SUSTAINABLE ENERGY CONSUMPTION AND PRODUCTION (SECP) IN AGRICULTURE AND INTEGRATED WASTE MANAGEMENT: RESEARCH AND TRAINING 2016
ACKNOWLEDGEMENTS

This SWITCH AFRICA GREEN “Sustainable Energy Consumption and Production (SECP) in Agriculture and Integrated Waste Management” Research and Training Report represents a collaborative effort, made possible by the financial support by the European Union, and overseen by the United Nations Environmental Programme (UNEP) in collaboration with United Nations Development Programme (UNDP) and United Nations Office for Project Services (UNOPS). The REEEP and SANEDI team would like to thank everyone who contributed to this endeavor.

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# TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS 02

PROJECT BACKGROUND AND SCOPE 04

STUDY BOUNDARY 06

DATA LIMITATIONS 12

CHAPTER 1: REFERENCE FRAMEWORK 13

1.1 Background to SCP 13
1.2 SCP In the context of agriculture and waste management 20
1.3 Sustainable energy consumption and production concept defined 22
1.4 Energy usage and intensity of agricultural sub-sectors 24
1.5 Waste streams and conversion potential in agriculture 36

CHAPTER 2: OVERVIEW OF SOUTH AFRICA'S AGRICULTURAL AND AGRICULTURAL WASTE SECTORS 44

2.1 Size and dynamics 46
2.2 Energy usage in agriculture 48
2.3 Waste production by south africa’s agriculture 52
2.4 Priority sub-sectors for further analysis 54

CHAPTER 3: POLICY REVIEW 56

3.1 Agricultural sector policy framework analysis 58
3.2 Waste sector policy framework analysis 66

CHAPTER 4: SECP TECHNOLOGIES 68

4.1 Transition towards sustainable agriculture 70
4.2 Adoption of energy efficiency practices 70
4.3 Adoption of modern renewable energy technologies 79
4.4 Adoption of bioenergy technologies 95

CHAPTER 5: SECP PRACTICES IN SOUTH AFRICA 101

5.1 Opportunities for SECP in agriculture 102
5.2 Crop production practices to reduce energy usage 103
5.3 Horticultural practices to reduce energy usage 106
5.4 Animal and animal product practices to reduce energy usage 115

CHAPTER 6: SUPPORT MECHANISMS AND INITIATIVES 125

6.1 Financial mechanisms 126
6.2 Non-financial mechanisms 148
6.3 Tools 152

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS 153

REFERENCES 156
ACRONYMS AND ABBREVIATIONS

10YFP  10-Year Framework of Programmes
CA    Conservation Agriculture
CHP   Co-generation of electricity and heat
COP   Conference of the parties
CSA   Climate Smart Agriculture
FAO   Food and Agriculture Organisation
GDP   Gross Domestic Product
GDP   Gross Domestic Product
GHG   Greenhouse Gas
IAFS  Integrated Arable Farming Systems
ISO   International Organisation for Standardisation
km$^2$ square kilometre
LCA   Life Cycle Assessment
MDG   Millennium Development Goal
MJ    megajoule
MSM   Micro, Small, and Medium Enterprises
OPAP  Organic Production and Agroecology Practices
PCB   Polychlorinated biphenyl
PJ    petajoule
REEEP Renewable Energy and Energy Efficiency Partnership
SCP   Sustainable Consumption and Production
SDG   Sustainable Development Goal
SECP  Sustainable Energy Consumption and Production
UN    United Nations
UNDRIP United Nations Declaration on the Rights of Indigenous Peoples
UNEP  United Nations Environment Programme
UNFC  United Nations Framework Classification
VFD   Variable Frequency Drive
VSD   Variable Speed Drive
WEF   World Economic Forum
WSSD  World Summit of Sustainable Development
Sustainable Energy Consumption and Production (SECP) is a programme designed and implemented by the Renewable Energy and Energy Efficiency Partnership (REEEP). The programme focuses on supporting African countries in the transition to the Inclusive Green Economy through the application of Sustainable Consumption and Production patterns and practices. In this context, REEEP partnered with SANEDI to implement the initiative in South Africa in order to assist the local business communities and entrepreneurs in the agricultural and waste management sectors to implement Sustainable Consumption and Production (SCP) practices within their respective industries. The beneficiaries of the programme include intermediary business organisations, and national and local government spheres.

The current study focuses on agriculture and integrated waste management with a specific emphasis on sustainable energy SCP practices, i.e. Sustainable Energy Consumption and Production (SECP), employed in these two sectors. The study aims to produce outputs that will contribute towards the achievement of aims set by REEEP and SANEDI with respect to the SWITCH Africa Green programme.

The ultimate goal pursued by the study is to equip REEEP and SANEDI with sufficient information to be disseminated and shared with the Micro, Small, and Medium Enterprises (MSMEs) in the above-mentioned sectors in order to facilitate their transition into becoming prominent players in the development of the Inclusive Green Economy. Furthermore, this information will be shared during four training workshops to be conducted by the team.

The study is divided into a research component and a workshop component, as indicated in the figure across.
STUDY BOUNDARY

The study focuses on energy usage by MSMEs within two sectors, i.e. agriculture and waste. Considering the vast diversity of these sectors, it is important to define the study boundaries in order to ensure a focused analysis and investigation into SECP practices. The following paragraphs define the MSMEs, as well as the sub-sectors within agriculture and waste, which will be the focus of the study, as well as the energy component within these industries.

STUDY BOUNDARY – MSMES

According to the National Small Business Amendment Act of 2004, a small enterprise is defined as "a separate and distinct business entity, together with its branches or subsidiaries, if any, including co-operative enterprises, managed by one owner or more predominantly carried on in any sector or subsector of the economy mentioned in column 1 of the Schedule and classified as a micro-, a very small, a small or a medium enterprise by satisfying the criteria mentioned in columns 3, 4 and 5 of the Schedule". According to the above-mentioned schedule, small enterprises within the agricultural sector are defined as follows:

<table>
<thead>
<tr>
<th>Size/class</th>
<th>Full-time equivalent of paid employees</th>
<th>Total annual turnover</th>
<th>Total gross asset value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro</td>
<td>&lt;5</td>
<td>&lt;R200 000</td>
<td>&lt;R100 000</td>
</tr>
<tr>
<td>Very small</td>
<td>&lt;10</td>
<td>&lt;R500 000</td>
<td>&lt;R500 000</td>
</tr>
<tr>
<td>Small</td>
<td>&lt;50</td>
<td>&lt;R3 000 000</td>
<td>&lt;R3 000 000</td>
</tr>
<tr>
<td>Medium</td>
<td>&lt;100</td>
<td>&lt;R5 000 000</td>
<td>&lt;R5 000 000</td>
</tr>
</tbody>
</table>

(Minister of Trade and Industry, 2003)

Agriculture, similar to other industries, include both formal and informal businesses, where the latter primarily comprise of subsistence farming and other informal activities that are not registered with adequate authorities (i.e. CIPRO, SARS), some of which are also cooperatives. It is worth mentioning that about 356 000 people of working age were reported to work on small farms and plots, or to collect products from the sea and forests for subsistence in 2007 (the dti, 2008); and there were about 836 agricultural cooperatives in 2010 (DAFF, 2011). Some of the challenges facing formal and informal businesses within agriculture are similar; however, access to finance, skills development and capacity building, low literary levels, and the age of members are more prominent among the informal businesses than formal businesses. While it is acknowledged that these businesses are likely to benefit significantly from SECP practices, the primary focus of the study will be on formal MSMEs. Best practices and recommendations on integrated SECP practices in the day-to-day operations of agricultural MSMEs will also be applicable to informal businesses, which may first need to address other challenges associated with their poorer performance and general operations prior to, or while integrating SECP practices.
STUDY BOUNDARY – AGRICULTURE

The agricultural sector (excluding forestry and fisheries) is a highly diverse industry. It can be largely categorised into three major groups; i.e. field crops, horticulture, and animals and animal products. Furthermore, the industry can be distinguished in terms of three major agrarian zones: rural, peri-urban, and urban agriculture, which have some similarities but also notable differences when it comes to scale of activities and in some instances, to products grown. The key characteristics of the agrarian zones are outlined in the next figure. All of the agrarian zones are included in the study.

FIGURE II: AGRARIAN ZONES AND CORE AGRICULTURAL INDUSTRIES
STUDY BOUNDARY – WASTE

According to the National Environmental Management: Waste Act, 2008, as amended, waste is defined as:
• Any substance, material, or object that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act; or
• Any other substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the Gazette, but any waste or portion of waste, referred to in paragraphs (a) and (b), ceases to be a waste:
  o once an application for its re-use, recycling or recovery has been approved or, after such approval, once it is, or has been re-used, recycled or recovered;
  o where approval is not required, once a waste is, or has been re-used, recycled or recovered;
  o where the Minister has, in terms of section 74, exempted any waste or a portion of waste generated by a particular process from the definition of waste; or
  o where the Minister has, in the prescribed manner, excluded any waste stream or a portion of a waste stream from the definition of waste.

According to waste classification and management regulations gazetted on 23 August 2013, waste is classified in terms of two types – general or hazardous, where:
• “General waste” means waste that does not pose an immediate hazard or threat to health or to the environment, and includes:
  o Domestic waste
  o Business waste not containing hazardous waste or hazardous chemicals
  o Non-infectious animal carcasses
  o Garden waste
  o Waste packaging
  o Waste tyres
  o Building and demolition waste not containing hazardous waste or hazardous chemicals
  o Excavated earth material not containing hazardous waste, or hazardous chemicals
• “Hazardous waste” means any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment. It includes the following categories:
  o Waste products
    Asbestos waste
    PCB waste and PCB containing waste
    Expired, spoil and unusable hazardous products
  o Mixed waste
    General waste, excluding domestic waste, which contains hazardous waste or hazardous chemicals
    Mixed, hazardous chemical wastes from analytical laboratories and laboratories from academic institutions in containers less than 100 litres
  o Other
    Health Care Risk Waste
The sources or origin of waste, in turn, can be numerous and include residential, industrial, commercial, institutional, construction and demolition, municipal services, process (manufacturing, etc.) and agricultural activities, as outlined below.

