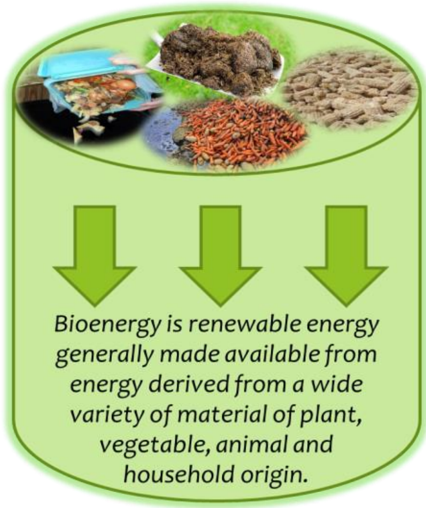

Figure 8: Bioenergy defined

Conversion technologies for bioenergy could include the following, among others: pyrolysis, gasification, combustion, anaerobic digestion, hydrolysis and fermentation, etc. These could be classified into the following categories (UNIDO, n.d.; Powering Agriculture, 2016a):

- Physical/Mechanical: e.g. drying, size reduction, densification, etc.
- Thermochemical processes: e.g. pyrolysis and gasification
- Biochemical: e.g. anaerobic digestion and fermentation
- Other processes: e.g. transesterification

Following the different conversion processes, primary products, such as tars and oils, syngas, heat, biogas, and ethanol are produced, which will require further conversion in order to produce the required energy end-use products to be applied in agriculture. It is imperative to note that, following conversion, the resultant products can be in different forms; i.e. (UNIDO, n.d.):

- Solid fuels: e.g. solid biomass, which could be used for cooking and lighting (direct combustion), motive power for small industry and electric needs (with electric motor).
- Liquid fuels: e.g. liquid biofuels (such as ethanol produced from sugar cane, bio-diesel produced from rapeseed, jatropha, etc.), which could be utilised for transport fuel and mechanical power, heating and electricity generation, or as some form of cooking fuel.
- Gaseous fuels: e.g. biogas, which can be used to generate electricity, or for cooking and lighting (household-scale digesters), motive power for small industry, etc.

With respect to feedstock, the main feedstocks commonly used to produce bioenergy in agriculture include food waste, farm manures and slurries, agro-industrial wastewaters, and crop residues (Powering Agriculture, 2016a). Crop residue feedstock should be understood in different parts; that is, the residues can come from crops grown for traditional purposes, e.g. corn for food and tobacco for cigarettes, or they could also be derived from energy crops (i.e., those grown specifically for the production of energy) (Powering Agriculture, 2016a). Examples of energy crops are sugar cane, sugar beets, switch grass, etc.

## PYROLYSIS

Pyrolysis is an endothermic thermal decomposition process, which utilises high temperatures (400°C-900°C) and pressure in a sealed chamber in the absence of oxygen in order to decompose organic matter, resulting in synthetic natural gas (syngas), pyrolysis oil (bio-oil), or char (bio-char) (Powering Agriculture, 2016a) (EREF, 2013). Further conversion of syngas and pyrolysis oil results in different energy products. Pyrolysis oil has the most end-uses including, for example, production of thermal energy that can be used to heat buildings or water, or for power generation (Powering Agriculture, 2016a).

There are many pyrolysis technologies. Plasma pyrolysis, catalytic pyrolysis, and flash pyrolysis are the most common ones. For agricultural applications, auger and fluidised bed (BFB and CFB) reactor technologies that are part of fast and flash pyrolysis, respectively, currently are the most commercially relevant (Marshal, 2013)

Sources of agricultural biomass that can be considered as a potential feedstock for commercial pyrolysis application are numerous. Some of these include corn stover and wheat straw, vines and culls from horticultural produce, grape skins and grape residues, animal products, as well as energy crops.

## GASIFICATION

Gasification is a thermochemical conversion of carbon-based feedstock into a synthetic natural gas (syngas) through either a chemical or a heat process (Powering Agriculture, 2016a). Biomass gasification implies incomplete combustion of biomass, which results in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen ($H_2$) and traces of Methane ($CH_4$) (Rajvanshi, 1986).