**FIGURE III: WASTE SECTOR STUDY BOUNDARY**

As illustrated above, considering that the focus of the study is on agriculture, the study boundary as it relates to the waste sector will also be defined as waste generated by agricultural activities, which can either be general or hazardous waste depending on the agricultural sub-sector considered and waste products generated by it.
**STUDY BOUNDARY – ENERGY**

While the sectoral focus of the study is on agriculture and waste within the agricultural sector, the assessment of SCP practices within these industries will zoom onto the energy usage in production and consumption practices of these two sectors. Schematically, the boundary of the study as it relates to the energy, agriculture, and waste can therefore, be presented as follows:

**FIGURE IV: STUDY BOUNDARY IN RELATION TO ENERGY FOCUS AREA WITHIN AGRICULTURE AND AGRICULTURAL WASTE SECTORS**

From the above, it is clear that the focus of the study will be on:
- Energy usage and opportunities for improving its efficiency in the agricultural sector, and specifically within urban and peri-urban agriculture; as well as
- Opportunities for utilising waste as input into the generation of energy-related products that may be utilised in the agricultural sector itself; thus closing the loop, or sold for other uses.
DATA LIMITATIONS

The study employed both primary and secondary data. The former is largely related to the information on the energy sources and energy intensity of various agricultural activities. It became apparent though, that such data does not exist for South Africa and all energy-related data are either aggregated at a sectoral level; thus providing no information on subsectors and various agricultural activities, or alternatively the information was outdated. The following table outlines the data-related gaps that were identified throughout the study.

**TABLE II: DATA LIMITATIONS OBSERVED THROUGHOUT THE STUDY**

<table>
<thead>
<tr>
<th>Data</th>
<th>Limitation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural sector's comprehensive energy usage in South Africa</td>
<td>The Department of Energy (DOE) reports on the energy sources and energy consumption in its annual Energy Balance statistical releases. The Energy Balance data are not official statistics and are not gathered using the bottom-up approach, but rather a top-down approach. The data is not verified by the DOE, suggesting that under and over estimations with respect to consumptions and production of bioenergy The latest data available is for 2012.</td>
<td>Use of the DOE’s energy balances and assuming that it illustrates the key trends in energy consumption by the agricultural sector.</td>
</tr>
<tr>
<td>Sub-sector level energy usage related data</td>
<td>South Africa does not have energy-related statistics for the agricultural sub-sectors and agricultural value chains.</td>
<td>Country level statistics has to be used.</td>
</tr>
<tr>
<td>Energy intensity of agricultural sub-sectors</td>
<td>No South African data available indicating energy intensity of various sub-sectors in agriculture.</td>
<td>US and European data for energy-intensity of various agricultural subsectors had to be applied.</td>
</tr>
<tr>
<td>Waste streams in agricultural sub-sectors</td>
<td>General statistics on waste streams in the country are scarce and those that are available are outdated No specific information on agricultural waste exists.</td>
<td>Qualitative assessment making use of US and European information.</td>
</tr>
</tbody>
</table>
CHAPTER 1
REFERENCE FRAMEWORK

KEY FINDINGS

Sustainable Consumption and Production (SCP) is the broad concept that was introduced through the Sustainable Development Goals (SDG 12) and that promotes efficient use of resources throughout the global economy and society. Efficient use of energy is not iterated in any of the SCP targets but is implicit. Energy receives special attention in SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all, which emphasises the need to increase the use of renewable energy sources and improve energy efficiency globally. The combination of SDG 12, which focuses on Sustainable Consumption and Production, and SDG 7, which promotes sustainable use of energy and deployment of renewables, renders the new term coined for this specific study, namely Sustainable Energy Consumption and Production (SECP).

In the context of the agricultural sector, this term is closely linked to energy-smart food systems, a concept that was introduced by the Food and Agriculture Organisation (FAO). Both of these promote the increased usage of renewables and reduced use of non-renewable energy sources; relying on more energy efficient low-carbon methodologies, techniques and technologies; minimising waste generation; reducing GHG emissions and pollution from use energy in general; as well as increased access to affordable modern energy services.

Agriculture is heavily reliant on energy as a production factor, which makes it highly susceptible to energy prices and energy availability. South Africa does not have data on energy usage and energy intensity in the agricultural and agricultural waste sub-sectors, though, highlighted the following:

• Crop production is the least energy intensive, as a result of low energy intense activities.
• Horticulture is marginally more energy intensive than crop production, with exception of greenhouse activities, which are highly energy-intensive.
• Animal and animal products consume the largest amount of energy, more so than crop and horticulture making it 5-7 times more energy intensive.
• Most of the waste generated in crop production is utilised for other farm activities; bagasse is commonly used for waste-to-energy generation of biogas.
• Horticultural waste such as fruit skins or peels, vegetable waste and peeps have high potential to be used as energy source and can be fed into bio-digesters, which can be set up for self-energy consumption or steam production.
• Animal and animal products waste such as manure also have a high potential for feed use in bio-digesters to produce methane gas, which can provide electricity for fuel, gas or steam.

1.1 BACKGROUND TO SCP

Working definition of SCP
The use of services and related products, which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardise the needs of future generations.
1.1.1 THE IMPORTANCE OF SCP

SCP is primarily aimed at improving the well-being of people; i.e. improving their economic and social development, while decoupling economic growth from environmental impacts (UNEP, 2006). It is interlinked; hence it can be equated to two faces of the same coin, where (UNEP, 2006):

- **Sustainable production** relates to the supply side, and focusses on the economic, social and environmental impacts of production processes; and
- **Sustainable consumption** addresses the demand side, and focusses on consumers' choices of goods and services to fulfil basic needs and improve the quality of life.

SCP is about 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, 2016). The efficient utilisation of resources, as advocated for through the SCP concept, is vital, especially considering the following facts about the global economy (United Nations, 2016):

- Three billion tonnes of food are wasted every year; while almost 1 billion people go undernourished, and another 1 billion go hungry.
- Man is polluting water faster than nature can recycle and purify water in rivers and lakes.
- More than one billion people still do not have access to fresh water.
- Only a fifth of the world's final energy consumption in 2013 was from renewable energy sources.
- The food sector accounts for around 30% of the world’s total energy consumption, and accounts for around 22% of total Greenhouse Gas emissions.
- Should the global population reach 9.6 billion by 2050, the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles.

1.1.2 SDGS AND SDG 12

**FIGURE 1.1: THE EMERGENCE OF SCP FRAMEWORK**

Figure 1.1 illustrates the timelines toward the development and evolvement of the SCP concept in agriculture.
INTEGRATED WASTE MANAGEMENT: RESEARCH AND TRAINING

2012

WSSD Rio +20. EU Commission: Report on the future we want - Sustainable Agriculture

2013

Formulation of world reports by UN agencies

2014

WSSD New York

2015

FAO - Family Farming - Year of Family Farming

2016

World Economic Forum (WEF-Davos); FAO: Creation of the Family Farming Global Platform

Switch Africa Green - SCP - SECP
<table>
<thead>
<tr>
<th>Activity/event</th>
<th>Key outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987 World Commission on Environment and Development</td>
<td>A new concept of Sustainable Development is presented.</td>
</tr>
<tr>
<td>2002 World Summit of Sustainable Development (WSSD), Johannesburg</td>
<td>Introduction of the Millennium Development Goals (MDG’s) and the Triple Bottom Line agenda (People, Planet, Prosperity).</td>
</tr>
<tr>
<td>2008 Special FAO congress on world food crisis</td>
<td>All UN agencies called to look into the SCP guidelines.</td>
</tr>
<tr>
<td>2008 EU – SCP/SIP action plan adopted</td>
<td></td>
</tr>
<tr>
<td>2010 UNDRIP – Indigenous People Rights Charter</td>
<td>SCP principles strongly feature in the unanimously accepted and signed charter.</td>
</tr>
<tr>
<td>2010 UNHRC – Right to Food Report</td>
<td>Makes reference to the necessity to adopt new agrarian approaches aligned to SCP guidelines.</td>
</tr>
<tr>
<td>UNFCC – COP 17</td>
<td>Formulation of Climate Smart Agriculture (CSA) and Conservation Agriculture (CA) concepts, as well as the capturing in of SCP principles in the Mitigation and Adaptation to Climate Chang Strategies.</td>
</tr>
</tbody>
</table>
| 2013 Formulation of World Reports by UN agencies  | • UNCTAD “Wake up before it’s too late” Sustainable Agriculture Report  \  
• UNDP – Sustainable Livelihoods Guidelines \  
• UNEP- 10 years SCP framework validated  \  
• UNHRC: Right to Food Final report  \  
• UNEP-UNIDO: RECP (Resources Efficiency and Cleaner Production) – Agro-processing/Agri-Waste |
| 2014 FAO – Family Farming                         | Recorded that globally 90% of farms are run by an individual or a family, which produce 80% of world food, and occupy 70 to 80% farm land.          |
| 2015 WSSD New York                                 | Unanimous Adoption of Sustainable Development Goals (SDG’s) - SCP is Outcome 12.                                                             |
| 2016 World Economic Forum (WEF – Davos)           | • Introduction of the “4th Industrial Revolution “– GDP indicators are questioned in measuring and evaluating sustainability and development.        |
| 2016 FAO: Creation of the Family Farming Global Platform | • Family Farming is associated to best Sustainable production and consumption practices in agriculture (FAO).                                  |

As can be established, the SCP was adopted in 2015 as part of the seventeen SDGs (refer to Figure 1-2), where it appears as a stand-alone goal (i.e. SDG 12: Ensure sustainable consumption and production patterns) and as a central component of many of the other goals and proposed targets (UNEP, 2016).
FIGURE 1: THE 17 SUSTAINABLE DEVELOPMENT GOALS

Eleven targets specific to SDG-12 (ensuring sustainable consumption and production) have been set and various indicators have been proposed to measure the progress with respect to achieving some of these targets. Table 1-2 outlines the set targets and the various proposed indicators.