A variety of gasification technologies exists, but most of them are not deployed on commercial scale (Bundschuh, J. and Chen, G., 2014). This is largely due to the operational and structural problems, as well as low profitability of the solutions (Bundschuh, J. and Chen, G., 2014). The majority of commercially available solutions rely on wood as a source of material and include (Bundschuh, J. and Chen, G., 2014):

- Fixed-bed reactors
- Fluidised-bed reactors
- Entrained-flow bed reactors
- Countercurrent-flow reactors

Applications for biomass gasifier and producer gas include (Rajvanshi, 1986):

- Use in the shaft power systems to drive machinery and equipment used in agriculture
- Use in irrigation systems
- Use in direct heat systems such as drying, green house heating, refrigeration, and cooling
- Run a fuel cell plant

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# Case studies: Gasification

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| *Husk Power Systems in Bihar, India (UNDP , 2013)* | HPS procures the rice husk from the farmers and suppliers at competitive prices (approximately, Rs 1–2 per kilogram); farmers have an incentive to supply the rice husk in order to ensure that electricity remains available in their villages.<br><br>Most of the biomass gasification plants are 25–100 kWe in capacity, and each use about 330 kg/day or 50–60kg/hr of rice husk to generate power for six hours a day.<br><br>The total landed cost of a 32 kW plant, including distribution system, is less than US$ 1 000 per kW.<br><br>The cost of producing 32 kW of electricity per month is Rs 22 000, which includes cost of raw material, salaries, and maintenance. |
| *Coredale Farms (Kriel, 2015 ).* | Coredale Farms makes use of wood from invasive alien trees in a gasification boiler to heat up their broiler houses instead of liquid petroleum gas.<br><br>The gas boilers have a capacity of 130kWh, which meets the demands to dry and heat out the litter.<br><br>Reduces humidity levels in broiler houses.<br><br>Provides a better ventilation environment for chickens to grow as a result of improved capacity in Coredale Farms newer machines.<br><br>Heating costs for chicken decreased from R1,88/chicken to 6c/chicken.<br><br>Only 10% of energy is lost during the gasification process.<br><br>Remaining ash is used as compost for the farm.<br><br>The cost to transition to wood gasification was R1 million, this is made up of the accumulation tanks and wood gasification boilers, which range between R150,000 and R170,000 dependent on design and capacity.<br><br>The payback period for this system was two years. |

## FERMENTATION

The fermentation process is also similar to anaerobic digestion, but the end-product is typically some form of alcohol (e.g. ethanol) rather than methane (EREF, 2013). In other words, ethanol fermentation, also referred to as alcoholic fermentation, is a biological process that converts sugars such as glucose, fructose, and sucrose into cellular energy, producing ethanol and carbon dioxide.

The process is considered an anaerobic process since yeasts are utilised for the conversion in the absence of oxygen. Starchy plants (e.g. corn and sugarcane) are often used in a biochemical process that converts sugars into alcohol (e.g. ethanol). For South African conditions, it is important to observe that Cassava is the starchy crop with the highest energy content per acre; however, it has not been considered in the ethanol production equation.

Examples of applications in agriculture include:

- Ethanol can be utilised as a farm transport and machinery fuel
- Resultant fuel can also be utilised to power an engine and produce electricity

## ANAEROBIC DIGESTION

Anaerobic digestion is an established technology for the treatment of waste and wastewater (de Mes, Stams, Reith, & Zeeman, n.d.). The process involves the decomposition of organic or biological waste by microorganisms in an oxygen free environment (Powering Agriculture, 2016a) to produce biogas; a gas composed mostly of methane (55-75%) as well as carbon dioxide (25-45%) (de Mes, Stams, Reith, & Zeeman, n.d.).

Examples of applications of the methane gas produced in agriculture include:

- Electricity
- Cooking
- Lighting
- A gas heater system
- Co-generation of electricity and heat
- Natural gas
- Fuel gas in replacement of grid electricity and petroleum products

# Case studies: Anaerobic Digestion

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| *Greenway Farms* | A biogas plant on the farm, with carrot pulp waste fed into bio-digester and the methane gas is used to fuel the boilers in the carrot juice factory.<br><br>Potential implementation of a second bio-digester to cogenerate.<br><br>The initial start-up costs of a bio-digester are expensive; however, the long-term benefits are electricity savings.<br><br>The payback period is indicated by Greenway Farms to be between 8-10 years. |
| *Uilenkraal Farm (Claassen, 2015)* | Uilenkraal farm has implemented a bio-digester which use cattle manure as fuel to generate electricity for their farm.<br><br>The biogas fuels their two generators, resulting in a production capacity of 200kWh a day for each generator.<br><br>Potential use of compost from the bio-digester for on farm crops.<br><br>The farm experienced a 90% reduction in their electricity bill, firstly it decreased from R110,000 to R45,000, it then dropped drastically again to R12,000 as a result of the 2 generators coming into effect.<br><br>No moving parts in the bio-digester allows for simplistic maintenance.<br><br>Investment in the plant costed R10 million.<br><br>The payback period is 10 years. |

## TRANSESTERIFICATION

Transesterification is a process used to convert oils or fats into biodiesel. This involves the removal of water and contaminants from the feedstock, then mixing it with alcohol (typically methanol) and a catalyst (e.g. sodium hydroxide, potassium hydroxide) to produce fatty acid methyl esters and glycerine as by-products (Powering Agriculture, 2016a). While the produced glycerine can be used in pharmaceuticals and cosmetics, it is the esters that are of major significance to this study since these are considered as biodiesel and could be used as vehicle and machinery fuel or for other fuel.

Biodiesel is simply a liquid fuel derived from vegetable oils and fats, which has similar combustion properties to regular petroleum diesel fuel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. Biodiesel is biodegradable, non-toxic, and has significantly fewer emissions than petroleum-based diesel when burned. At present, oil straight from the agricultural industry represents the greatest potential source, but it is not being used for commercial production of biodiesel simply because the raw oil is too expensive.

Similar to conventional petroleum products, biodiesel can be used in generators to produce electricity, as well as a fuel to power farm transport and other machinery as can be established from the following case study of an American dairy farmer in Alburgh.

## Case studies: Transesterification

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| *On-farm biodiesel production at Borderview farm in Alburgh, USA (Vermont Bioenergy Initiative, 2013)* | An American dairy farmer at a Borderview farm in Alburgh, USA, makes biodiesel from locally-grown sunflower seeds.<br><br>The finished biodiesel is stored in about 950l pallet tanks.<br><br>The automated processor runs through several stages of processing in about 48 hours (esterification, transesterification, settling, washing, and drying), with one break after 24 hours to remove the glycerine by-product.<br><br>The installed capacity of the facility can process 100 tons of seeds from 138 acres of sunflowers per year, yielding about 39 750l of biodiesel and 64 tons of sunflower meal.<br><br>The farmer has since switched from purchasing diesel for five tractors and one truck, to making his own biodiesel.<br><br>His annual biodiesel use has ranged from 1 895 to 11 360l per year and has saved him from US$500 to US$4 000 per year in fuel costs. |

# What have you learned?

**What is the linkage between energy and agriculture?**

**What are direct and indirect energy uses in agriculture and its sub-sectors?**

**How much energy do you use on your farm?**

**Based on your knowledge, which activities on your farm consume the most energy?**

**What is energy efficiency?**

**What is renewable energy?**

**What is the process that you should follow to identify opportunities to save on energy usage and deploy more energy efficient and renewable energy technologies?**

**What energy efficient and renewable energy technologies can you deploy?**

**Where can you save energy?**

**Which technology would work best for you?**

# What you need to know when purchasing RE technologies?

## Solar PV panels

| | | |
|---|---|---|
| Size | 20W-300W | **Checklist:** |
| Lifespan | 20-25 years | • EE practices adopted |
| Cost | R25 000 – R35 000/kWp | • Unobstructed access to sunlight |
| Payback period | 3-5 years | • Space (roof or ground) |
| | | • Get a few quotes |
| | | • Reliable installer (Eskom, association, etc.) |
| | | • Reliable and appropriate size of inverter: off-grid or grid tie, appliances and equipment |
| | | • Warranty |