TABLE II: DATA LIMITATIONS OBSERVED THROUGHOUT THE STUDY

<table>
<thead>
<tr>
<th>Target 12.1</th>
<th>Implement the 10-year framework of programmes on sustainable consumption and production; all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Indicators</td>
<td>Country implements and reports on System of Environmental-Economic Accounting (SEEA) accounts.</td>
</tr>
<tr>
<td>Target 12.2</td>
<td>By 2030, achieve the sustainable management and efficient use of natural resources.</td>
</tr>
<tr>
<td>Proposed Indicators</td>
<td>Country implements and reports on System of Environmental-Economic Accounting (SEEA) accounts.</td>
</tr>
<tr>
<td></td>
<td>Disclosure of Natural Resource Rights Holdings.</td>
</tr>
<tr>
<td></td>
<td>Revenues, expenditures, and financing of all central government entities that are presented on a gross basis in public budget documentation and authorised by the legislature.</td>
</tr>
<tr>
<td>Target 12.3</td>
<td>By 2030, halve the per capita global food waste at retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.</td>
</tr>
<tr>
<td>Proposed Indicators</td>
<td>Global Food Loss Indicator [or other indicator to be developed to track the share of food lost or wasted in the value chain after harvest].</td>
</tr>
</tbody>
</table>
### TABLE II: DATA LIMITATIONS OBSERVED THROUGHOUT THE STUDY CONTINUED

#### Target 12.4

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment.

**Proposed Indicators**
- Nitrogen use efficiency in food systems.
- Country implements and reports on System of Environmental-Economic Accounting (SEEA) accounts.
- Mean urban air pollution of particulate matter (PM10 and PM2.5).
- Consumption of ozone-depleting substances.
- Aerosol optical depth (AOD).

#### Target 12.5

By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

**Proposed Indicators**
- Percentage of wastewater flows treated to national standards [and reused] – to be developed.
- Percentage of urban solid waste regularly collected and well managed.
- Global Food Loss Indicator [or other indicator to be developed to track the share of food lost or wasted in the value chain after harvest].

#### Target 12.6

Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

**Proposed Indicators**
- [Share of companies valued at more than [$1 billion] that publish integrated monitoring] – to be developed.

#### Target 12.7

Promote public procurement practices that are sustainable, in accordance with national policies and priorities.

#### Target 12.8

Promote public procurement practices that are sustainable, in accordance with national policies and priorities.

#### Target 12.a

Support developing countries to strengthen their scientific and technological capacity in order to move towards more sustainable patterns of consumption and production.

**Proposed Indicators**
- Personnel in R&D (per million inhabitants).

#### Target 12.b

Develop and implement tools to monitor sustainable development impacts for sustainable tourism that create jobs and promotes local culture and products.

#### Target 12.c

Rationalise inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimising the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

**Proposed Indicators**
- Annual report by Bank for International Settlements (BIS), International Accounting Standards Board (IASB), International Financial Reporting Standards (IFRS), International Monetary Fund (IMF), World Intellectual Property Organisation (WIPO), and World Trade Organisation (WTO) [other organisations to be added] on the relationship between international rules and the SDGs and the implementation of relevant SDG targets.

(SDNS, 2015)
1.1.3 SCP GLOBAL IMPLEMENTATION

The 10-Year Framework of Programmes (10YFP), a global framework of action adopted at the Rio+20 conference in 2012 in order to enhance international cooperation to accelerate the shift towards SCP globally, set the following SCP implementation objectives (UNEP, 2013):

- Three billion tonnes of food are wasted every year; while almost 1 billion people go undernourished, and another 1 billion go hungry.
- Man is polluting water faster than nature can recycle and purify water in rivers and lakes.
- More than one billion people still do not have access to fresh water.
- Only a fifth of the world’s final energy consumption in 2013 was from renewable energy sources.
- The food sector accounts for around 30% of the world’s total energy consumption, and accounts for around 22% of total Greenhouse Gas emissions.
- Should the global population reach 9.6 billion by 2050, the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles.

Enabling all stakeholders to share information and knowledge on SCP tools, initiatives and best practices, raising awareness, and enhancing cooperation and development of new partnerships – including public-private partnerships.

The 10-Year Framework of Programmes (10YFP), a global framework of action adopted at the Rio+20 conference in 2012 in order to enhance international cooperation to accelerate the shift towards SCP globally, set the following SCP implementation objectives (UNEP, 2013):

- Supporting regional and national policies and initiatives in order to accelerate the shift towards SCP, contributing to resource efficiency and decoupling economic growth from environmental degradation and resource use, while creating new job/market opportunities and contributing to poverty eradication and social development.
- Mainstreaming SCP into sustainable development policies, programmes and strategies, as appropriate, including into poverty reduction strategies.
- Providing financial and technical assistance and capacity building to developing countries, supporting the implementation of SCP activities at regional and national levels.

Enabling all stakeholders to share information and knowledge on SCP tools, initiatives and best practices, raising awareness, and enhancing cooperation and development of new partnerships – including public-private partnerships.
1.2 SCP IN THE CONTEXT OF AGRICULTURE AND WASTE MANAGEMENT

SCP is a broad concept. The earlier discussions on SCP, presented in this study, apply to multiple sectors of the economy. In order understand SCP within the context of agriculture and waste management, it is imperative to consider other definitions of SCP, which have been given by other key global agencies such as FAO, as well as reviewing other relevant literature on sustainable agriculture.

The Food and Agriculture Organisation of the United Nations (FAO) defines SCP in the context of food and agriculture as a “consumer-driven, holistic concept that refers to the integrated implementation of sustainable patterns of food consumption and production, respecting the carrying capacities of natural ecosystems. It requires consideration of all the aspects and phases in the life of a product, from production to consumption, and includes such issues as sustainable lifestyles, sustainable diets, food losses and food waste management and recycling, voluntary sustainability standards, and environmentally friendly behaviours and methods that minimize adverse impacts on the environment and do not jeopardize the needs of present and future generations” (FAO, 2016).

With respect to the SDGs, the following four SDG 12 targets specifically relate to agricultural and waste management activities:

• Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources.
• Target 12.3: By 2030, halve the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.
• Target 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment.
• Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

With respect to the subject around sustainable agriculture, Figure 1-3 summarises some of the key differences between conventional and sustainable agricultural practices.
From the above, it is that:

**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, etc. 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.

**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. Often, sustainable agriculture implies adoption of Organic Production and Agroecology Practices (OPAP).

---

**FIGURE 1-3: CONVENTIONAL AGRICULTURE VS SUSTAINABLE AGRICULTURE**

<table>
<thead>
<tr>
<th>Conventional Agriculture</th>
<th>Sustainable Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td>Conventional agriculture (industrial agriculture) refers to systems of farming that are typically highly resource- and energy-intensive, but also generate higher yields. The goal of conventional agriculture is to maximise on potential yield.</td>
<td>Sustainable agriculture (Organic Production and Agroecology Practices - OPAP) is a collective term for different approaches to farming, which are ecologically sound, economically viable, and socially just, culturally appropriate and based on holistic scientific and whole system approach.</td>
</tr>
<tr>
<td><strong>Principles</strong></td>
<td></td>
</tr>
<tr>
<td>Industrialisation towards optimal yield production performance.</td>
<td>Integration of nature and man in the process of land and resources management.</td>
</tr>
<tr>
<td>Economic growth and market supply-demand requisites.</td>
<td>Sustainable development and local markets self-sufficiency and autonomy.</td>
</tr>
<tr>
<td>Priority on capital and financial returns.</td>
<td>Capital retention and resource assets conservation.</td>
</tr>
<tr>
<td>Monopolisation, globalisation and corporate interests’ concentration.</td>
<td>Localisation and entrepreneurial clusterisation.</td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
</tr>
<tr>
<td>Extensive use of synthetic chemical fertilisers, pesticides, herbicides and other continual inputs.</td>
<td>Relies on crop rotation, animal and plant manures as fertilisers, biological and ecological weed, fungi, nematodes and pest control.</td>
</tr>
<tr>
<td>Uses genetically modified seeds and hybrid breeds.</td>
<td>Manages interactivities between Heirlooms seed and indigenous breeds.</td>
</tr>
<tr>
<td><strong>Activities</strong></td>
<td></td>
</tr>
<tr>
<td>Intensive water irrigation systems.</td>
<td>Efficient water retention in soils and selective irrigation.</td>
</tr>
<tr>
<td>Intensive tillage.</td>
<td>Minimum, reduced, or no tillage.</td>
</tr>
<tr>
<td>Confined and concentrated animal feeding operations.</td>
<td>Free-range feeding practices.</td>
</tr>
<tr>
<td>Extensive production of animal feed.</td>
<td>Introduction of agro-forestry, ecological zones and land parcellisation, animal-plant companionship.</td>
</tr>
<tr>
<td>Monoculture and large scale farming operations.</td>
<td></td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td></td>
</tr>
<tr>
<td>Agri-business.</td>
<td></td>
</tr>
<tr>
<td>Reliance on fossil fuels. Capital intensive equipment ownership.</td>
<td>Family farming or cooperatives.</td>
</tr>
<tr>
<td>High GHG emissions.</td>
<td>Reliance on biofuels or renewables.</td>
</tr>
<tr>
<td>Waste disposal and beneficiation.</td>
<td>Low-tech equipment on rental.</td>
</tr>
<tr>
<td>Low GHG emissions.</td>
<td>Low GHG emissions.</td>
</tr>
</tbody>
</table>
| Zero waste. | }
1.3 SUSTAINABLE ENERGY CONSUMPTION AND PRODUCTION CONCEPT DEFINED

Sustainable Energy Consumption and Production (SECP) is an exclusive concept; thus, this terminology is coined specifically for this project. There is no known existing body of literature that makes reference to SECP as a terminology, which means that a study-specific definition needs to be developed to define energy in the context of SCP practices, specifically within the agricultural and agricultural waste sectors.

A review of the SDG 12 targets and proposed indicators, reveals no inclusion of energy-related goals and targets as part of SCP. However, other literature on SCP makes specific reference to energy-related aspects:

- SCP entails 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. It is aimed at “doing more and better with less”, increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life (UNEP, 2010).

- An SCP system that supports sustainable development is one in which SCP is used in a way that minimises demands on non-renewable resources, e.g. fossil fuels and metals. It also minimises the adverse impacts on human health and the environment, e.g. pollution and contributions to climate change, or waste generation (United Nations Economic Commission for Africa, 2009).

Further review of the SDGs also shows that the aspect on sustainable energy is captured as a standalone goal, i.e. SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all. SDG 7.2 and 7.3 are directly in line with the concept of SECP.

Table 1-3 outlines the five targets set for sustainable energy as well as the proposed indicators for each of those targets.

**TABLE 1-3: TARGETS AND PROPOSED INDICATORS FOR SDG 7**

<table>
<thead>
<tr>
<th>Target 7.1</th>
<th>By 2030 ensure universal access to affordable, reliable, and modern energy services.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposed Indicators</strong></td>
<td>Share of the population using modern cooking solutions, by urban/rural.</td>
</tr>
<tr>
<td></td>
<td>Share of the population using reliable electricity, by urban/rural.</td>
</tr>
<tr>
<td></td>
<td>Primary energy by type.</td>
</tr>
<tr>
<td>Target 7.2</td>
<td>Increase substantially the share of renewable energy in the global energy mix by 2030.</td>
</tr>
<tr>
<td><strong>Proposed Indicators</strong></td>
<td>Implicit incentives for low-carbon energy in the electricity sector (measured as US$/MWh or US$ per ton avoided CO₂).</td>
</tr>
<tr>
<td></td>
<td>Share of energy from renewables.</td>
</tr>
<tr>
<td>Target 7.3</td>
<td>Double the global rate of improvement in energy efficiency by 2030.</td>
</tr>
<tr>
<td><strong>Proposed Indicators</strong></td>
<td>Rate of primary energy intensity improvement.</td>
</tr>
<tr>
<td>Target 7.4</td>
<td>By 2030, enhance international cooperation to facilitate access to clean energy research and technologies, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies.</td>
</tr>
<tr>
<td><strong>Proposed Indicators</strong></td>
<td>Official development assistance and net private grants as percent of GNI.</td>
</tr>
<tr>
<td></td>
<td>Domestic revenues allocated to sustainable development as percent of GNI, by sector.</td>
</tr>
<tr>
<td></td>
<td>Private net flows for sustainable development at market rates as share of high-income country GNI, by sector.</td>
</tr>
<tr>
<td></td>
<td>Fossil fuel subsidies ($ or %GNI).</td>
</tr>
<tr>
<td>Target 7.5</td>
<td>By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, particularly LDCs and SIDS.</td>
</tr>
<tr>
<td><strong>Proposed Indicators</strong></td>
<td>Share of the population using reliable electricity, by urban/rural.</td>
</tr>
<tr>
<td></td>
<td>Implicit incentives for low-carbon energy in the electricity sector (measured as US$/MWh or US$ per ton avoided CO₂).</td>
</tr>
</tbody>
</table>

(SDSN, 2015)
Sustainable energy is defined as the provision of energy in such a way that it meets the needs of the present without compromising the ability of the future generations to meet their own needs (REEEP/SERN, 2004). It is made up of two key components; renewable energy and energy efficiency (ReeEP/SERN, 2004). Considering the above, it is therefore, clear that sustainable energy covers the following three key aspects:

• Universal access to affordable, reliable and modern energy services;
• Increased use of renewable energy resources; and
• Increased utilisation of energy efficiency technologies.

For the purposes of this study, SECP entails integrating aspects of SDG 12 (SCP) and SDG 7 (Sustainable Energy).

**FIGURE 1-4: SECP IN THE CONTEXT OF SDG 12 AND SDG 7**

Based on the various definitions as well as the SDG targets of SCP and sustainable energy given above, the following aspects can be incorporated as key elements of SECP:

- The increased utilisation of renewable energy sources.
- The use of energy efficiency methodologies, techniques and technologies.
- Minimised waste generation through separation at source, prevention, reduction, recycling and reuse.
- Reduced pollution from energy use and generation activities.
- Replacement or minimised use of non-renewable energy resources.
- Increased access to affordable, reliable and modern energy services.

SECP in the agriculture and integrated waste management context could therefore, entail the following practices:

1. Improvements towards mainstreaming the utilisation of renewable energy resources across the entire agricultural value chain. Target 7.2 of the SDG goals specifically promotes the generation of energy from renewable sources.
2. Expanding the utilisation of energy efficiency techniques and technologies across the entire agricultural value chain. Target 7.3 focuses on increasing energy efficiency, the indicator emphasises the urgency of doubling the energy efficiency rate, which would entail the utilisation of energy efficient practices in all areas of the value chain.
3. Minimising the generation of waste across the entire agricultural value chain through prevention, reduction, recycling and reuse measures, e.g. waste-to-energy projects.
4. Minimising any other energy-related aspects of agriculture that result in the pollution of the environment.
5. Replacing or minimising the use of non-renewable fuels across the entire agricultural value chain.

Considering the above definition of SECP, it becomes clear that it is closed related to the FAO’s (2011) concept of energy smart food systems, which involves improving the access to modern energy services, relying on more energy efficient low-carbon energy systems, promoting bioenergy, and reducing GHG emissions. The transition towards energy smart food systems is seen by FAO (2011) through the adoption of the following practices:

- Low-carbon energy systems that reduce the use of fossil fuels
- Renewable energy practices
- Evaluation of direct and indirect energy consumption within the value chain
- Reliance on the crop rotation practices, the use of organic fertilisers and biological pest control mechanisms, selective irrigation and minimum tillage, but is not limited to the mentioned, will help achieve this.
1.4 ENERGY USAGE AND INTENSITY OF AGRICULTURAL SUB-SECTORS

The agricultural sector is one that 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 consumption in agriculture can be classified as either direct or indirect (CRS, 2004).
• **Direct energy consumption** refers to energy used from primary or secondary fuel sources such as diesel, oil, gas, solar and electricity (Bundschuh & Chen, 2014) for crop production, grain drying, animal and animal product production, poultry, transportation of farm products and personal energy use (for example, heating farmhouse and driving to town) (CAEEDAC, 2000).
• **Indirect energy consumption** on the other hand, refers to embodied energy used to produce equipment and other goods and services (i.e. intermediate inputs) that are used as in inputs in agriculture (Bundschuh & Chen, 2014). As an example, this could be the energy used in the manufacture, packaging and transport of fertilisers, pesticides, seed, and farm machinery (CAEEDAC, 2000).

Table 1-4 illustrates the classification of energy consumption in plant and animal production activities.

**TABLE 1-4: ENERGY INPUT FOR PLANT AND ANIMAL PRODUCTION ACTIVITIES**

<table>
<thead>
<tr>
<th>Item</th>
<th>Crop production</th>
<th>Animal Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Energy Input</td>
<td>Fuel, lubricant, oil heating</td>
<td>Fuel, lubricant, electricity, gas heating</td>
</tr>
<tr>
<td>Indirect Energy Input</td>
<td>Machines, fertilisers, pesticides, seeds, machine sheds</td>
<td>Machines, sheds, fodder import, fodder processed</td>
</tr>
</tbody>
</table>

Energy usage differs among agricultural sub-sectors. The following sections present energy usage profiles for the three agricultural sub-sectors considered for this study, i.e. crop production, horticulture, and animal production.

**FIGURE 1-5: ENERGY CONSUMPTION IN CROP PRODUCTION**

- Direct
  - Transporting intermediate inputs to the farm
  - Tractors and farm machinery
  - Irrigation and fertigation
  - Heating
- Indirect
  - Fertiliser production
  - Seed production
  - Chemicals production (pesticides)

- Input Supply
  - Farming/Production
  - Post-harvest handling
- Processing and packaging
  - Storage
  - Ventilation
  - Drying
  - Curing and fermenting
  - Transporting produce
- Transporting machinery
- Transporting processed products
- Storage and warehousing
- Retail and Distribution
FIGURE 1-5: ENERGY CONSUMPTION IN CROP PRODUCTION

The following diagram illustrates energy flows along the cereal production value chain, which is used as an example for crop production sub-sector. It shows that agriculture, or farm production and agribusiness activities account for only 17% of the total energy used in the cereal production value chain. The majority of energy along this value chain is spent on processing (i.e. food processing and brand marketing) and retail (i.e. wholesale and retail trade and marketing services); however, the data presented is based on US statistics due to statistics for energy usage within the agricultural sector in South Africa not available at present.