## Bio-digesters

| | | |
|---|---|---|
| Lifespan | 30-50 years | **Checklist:** |
| Energy capacity | 6kWh/m³ | • Sufficient amounts of waste |
| Payback period | 8-12 years | • Install closer to the waste source |
| | | • Sizing |
| | | • Environmental regulations |

## Variable speed Drives (VSDs)

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| Size | 0.18 kW to 16MM | **Checklist:** |
| Lifespan | 8 years | • Conduct energy audit |
| Cost | R1 500-R40 000 | • Compile a motor/drive inventory |
| | | • Prioritise motors/drives |
| | | • Contact a specialist installer/contractor |

# Quality check

Before investing in renewable energy and energy efficiency solutions, seeking assistance from a credible industry expert is essential to ensure purchases are made from reliable suppliers whose products meet the industry standards.

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| SABS<br>South African Bureau of Standards | SABS provide the standardisation for solar water heating systems and panels, solar energy conversion, appliance safety, appliance performance, construction standards, water and sanitation, utilisation in space and water heating, cooling, industrial process heating and air conditioning. Before investing in renewable energy or energy efficiency technology, SABS accredited suppliers will ensure quality checks have been carried out on the products (SABS, n.d.). |
| agriculture, forestry & fisheries<br>Department: Agriculture, Forestry and Fisheries<br>REPUBLIC OF SOUTH AFRICA<br>energy<br>Department: Energy<br>REPUBLIC OF SOUTH AFRICA<br>sanedi<br>South African National Energy Development Institute | The Department of Agriculture, Forestry and Fisheries, SANEDI and The Department of Energy can provide assistance in which credible suppliers there are out there to purchase renewable energy and energy efficient technologies from. |
| Eskom | Eskom has an accredited Solar Water Heating suppliers list available on the internet. In addition, Eskom has an Energy Advisors division who provide assistance for the agricultural sector, free of charge. |

# Financial support mechanisms

Costs associated with the investment in renewable energy and energy efficiency solutions can be high. Financial assistance available to farmers comes in the following forms and provided by organisations as indicated in the table below:

- Loans
- Tax incentives
- Funds
- Rebates
- Competitions
- Investments
- Grants

| ORGANISATION | PROGRAMME/INCENTIVE | CONTACT DETAILS |
|---|---|---|
| The Industrial Development Corporation (IDC) and the German Development Bank (KfW) | Green Energy Efficiency Fund | +27 (0) 11 269 3000 |
| SARS/SANEDI | 12L of the Income Tax Act, 1962 (Act No. 58 of 1962) | +27 (0) 11 038 4300 |
| SARS | Section 12B of the Income Tax Act, 1962 (Act No. 58 of 1962) | 0800 00 7277 |
| Nedbank | Commercial Renewable Energy Financing Offering | +27 (0) 860 116 400 |
| ABSA and the French Development Agency (AFD) | Clean Energy Project Funding/Renewable Energy Funding | + 27 (0) 860 008 600 |
| WWF-SA and Nedbank | The WWF Nedbank Green Trust | +27 (0) 21 657 6600 |
| FNB | Lending Solutions- Agriculture | +27 (0) 87 328 0298 |
| Department of Agriculture Forestry and Fisheries | Micro Agricultural Financial Institutions of South Africa Scheme (MAFISA) | +27 (0) 12 319 7263 / 6825 / 7216 |
| The Land Bank | Farming Incentive | +27 (0) 12 686 0500 |
| The Department of Environmental Affairs (DEA) and the Development Bank of Southern Africa (DBSA) | The Green Fund | +27 (0) 11 313 3611 |
| Inspired Evolution Investment Management (Pty) Ltd | Inspired Evolution Fund | +27 (0) 82 496 0522 |