FIGURE 1-6: EXAMPLE OF ENERGY USAGE ALONG THE VALUE CHAIN OF CEREALS PRODUCTION BASED ON US DATA (CANNING, ET AL., 2010)

DIRECT ENERGY USAGE IN CROP PRODUCTION

With regard to direct energy usage, different energy sources are consumed in order to meet the various energy needs that are required in crop production. Table 1-5 outlines some of the conventional energy sources utilised in certain crop production activities at a farm level. An energy study conducted for the agricultural sector in the UK in 2007 revealed that the use of petroleum products dominated energy use within the crop production sector (71%), with the great bulk of energy going towards mobile machinery (Warwick HRI, 2007). The crop production value chain using the conventional energy approach, is rather standardised in the agricultural industry. Statistics for direct energy usage for crop production in South Africa are unavailable. Although the statistics presented are based on a study conducted in the UK on the direct energy usage within crop production, it can be seen that the use of diesel as fuel is a common denominator in crop production within South Africa and the UK. This is due to the intense use of diesel when operating farming equipment such as tractors.
### TABLE 1-5: DIRECT ENERGY USES IN CROP PRODUCTION

<table>
<thead>
<tr>
<th>Energy demand source</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating farm machinery and trucks</td>
<td>Petroleum products: diesel, petrol, lubricants</td>
</tr>
<tr>
<td>• Field work (tractors, mowers, combine harvesters, tillers, harvesters, spreaders, sorters, planters, balers, pickers, conveyors, elevators, etc.)&lt;br&gt;• Trucks used in input purchases and deliveries</td>
<td>Petroleum products: diesel, petrol, lubricants</td>
</tr>
<tr>
<td>Operating small vehicles</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>For farm management activities</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>Operating small equipment</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Irrigation and fertigation systems</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Drying of grain</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Threshing</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Winnowing</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Ginning</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Curing and fermenting</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Heating and cooling</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Crop flaming</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Processing and packaging</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>General farm overhead (buildings, infrastructure and appliances)</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Lighting for houses, sheds</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Farm household appliance</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Electric fence for security</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Generators</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Dams management</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>Storage (buildings)</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Temperature controls</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
<tr>
<td>• Lighting</td>
<td>Petroleum products: diesel, petrol, LPG</td>
</tr>
</tbody>
</table>

### INDIRECT ENERGY USAGE IN CROP PRODUCTION

As can be established from the given diagram, energy is consumed in several ways within the crop production sub-sector. With respect to indirect energy, the production of fertilisers, used as inputs in crop production, is believed to be the most energy-intensive activity. Fertiliser accounted for slightly more than half of indirect energy use in US farms in 2011 (USDA, 2013). Again, South African data are not available, hence the use of US statistics.

Fertilisers can be classified into three nutrient categories, i.e. Nitrogen, Phosphate, and Potash (USDA, 2013); with nitrogen-based fertilisers being the most consumed and most energy-intensive of these three groups. The production of ammonia, from which almost all nitrogen fertilisers are derived, consumes enormous amounts of natural gas and coal (WWF, 2014). Nitrogen fertiliser production can account for more than 50% of total energy use in commercial agriculture (Woods, et al., 2010).

It can be acknowledged that nitrogen fertilisers are far more energy intensive due to the nature of which it is generated; however, there are not statistics available in South Africa for the energy usage within agriculture of nitrogen fertilisers, thus the use of US statistics for the purpose of this study.

Pesticides are also an energy-intensive agricultural input (USDA, 2013). Pesticides include herbicides (to manage plants and weeds), insecticides (to manage insects), and fungicides (to manage fungi) (USDA, 2013).
ENERGY INTENSITY OF VARIOUS CROPS

Figure 1-7 shows the estimated energy inputs required to produce some of the crops (i.e., farming and agribusiness activities only), based on the data sourced from the European Union, as there are no statistics available for South Africa for the energy consumed for the different types of crops produced. Sunflower seed, maize, and durum wheat appear to consume the largest amount of energy in their production processes. The majority of crop production, though, appears to have relatively the same energy-intensity ranging between 2.63 MJ/kg and 3.58 MJ/kg. However, SECP implementation plays a role in wheat production to optimise energy efficiency. Eskom discusses the direct and indirect energy usage in grain farming within South Africa and states that improvement in the drying process through the installation of dryers, which are specifically designed for energy efficiency will reduce energy usage along with moisture and temperature maintenance (Eskom n.d.).

The opportunities for waste-to-energy practices within crop production cannot be ignored to reduce the reliance on electricity and diesel. Biomass as fuel can replace petroleum products and generate heat and power thus saving in electricity costs.

**FIGURE 1-7: ENERGY CONSUMPTION PER KG OF CROP PRODUCED (KEMPEN & KRAENZLEIN, 2007)**

Due to the difference in properties of agricultural products and employed agricultural practices in their production, the inputs used in production of crops differ from one crop to another. The following diagram, for example, shows that feed/fertilisers and diesel account for the majority of energy input into cereal production, while electricity and feed/fertilisers are the largest energy inputs into maize production.
While the above results do not include other popular South African field crops such as cotton and tobacco, it is generally known that these crops require other types of energy outlays, even after harvest. Cotton needs to be ginned to separate the lint from seeds and foreign matter; while tobacco has to be cured through a process of heating and drying (CRS, 2004).

It should also be highlighted that the above information primarily reflects the energy intensity of crop production following conventional agricultural practices. Organic farming or Integrated Arable Farming Systems (IAFS), which are inherent to sustainable agricultural practices, are generally associated with a better energy efficiency than conventional farming (Woods, et al., 2010). However, reduced fossil energy inputs in organic farming is achieved at a cost of higher human energy inputs and lower yields (Woods, et al., 2010).
1.4.2 HORTICULTURAL SUB-SECTOR ENERGY USAGE AND ENERGY INTENSITY

Figure 1-9 illustrates various direct and indirect energy consuming activities in the horticultural sub-sector.

**FIGURE 1-9: ENERGY CONSUMPTION IN HORTICULTURE**

The flows of energy along the value chain of selected horticultural products are illustrated in Figure 1-10. It shows that on average, about half of all energy that is used in the value chain of producing fresh vegetables or fresh fruits, for example, is consumed by agricultural activities, which is significantly greater compared to the energy usage along the crop production value chain. Following the agricultural activities is the wholesale and retail activities that consume on average about a third of energy used along their production value chains. For the purpose of the study, US data was used as there is no available data for energy usage along the value chain in South Africa.

**FIGURE 1-10: EXAMPLE OF ENERGY USAGE ALONG THE VALUE CHAIN OF SELECTED HORTICULTURAL PRODUCTS BASED ON US DATA (CANNING, ET AL., 2010)**
DIRECT ENERGY USAGE IN HORTICULTURAL PRODUCTION

There are various horticultural activities that utilise different energy sources. Table 1-6 outlines the various horticultural activities that consume direct energy at farm level and the respective energy sources that are normally utilised.

TABLE 1-6: DIRECT ENERGY USES IN HORTICULTURE

<table>
<thead>
<tr>
<th>Energy demand source</th>
<th>Energy Source</th>
</tr>
</thead>
</table>
| Operating farm machinery and trucks | • Field work (tractors, mowers, combine harvesters, tillers, harrows, spreaders, sorters, planters, conveyors, etc.)
|                               | • Trucks used in input purchases and deliveries     |
| Operating small vehicles     | Farm management activities                         |
| Greenhouse management        | • Lighting                                          |
|                               | • Temperature regulation                           |
|                               | • Plant disease and insect control                  |
|                               | • Fertilisation                                     |
|                               | • Automated irrigation and moisturising systems     |
| Operating small equipment    | • Irrigation and fertigation systems
|                               | • Heating for frost protection                      |
|                               | • Curing and fermenting                             |
|                               | • Pickers                                           |
|                               | • Crop flaming                                      |
|                               | • Processing and packaging                          |
| General farm overhead        | • Lighting for houses, sheds                        |
|                               | • Farm household appliance                         |
|                               | • Electric fence for security                       |
|                               | • Generators                                        |
| Storage                      | • Temperature controls                              |
|                               | • Lighting                                          |

With regard to direct energy uses within the horticulture sub-sector, the use of greenhouses and other temperature-controlled structures, e.g. mushroom houses, cannot be overlooked (Warwick HRI, 2007). In the UK, electricity use in horticulture tends to be low for all commodities except mushrooms, cut flowers and pot plants (Warwick HRI, 2007).

ENERGY INTENSITY OF VARIOUS HORTICULTURAL CROPS.

Figure 1-11 illustrates the energy intensity of some horticultural products based on European experience as there was no data available for South Africa. It can be concluded that many of horticultural products appear to be more energy-intensive when compared to conventional field crops; however, some require considerably less energy to produce a unit of output than crops. It can be picked up though, that horticultural products that are generally grown in green houses, appear to be notably more energy-intensive than those grown in trees (i.e. deciduous fruits) or in open fields (i.e. potatoes).
FIGURE 1-11: ENERGY CONSUMPTION PER KG OF HORTICULTURAL PRODUCT PRODUCED (KEMPEN & KRAENZLEIN, 2007)

- Tomatoes: 8.2 MJ/Kg
- Other vegetables: 8.53 MJ/Kg
- Apples, pears, and peaches: 1.3 MJ/Kg
- Citrus fruits: 4.22 MJ/Kg
- Olive for oil: 12.62 MJ/Kg
- Table wine: 5.26 MJ/Kg
- Potatoes: 1.62 MJ/Kg

1.4.3 ANIMAL AND ANIMAL PRODUCTS ENERGY USAGE AND ENERGY INTENSITY

Figure 1-12 illustrates various direct and indirect energy consuming activities in animal production.

FIGURE 1-12: ENERGY CONSUMPTION IN ANIMAL PRODUCTION

- Direct:
  - Transporting intermediate inputs to the farm
  - Farm machinery
  - Lighting
  - Animal feeding
  - Ventilation
  - Space heating
  - Animal waste-handling

- Indirect:
  - Animal fodder production
  - Chemicals production (pesticides)
  - Farm machinery and equipment manufacturing

- Processing:
  - Processing and packaging machinery
  - Transporting processed products
  - Cold storage and refrigeration

- Storage
- Transportation
- Retail and Distribution

MJ/Kg
The energy usage along the value chains of selected animal and animal products vary depending on the product considered in Figure 1-13; however, it can be concluded that agricultural or farming activities account for at least a third of total energy used in their value chains with processing and packaging accounting for the second most energy-intensive activity along the value chains; this is based on US data as the statistics for South Africa could not be found.


<table>
<thead>
<tr>
<th>Egg products</th>
<th>Poultry</th>
<th>Pork</th>
<th>Beef</th>
<th>Dairy products</th>
<th>Fruits dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh dairy</td>
<td>Dairy</td>
<td>Beef</td>
<td>Dairy</td>
<td>Dairy products</td>
<td>Fruits dairy</td>
</tr>
<tr>
<td>55%</td>
<td>38%</td>
<td>42%</td>
<td>41%</td>
<td>34%</td>
<td>36%</td>
</tr>
<tr>
<td>19%</td>
<td>32%</td>
<td>27%</td>
<td>26%</td>
<td>31%</td>
<td>32%</td>
</tr>
<tr>
<td>2%</td>
<td>5%</td>
<td>3%</td>
<td>3%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>17%</td>
<td>20%</td>
<td>22%</td>
<td>23%</td>
<td>23%</td>
<td>21%</td>
</tr>
</tbody>
</table>

**DIRECT ENERGY USAGE IN ANIMAL AND ANIMAL PRODUCT PRODUCTION**

The animal production sub-sector is also heavily reliant on energy to sustain the production activities. Similar to the crop production and horticulture sub-sectors, the animal production sub-sector is also constituted of various energy consuming activities, which utilise different energy sources. Table 1-7 is a snapshot of the various energy consuming activities and the respective energy sources that characterise the animal production sub-sector.
TABLE 1-7: DIRECT ENERGY USES IN ANIMAL PRODUCTION

<table>
<thead>
<tr>
<th>Energy demand source</th>
<th>Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating farm machinery and trucks</td>
<td>• Animal farm machinery</td>
</tr>
<tr>
<td></td>
<td>• Processing and packaging</td>
</tr>
<tr>
<td></td>
<td>• Trucks used in input purchases and deliveries</td>
</tr>
<tr>
<td></td>
<td>• Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol, lubricants</td>
</tr>
<tr>
<td></td>
<td>• Electricity</td>
</tr>
<tr>
<td>Operating small vehicles</td>
<td>Farm management activities</td>
</tr>
<tr>
<td></td>
<td>Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol, lubricants</td>
</tr>
<tr>
<td>Operating small equipment</td>
<td>• Animal feeding and watering systems</td>
</tr>
<tr>
<td></td>
<td>• Waste handling systems</td>
</tr>
<tr>
<td></td>
<td>• HVAC</td>
</tr>
<tr>
<td></td>
<td>• Lighting systems</td>
</tr>
<tr>
<td></td>
<td>• Sanitation systems</td>
</tr>
<tr>
<td></td>
<td>Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol, LPG</td>
</tr>
<tr>
<td></td>
<td>• Electricity</td>
</tr>
<tr>
<td>Pasture management</td>
<td>• Irrigation</td>
</tr>
<tr>
<td></td>
<td>• Weed control</td>
</tr>
<tr>
<td></td>
<td>• Fertilisation</td>
</tr>
<tr>
<td></td>
<td>• Fencing and gates management</td>
</tr>
<tr>
<td></td>
<td>Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol</td>
</tr>
<tr>
<td></td>
<td>• Electricity</td>
</tr>
<tr>
<td>General farm overhead</td>
<td>• Lighting for houses, sheds</td>
</tr>
<tr>
<td></td>
<td>• Farm household appliance</td>
</tr>
<tr>
<td></td>
<td>• Electric fence for security</td>
</tr>
<tr>
<td></td>
<td>• Generators</td>
</tr>
<tr>
<td></td>
<td>• Alien or wild biomass control</td>
</tr>
<tr>
<td></td>
<td>Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol, LPG</td>
</tr>
<tr>
<td></td>
<td>• Electricity</td>
</tr>
<tr>
<td>Storage</td>
<td>• Cold storage for processed meet</td>
</tr>
<tr>
<td></td>
<td>• Storage for veterinary products</td>
</tr>
<tr>
<td></td>
<td>Petroleum products:</td>
</tr>
<tr>
<td></td>
<td>diesel, petrol, LPG</td>
</tr>
<tr>
<td></td>
<td>• Electricity</td>
</tr>
</tbody>
</table>

ENERGY INTENSITY WITHIN THE ANIMAL PRODUCTION SUB-SECTOR

Animal and animal products production is considerably more energy-intensive per unit of output compared to production of crops and horticulture. On average, it is five to seven times more energy-intensive than production of crop or horticultural products (Figure 1-14). This is largely due to the concentration effect as animals are fed on crops (Woods, et al., 2010).

FIGURE 1-14: ENERGY CONSUMPTIONS PER KG OF ANIMAL AND ANIMAL PRODUCTS PRODUCED (KEMPEN & KRAENZLEIN, 2007)

<table>
<thead>
<tr>
<th>Product</th>
<th>Energy Consumption (MJ/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>65.87</td>
</tr>
<tr>
<td>Pork meat</td>
<td>35.86</td>
</tr>
<tr>
<td>Poultry meat</td>
<td>24.83</td>
</tr>
<tr>
<td>Cow milk</td>
<td>4.91</td>
</tr>
<tr>
<td>Eggs</td>
<td>19.39</td>
</tr>
</tbody>
</table>

MJ/Kg
The energy usage in production of animal and animal products differ significantly depending on the item considered (refer to figure 1-15).

**FIGURE 1-15: BREAKDOWN OF ENERGY INPUTS FOR SELECTED ANIMAL AND ANIMAL PRODUCTS PRODUCTION ACTIVITIES (KEMPEN & KRAENZLEIN, 2007)**

As illustrated in Figure 1-15, the majority of energy consumed by pig breeding, for example, involves fuel and electricity, as well as feed. While these two items appear to also be the largest energy inputs in milk production, the energy consumption structure in beef meat production differ significantly. Feed and young animals are the largest energy consuming items in production of beef meat.
1.4.4 SYNTHESIS

Considering the information presented in this section, the agricultural sub-sectors and products thereof and be categorised into high, medium, and low energy-intensive groups.

TABLE 1-8: ENERGY INTENSITY CATEGORISATION

<table>
<thead>
<tr>
<th>Agricultural product</th>
<th>Energy intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td><strong>Crops</strong></td>
<td></td>
</tr>
<tr>
<td>Soft wheat</td>
<td></td>
</tr>
<tr>
<td>Durum wheat</td>
<td></td>
</tr>
<tr>
<td>Rye and muslin</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
</tr>
<tr>
<td>Other cereals</td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
</tr>
<tr>
<td>Sunflower seed</td>
<td></td>
</tr>
<tr>
<td><strong>Horticultural products</strong></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td></td>
</tr>
<tr>
<td>Other vegetables</td>
<td></td>
</tr>
<tr>
<td>Apples, pears and peaches</td>
<td></td>
</tr>
<tr>
<td>Citrus fruits</td>
<td></td>
</tr>
<tr>
<td>Olive for oil</td>
<td></td>
</tr>
<tr>
<td>Table wine</td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td><strong>Animal and animal products</strong></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td></td>
</tr>
<tr>
<td>Pork meat</td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
</tr>
</tbody>
</table>

The following can be highlighted:

- Overall, it is clear that animal and animal product production hosts the most energy-intensive group of activities; importantly their energy intensity by far exceeds the energy intensity of crop or horticultural production. A third of total energy used in the animal and animal products value chain is from agricultural and farming activities. This is a result of the animal’s reliance on crops as their food source.

- Crop production and horticultural product production include activities that are both medium and low energy-intensive. However, on average, horticultural activities appear to be slightly more energy-intensive than crop production activities.

- Although crop production is low in energy intensity, petroleum products dominated as the largest energy user within crop production.

- Horticultural activities are medium-to low-in energy intensity, a third of the energy usage is consumed in wholesale and retail activities.
1.5 WASTE STREAMS AND WASTE CONVERSION POTENTIAL IN AGRICULTURAL SUB-SECTORS

Agricultural waste (or simply – farm waste), in the context of this study, is understood as any residue or waste materials generated in the course of agricultural activities. It can be in solid form (dry waste), liquid form (wet waste), or slurries depending on the nature of agricultural activities (Nova Science Publishers, 2016).

- Dry waste or solid waste includes grass, nut shells, barks, straw, husks, peeps, tyres, and other dry waste materials that are created during the production of various agricultural products. Many of these can be used in anaerobic combustion or bio-digesters to generate energy or energy products.
- Wet waste in the agricultural sector consists of uncompromised animal waste (e.g. domestic manures, faeces, guano, feathers) and compromised animal waste (e.g. carcasses, pig faeces, processed food waste). Many of these can also be used in bio-digesters to extract gas and produce fuels.

The following sections examine the waste products generated by each agricultural sub-sector considered, and discusses the potential of some of the waste streams to be used in production of energy or energy products.

1.5.1 CROP PRODUCTION SUB-SECTOR WASTE AND ENERGY POTENTIAL

Figure 1-16 outlines the various streams of waste generated across the field crop production value chain.

FIGURE 1-16: WASTE GENERATED ALONG THE CROP PRODUCTION VALUE CHAIN
Based on the given diagram, it can be established that there are various forms of waste materials that are generated across the entire crop production value chain. The following aspects can be highlighted with regard to waste generation in field crop production:

- The agricultural sector does not only produce waste, but uses products from pollution and waste intensive industries. Most of the waste originates from the use of agri-chemical fertilisers and other inputs as these are mostly derived from a fossil fuels refinery or chemical manufacturing processes.
- Materials that are not biodegradable, such as agrichemical fertiliser and inputs could be considered as hazardous waste introduced in the soil.
- Most of the dry green waste is generated at production level.
- The wastage of the water resources comes from the intensive irrigation systems (Pivot and sprinklers).
- Most of the waste comes from the agro-processing sector and is actually minimal, as the industries involved are well structured in the value chain and find ways to beneficiate most of their waste.
- Another aspect that has to be included into waste is the amount of agricultural equipment which is beyond repair, obsolete or discarded and filling the entire “scrap yards”.

The following sections provide insight into some of the waste streams created during production of crops and their possible application in generation of energy or energy products.

**STRAW AND WEEDS**

Straw and weeds are mainly fibres with root stems that are often left in the field for minimal organic re-introduction in the soil. They are mainly baled towards various uses on and off farm products, such as animal feed, litter, and organic soil fertility products. These are often not considered as waste by the farmers, unless the logistical costs to handle or transport them are too exhaustive against their profit potential.