| ORGANISATION | PROGRAMME/INCENTIVE | CONTACT DETAILS |
|---|---|---|
| Eskom | ESco Funding Model | +27 (0) 86 003 7566 |
| African Development Bank Group | Sustainable Energy Fund for South Africa | +27 (0) 12 003 6900 |
| Supported by Australia, Denmark, the Netherlands, Sweden and the United Kingdom, as well as the International Fund for Agricultural Development (IFAD) | The African Enterprise Challenge Fund | +254 (20) 269 9137/8/9 |
| Department Agriculture, Forestry and Fisheries/Micro-agricultural Financial Institutions of South Africa (Mafisa) | Comprehensive Agricultural Support Programme (CASP) | +27 (0) 12 319 7553 |
| National Treasury | Carbon Tax Bill | +27 (0) 21 403 6411 |
| Department of Energy | Small Projects IPP Programme Grant | +27 (0) 12 406 8000 |
| South African Alternative Energy Association (SAAEA) | Funding for alternative energy projects and products | +27 (0) 71 637 8466 |
| National Empowerment Fund | Rural and Community Development Fund | +27 (0) 11 305 8000 |

# Non-financial assistance

Assistance is available in the form of programmes and advisory services offered for farmers wanting to invest in renewable energy and energy efficiency technologies. These are provided by various institutions and companies. Assistance is as follows:

- Technical knowledge
- Energy audits
- Energy advisory services
- Incentivised solutions
- Training
- Recommendations
- Cost-benefit analysis

| ORGANISATION | PROGRAMME/INCENTIVE | CONTACT DETAILS |
| --- | --- | --- |
| SANEDI | Energy and Agriculture Platform | +27 (0) 11 038 4300 |
| Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA) in partnership with AFRISAM | AFRISAM Renewable Energy | +27 (0) 53 833 1503 |
| Department of Agriculture, Rural Development and Land Administration | The Comprehensive Rural Development Programme | +27 (0) 13 243 0583 |
| National Cleaner Production Centre of South Africa (NCPC) | Energy Audits | +27 (0) 12 841 3915 |
| German Federal Ministry for Economic Cooperation and Development (BMZ) | South African- German Energy Programme | +27 (0) 12 423 6330 |

# Tools

Tools for assisting in assessing the viability of renewable energy and energy efficiency projects can be accessed via internet portals. The tools provide financial and economic assessments skills to help determine the risk and viability of projects.

| TOOL | DESCRIPTION |
|---|---|
| VCA-Tool 3.2. software for Cost-Benefit Analysis http://www.fao.org | The tool offers financial and economic analysis along the value chain for agriculture. The tool can be used as a probability analysis tool for each segment in the value chain. |
| Power Irrigation Tool http://www.fao.org | Used to determine the crop water requirements in a given period in the year and a given location. A benefit of the tool is that it comes preloaded with economic and technical reference values in order to generate energy costs and cash flows over time with different investment scenarios (FAO, 2015). |
| Decision-making for sustainable bioenergy http://www.fao.org | The FAO tool provides assessment, evaluation and response for sustainable bioenergy. It entails screening toolkits, indicators, policy responses. |
| Decision support tool for sustainable bioenergy https://cleanenergysolutions.org | The tool can be used to assess investment opportunities. It provides supporting resources and assistance in the decision-making process when opting for bioenergy. |
| Biofuels project screening tool kit http://www.fao.org | Assistance in the implementation, approval and design phase of liquid biofuel projects through screening and evaluation, which will identify sustainability issues within the project. |
| EX-ACT Climate Change Impact Assessment http://www.fao.org | Assess the impact of development projects in agriculture and how they affect carbon balances and greenhouse gas emissions. |
| CTI Private Financing Advisory Network (PFAN) http://cti-pfan.net | Farmers may contact PFAN at the early project stage for assistance in securing funds for the project and support for developing a business plans. The initial stage of assistance does not involve any cost. |
| GreenAgri http://www.greenagri.org.za | The Western Cape Department of Agriculture has established a networking platform for farmers to discuss policies, practices, initiatives, feedback, data collection and project discussions. The portal is centred around waste minimisation, sustainable farming practices, conservation farming and resource efficiency. |

## What have you learned?

**What do you need to know before purchasing a renewable energy and energy efficiency technologies?**

**What support do you require when purchasing renewable energy and energy efficiency technologies?**

# Glossary

**Agrarian:** related to fields, farming, or rural matters

**Battery bank**: Parallel wiring that is used to connect a group of batteries (Solar Mango , 2015)

**Biodiversity:** variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it (Greenfacts , 2016)

**Biofuel:** natural elements such as wood, waste material and crops to produce fuel (Green Facts, 2016)

**Biogas:** the gas that is produced from organic matter, which is broken down during the absence of oxygen in a biological process (Bio2Watt , 2016)

**Climate Change:** a change of climate, which is attributed directly or indirectly to human activity, which alters the composition of the global atmosphere and, which is in addition to natural climate variability observed over comparable time periods (United Nations, 1992)

**Climate-smart agriculture:** agriculture that is focused on the development goals and improving national food security. It should increase productivity and reduce GHG emissions (FAO , 2010 )

**Cogeneration:** a process that generates heat and energy simultaneously (Power Generation, 2016)

**Cultivar:** a plant or group of plants selected for desirable characteristics that can be maintained by propagation (Biosciences for Farming in Africa, 2016)

**Decomposition:** the separation of a substance into simpler substances or basic elements, primarily living organisms (ScienceDaily, 2016)

**Endothermic:** the absorption of energy in the form of heat from the surroundings (Diffen, n.d.)

**Energy Efficiency:** using less energy to provide the same service, or more services provided for the same energy (International Energy Agency , 2016)

**Green economy:** addressing the interdependence between social protection, natural ecosystem and economic growth through a sustainable development path (Department of Enviornmental Affairs , 2016)

**Greenhouse gas emissions:** absorption of infrared radiation that traps and holds heat in the atmosphere, most commonly caused by human activity (Lallanilla, 2015)

**Hydrocarbon:** hydrogen- and carbon-made organic compounds (Hydrocarbons, n.d.)

**Liquid biofuels:** fuels that can be produced directly or indirectly from renewable material of plant or animal origin (Green Facts, 2016)

**Methane:** a colourless, odourless, flammable gas that is the simplest hydrocarbon, emitted in the production of coal, oil and natural gas (US Environmental Protection Agency, 2016)

**Non-renewable energy sources:** coal, natural gas, crude oil and uranium (National Geographic Society , 2016)

**Photovoltaic (PV):** the conversion of sunlight directly into energy (National Renewable Energy Laboratory, n.d.)

**Renewable Energy:** energy that is collected from natural resources, which can be replenished such as wind, geothermal heat, rain, sunlight and tides (Penn State College of Agricultural Sciences , 2016)

**Sustainable Consumption and Production:** promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all (United Nations, n.d.)

**Sustainable Development:** development is focused on growing the economy and meeting our present needs without compromising the needs of the future (International Institute for Sustainable Development, n.d.)

**Sustainable Development Goals:** a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity (UNDP, 2016)

**Synthetic fertilisers:** fertilisers not of natural origins, man-made fertilisers (Gach, 2012)

**Thermal decomposition:** the breaking down of metal carbonates when heated strongly (BBC, 2014)

# Acronyms

**AFOLU:** Agriculture, forestry and other land uses

**EE:** Energy efficiency

**FAO:** The Food and Agriculture Organization of the United Nations

**GHG:** Greenhouse gas emissions

**NCPC:** National Cleaner Production Centre

**PFAN:** Private Financing Advisory Network

**PV:** Photovoltaic

**RE:** Renewable energy

**REEEP:** Renewable Energy and Energy Efficiency Partnership

**SABS:** South African Bureau of Standards

**SANEDI:** South African National Energy Development Institute

**SARS:** South African Revenue Services

**SDG:** Sustainable Development Goal

**SECP:** Sustainable Energy Consumption and Production

**VSD:** Variable Speed Drive

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