**GRAIN MILLING WASTE**

Grain milling waste is minimal and its residual products find their way in a variety of uses in the animal and human food industry (thickeners, stabilisers, binders, etc.).

**SEED MILLING WASTE**

Activities such as the production of sunflower or canola oil produce ester-based waste such as oil cake, which is disposed as animal feed fattening products. The challenge is the sludge, which is also disposed through animal feed products. In South Africa, fine extraction of natural waxes from these waste streams has not been adopted by industry players, as a result of a monopoly from Sasol in petroleum waxes, preventing its introduction in the downstream value chain. Husks are currently disposed as organic fodder to soils, yet they could be better used as oil soaking agents to industrial oil waste (oil spills) to produce an effective fuel for localised electricity generation.

**BAGASSE**

Bagasse is produced during sugar cane processing activities. Bagasse is a light fibre material, which can be used in power generation units (boilers feed).

**FILTER CAKE**

In the processing of sugar cane, filter cake is solid waste produced from the process. This waste has high potential for biogas generation, which can then be used as fuel for farming operations.

**WASTEWATER**

Liquid waste, which consists of waste water produced from the sugar cane industry, can be harmful to the environment. If not disposed correctly it has the potential to contaminate subsurface and surface waters. The conventional method of treating waste water; aerobic activated sludge treatment and tertiary removal treatment has limited energy recovery potential. Waste water can also be used for biogas generation.

**NUT SHELLS**

The waste generated from the nut orchards and de-husking facilities is an important under-looked material, mostly used for horticultural ground cover or mulches. All nuts have a high combustible calorific value that can be used in the generation of energy. Added to this, there is a variety of wild nuts that can be used in this way including palm seeds, bluegum pods, etc.
1.5.2 HORTICULTURAL SUB-SECTOR WASTE AND ENERGY CONVERSION POTENTIAL

Figure 1-17 provides a snapshot of the various streams of waste generated across the horticulture produce value chain.

**FIGURE 1-17: WASTE GENERATED ALONG THE HORTICULTURAL VALUE CHAIN**

- **Input Supply**
  - Agri-chemical industries are beneficiating waste materials from polluting industries as fertilisers.
  - These are non-degradable

- **Farming/Production**
  - Wet green waste
  - Tyres
  - Pallets
  - Obsolete equipment
  - Mechanical waste

- **Post-harvest handling**
  - Tyres
  - Plastics
  - Fresh produce waste
  - Paper cardboard
  - Waste effluents
  - Pallets
  - Obsolete equipment
  - Mechanical waste

- **Processing**
  - Tyres
  - Plastics
  - Fresh produce waste
  - Paper cardboard
  - Waste effluents
  - Pallets
  - Obsolete equipment
  - Mechanical waste

- **Retail and Distribution**
  - Food waste
  - Paper cardboard
  - Plastics
  - Waste effluents
  - Pallets

Based on the given diagram, the following aspects can be noted:

- The horticultural sector is relatively waste-intensive as the basket of products is far broader than that of the crop production sub-sector. This is also due to the more delicate logistics (waste from production and harvesting losses) and the fact that horticultural products have a high moisture content.
- The high moisture content of horticultural products accelerates their degradation as they are subject to biological interventions from micro-organisms. Their storage and shelf life requires energy in temperature control, and water in washing and cleaning. It is also their packaging that is waste intensive, as consumers require sophisticated forms of packaging, and a considerable amount of plastics, paper and glass, which represent a high proportion of solid waste after consumption.
- The use of agri-chemical fertilisers and inputs results in significant waste generation, as pollutants remain in the soil, air and water.
- Agro-processing activities also produce specific waste streams for each product.
- There is also generation of fresh fruit waste, which occurs at consumption level.

The following sections provide insight into some of the waste streams created during production of horticultural products and their possible utilisation in generation of energy or energy products.

**CITRUS PEEL, PEEPS AND PULP**

Citrus extractive industries are located around orchard producing areas and, for most of the operators (SMEs), have not addressed adequately challenges associated with peel, peep and pulp waste, which is mostly land filled in municipal sites. Fine separation of various materials, and the fine extraction of bio-chemicals such as flavouring agents, essential oils, animal feed and natural waxes would create income, and the remaining could be disposed through feeding bio-digesters for energy.

**OLIVE PROCESSING WASTE**

Olive peep can be utilised as an effective dense fuel to feed boilers, which can be set up in small units for self-energy consumption and steam production.

**FRUIT SKINS AND PEEPS**

After the juice extraction process, peeps from large fruits such as peaches could be used in small units for self-energy consumption and steam production.
1.5.3 ANIMAL AND ANIMAL PRODUCTS SUB-SECTOR WASTE AND ENERGY CONVERSION POTENTIAL

Figure 1-18 provides a snapshot of the various streams of waste generated across the animal production value chain.

**GRAPE AND WINE MAKING WASTE**

The waste streams in grape and wine-making activities mainly consist of the pulping waste, which finds its way into composting; grape seed extraction (resulting in oil cake for animal feed). One of the waste materials that has not found real application is the disposal of old vines wood, which could be used in the feeding of boilers for energy production or charcoal/biochar.

**VEGETABLE WASTE**

Often, generally recycled towards the production of animal feed, either fresh (piggeries, cattle, sheep, and poultry) or after its palletisation. The agro-processing waste is often land-filled, but an emerging trend is aligned towards the manufacture of Organic Soil Fertility products and their feeding into biodigesters for energy.

The following can be noted with respect to waste generated in the animal and animal products production sub-sector:

- Some waste streams from other sectors and sub-sectors, e.g. field crop production and horticulture can be utilised as animal feed supplements.
- Water effluents are quite common in most animal production activities hence water effluent treatment units are critical. Most water sewages in all animal operations are presenting serious challenges due to the high biological activities, which are difficult to manage.
- Large amounts of equipment and machinery that are used in most animal production activities generate scrap metal and mechanical waste.
- Tyre, bucket and pallet waste is also substantial within the animal production sub-sector and cannot be ignored.
- Waste from dead animals is also quite common. This type of waste poses high biological contamination risks.
- All waste streams have technology solutions for their safe disposal. The industry engages in beneficiation of the waste, but the financial crisis affecting the sector is directly affecting the waste sub-sector as operators are cutting costs on waste handling.
- The poultry sector is affected by competitive imports, mainly as the costs of energy and waste handling in South Africa are prohibitive.
Table 1-9 provides a summary of waste generation and handling aspects in certain animal production activities.

### TABLE 1-9: WASTE GENERATION IN VARIOUS ANIMAL PRODUCTION ACTIVITIES

<table>
<thead>
<tr>
<th>Animal Production Activity</th>
<th>Waste Related Aspects</th>
</tr>
</thead>
</table>
| Cattle meat production     | • Manure is one of the major waste materials generated.  
• Large amounts of free range animals are handled by herders in the communal and peri-urban areas. There is very little data on the waste generated but, the manure seems to be used as organic fertilisers.  
• The collection of manure could be improved by wide spreading of “kraal” sites. |
| Dairy production           | • Dairy production produces a large amount of manure as a result of large herds of animals.  
• High water usage in dairy production as a result of cleaning and washing operations results in enormous water effluents.  
• Large amounts of equipment and machinery generate scrap metal and mechanical waste. |
| Tannery production         | • Tannery is waste- and pollution-intensive.  
• Tannery requires large amount of water and generates vast amount of effluents, which require management at each step on the value chain. |
| Meat slaughtering, abattoir and processing | • Animal carcasses and their waste sub products are well handled and beneficiated in large operations.  
• Smaller operations tend to landfill their waste, or hand them over to beneficiation operators for pet food and other uses.  
• These activities require large amounts of water and generate vast amounts of effluents that require management at each step on the value chain. |
| Meat slaughtering, abattoir and processing | The following four activities can be identified:  
• Breeding  
  o These are small specialised operations where only guano is a waste.  
  o Water effluents treatment units are critical.  
• Hatching  
  o Almost similar to breeding activities but, nonetheless, hatching involves specialised hi-tech operations where equipment and temperature controls are critical. Guano, packaging and animal mortality generate most of the waste involved.  
  o Water effluents treatment units are critical.  
• Egg production  
  o Egg production is a specialised operation that is separate from meat production.  
  o Equipment and temperature controls are critical. Guano and packaging materials generate most of the waste involved.  
  o Low animal mortality.  
  o Water effluents treatment units are critical.  
• Poultry meat production, slaughtering and abattoirs  
  o This operation generates, relatively, the most waste - in particular feathers.  
  o Produces animal mortality, together with carcasses which pose high biological contamination risks.  
  o Produces guano and packaging solid waste.  
  o Water effluents treatment units are critical. |
Animal Production Activity | Waste Related Aspects
--- | ---
Piggeries production, slaughtering, abattoirs and processing | • This is relatively the most waste intensive activity, as pig breeding generates faeces and urine with bio-chemicals and microorganisms that are hazardous as they seep into the soils and reach the aquifers.
• Water effluents are a waste difficult to remediate.
• Slaughtering and abattoir waste is similar to that of other animals.

As indicated above, production of animal and animal products creates various types of waste. The following paragraphs describe the potential for energy conversion by most prominent waste streams in the animal and animal products production activities.

**CATTLE MANURE (NON-INFECTIOUS WASTE)**

Cattle manure is generated at cattle feedlots. Cattle manure is essential to the composition of complete and whole soil fertility products, often referred as composts as they contain critical bio-organisms, which are the main processors in the decomposition of organic matter and provide the organic life necessary to the good digesting functions from plant material. *Cattle manure generated in large quantities can be fed into bio-digesters to produce methane and energy (fuel, gas, electricity, steam).*

**EQUINE MANURE (NON-INFECTIOUS WASTE)**

Equine manure is generated at horse stables. This manure is high in fibre and particularly suitable for Mushroom production.

**POULTRY MANURE AND POULTRY PRODUCTION WASTE (NON-INFECTIOUS WASTE)**

This category of waste includes, for example, hatchery wastes, manure (bird excrement), litter (bedding materials such as sawdust, wood shavings, straw and peanut or rice hulls), and on-farm mortalities. The processing of poultry results in additional waste materials, including offal (feathers, entrails and organs of slaughtered birds), processing wastewater and bio-solids. Most of these by-products can provide organic and inorganic nutrients that are of value if managed and recycled properly, regardless of flock size.

**PIT LATRINES SLUDGE (NON-INFECTIOUS WASTE)**

Sludge is generated from human excrement. Effective and safe waste beneficiation technologies use the sludge produced in both latrines and waterless toilets to extract organic fertilisers which can be used for non-food crops and forestry, but if consolidated in special sites, they can be put into the bio-digester and used for energy.

**ANIMAL CARCASS WASTE (NON-INFECTIOUS WASTE)**

This type of waste is created from dead animals.

**DAIRY PROCESSING WASTE (NON-INFECTIOUS WASTE)**

The dairy waste consists mainly of raw materials lost during handling and processing and cleaning materials carried into the processing water. The composition involves a substantial concentration of fat, milk, protein, lactose, lactic acid, minerals, detergents and sanitisers. The majority of the pollutants are dissolved in either organic or inorganic form. Equipment cleaning along with whey and buttermilk contributes to the majority of the organic load. The unavoidable waste generation process includes rinsing, cleaning, and sanitisation of pipelines and equipment start up, product changeover and shut down of HTST and UHT processes, losses during the filling operations, spill over of lubricants from pipelines, joints, valves and pumps, etc. Dairy waste processing is particular to each operation and mainly can generate, after equalisation, neutralisation, separation and using biological extractive methods from the sludge activation process, either animal feed products or can be fed into bio-digesters for energy.

**WOOL PROCESSING WASTE (NON-INFECTIOUS WASTE)**

The high organic pollutant loadings from a wool mill’s effluent wastewater, and also from a wool mill’s dependency upon vital natural resources such as water and energy, which are often scarce in dry, rural areas where they are often situated, are a challenge. The scouring process involves washing the wool in a number of different “bowls” in open tanks, which contain various cleaning solutions - that together comprise a scouring line. This produces effluents containing grease and organic and mineral matter.
These are heavily contaminated effluents from the washing stages, which does require treatment prior to discharge to sewer. After passing through, the scouring line, the clean wool still contains some organic matter such as seed burrs. The process of waste beneficiation involves extracting grease from sludge tanks, and filtering contaminants. Remaining waste can be a feed for either organic soil fertility composting and degrading or bio-digesters.

**PIGGERY EFFLUENTS AND FAECES (NON-INFECTIOUS WASTE)**

This waste material is quite problematic, especially considering that such waste contaminates soils and aquifers with complex ammonia and nitrates compounds, organic carbon and, sometimes, also some hazardous macro-elements and microelements. Solutions are found in the setting up of bio-digesters, and the transformation of their solids into high nitrogen content materials used in the manufacturing of organic soil fertility products.

**GUTS AND TRIPE (NON-INFECTIOUS ANIMAL WASTE FROM CARCASSES)**

Guts and tripe animal waste are generated at slaughtering houses. They are often sold directly to operators outside the slaughtering houses as food. They could also be used as feed in a bio-digester (for energy production) or maggot factories (for animal feed) which will reduce the impact of increasing electricity costs. However, a farmer wanting to feed gut and tripe waste into a digester opposed to selling it as food would need to consider for what purpose they would intend to use it for in the farm operations. Use of biogas to fuel tractors would not be cost efficient as the biogas would need to be liquefied (Balsam 2006). It therefore, may be more suitable for a farmer to sell the gut and tripe waste. However, if the gut and tripe waste is used in the digester to produce biogas for heat, cooling and electricity purposes the benefits such as savings on electricity bills should be taken into account.

**BONE MEAT AND OTHERS (NON-INFECTIOUS ANIMAL WASTE FROM CARCASSES)**

Bone meat is extracted from the slaughtering and meat cutting process from all animals (except poultry) at the level of abattoirs or butchery where the bones are kept for various uses and beneficiated mainly in the production of resins, desiccants and binding agents (glue).

**FEATHER WASTE (NON-INFECTIOUS ANIMAL WASTE FROM CARCASSES)**

Feathers are the second most important waste from poultry breeding, slaughtering and plucking as hard sulphur bonds present in keratin (the substance present in a feather which gives hard protection to chicken, or for that matter in any other bird, against extreme environmental conditions) is the main source of pollution generated from that waste. The poultry feathers are either dumped, resulting in soil pollution; or burnt, resulting in air pollution. In both cases, the presence of sulphur dioxide in feathers is cause of pollution. Biopolymers (plastics) can be extracted from feather waste. The biggest plus of course, is that unlike most petroleum based thermoplastics, feather-based plastic does not depend on any fossil fuels.

**ANIMAL FAT WASTE (NON-INFECTIOUS ANIMAL WASTE FROM CARCASSES)**

Animal fat waste can be used in combination with sodium hydroxide to create soap through a saponification process.

**TANNERY WASTE (NON-INFECTIOUS ANIMAL WASTE FROM CARCASSES)**

Tanning operational technologies generate large quantities of waste. Processing 1 ton of rawhide yields only approximately 200kg of useful product, the remains are waste. Waste comprises untanned hide waste (fleshing, hide trimmings) tanned hide waste (shavings, cuttings from tanned hides, buffing dust) and residuals from sewage treatment plant. Untanned hide waste can, in certain cases, be used as raw material for the production of glues, gelatine, protein casings, as well as forage and fertilisers. Furthermore, tanned hide waste can be used for the production of the so-called composition leather. There are also technologies of transforming waste into biogas.
1.5.4 SYNTHESIS

Although no statistical information exists that could assist in determining the waste intensity of agricultural sub-sectors, the review of the waste generation practices among crop production, horticultural and animal and animal products production activities suggests the following:

- Crop production is considered to be the least waste-intensive sub-sector by far among the three core agricultural industries.
- Horticulture on the other hand, is considered to be the most waste-intensive sub-sector due to the more delicate logistics involved when compared to crop production, for example, and the fact that horticultural products have high moisture content that accelerates degradation of these products.
- The animals and animal products sub-sector contains both highly waste-intensive activities and low waste-intensive activities. For example, pig and poultry meat production activities produce large volume of animal waste, while egg production is associated with very small volumes of waste.

Agricultural waste comes in different forms; namely liquid, solid or as a slurry. It originates from residue or waste materials generated from agricultural activities. These waste streams from agricultural activities offer opportunities for waste-to-energy practices as summarized below:

- Although animal and animal products are the most energy intensive, there is a substantial opportunity to use animal waste for waste-to-energy practices, commonly waste can be fed into bio-digesters to produce biogas
- Similarities can be see with waste from horticultural activities, they also hold high potential to be fed into the bio- digesters for fuel and electricity as the opportunity to generate energy to be self-consumed through small units and steam production set up from olive peep and fruit peep waste which can be used as fuel to feed boilers
- Most crop production wasted is utilised in farm products
CHAPTER 2
OVERVIEW OF SOUTH AFRICA’S AGRICULTURAL AND AGRICULTURAL WASTE SECTORS

KEY FINDINGS

The agricultural sector in South Africa makes a small contribution to the country’s economy in terms of Gross Domestic Product (GDP), relative to the other industries. Although it accounts only for 1.9% of the country’s value added, it plays a significant role in providing employment, especially in rural areas, as well as foreign exchange earnings (DAFF, 2015). Therefore, retention of agricultural activities in the country and their sustainable growth are integral towards achievement of the country’s socio-economic priorities of alleviating poverty, reducing unemployment, and ensuring food security.

Although agriculture accounts for just about 2% of energy consumption in the country, its reliance on energy inputs is significant. Most of direct energy used in agriculture comes in the form of diesel. Electricity accounts for about a third of energy usage in agriculture; however, its share of the total energy usage in the sector has been steadily increasing over the years. Biomass contributes to 9-14% of total energy supply in South Africa, however the DOE balances do not reflect all individual or private consumption of energy.

Most of energy used in the South African agricultural sector is consumed in traction (67%), i.e. the use of farming machinery and equipment. It is followed by irrigation (~8%), Process heating (~6%), and water heating (~6%). All of these activities offer opportunities for introduction of more energy efficient technologies and use of renewables.

Agricultural activities in the country contribute about 6.1% towards solid waste generation (van der Merwe and Vosloo 1992). Along the food value chain, though, agricultural production accounts for about 26% of food waste created in the country. Horticultural activities generate the most food waste, with vegetable and fruit waste being the common source of food waste. At the same time these waste streams are also associated with high waste-to-energy potential.

The review of contributions of various agricultural products towards South Africa’s GDP, their energy intensity and waste generation intensity suggests that the following sectors could benefit the most and therefore should be prioritised for deployment of SECP practices:

- Priority sectors for energy efficiency and renewable deployment: maize, vegetables, beef, and poultry
- For opportunity to deploy waste-to-energy practices: vegetables, deciduous fruits, citrus fruits, poultry dairy, sugar cane, and pork meat
2.1 SIZE AND DYNAMICS

The agricultural sector’s contribution to South Africa’s Gross Domestic Product (GDP) is relatively small, with primary agriculture contributing an estimated 1.9% towards GDP in 2015 (DAFF, 2015). Nonetheless, the agricultural sector plays a significant role in providing employment, especially in rural areas, as well as foreign exchange earnings (DAFF, 2015). The sector accounted for approximately 6.2% and 4.4% of formal and informal employment in 2015, respectively (Stats SA, 2016). Furthermore, there are also strong backward and forward linkages from the agricultural sector into the economy; hence if the entire value chain of agriculture is taken into account, the sector is estimated to actually contribute about 14% of the GDP (WWF, 2010).

2.1.1 TOP GROSSING AGRICULTURAL INDUSTRIES

Figure 2-1 illustrates the agricultural sub-sectors’ contributions towards the sector’s gross value during the 2014/2015 period.

**FIGURE 2-1: 2014/2015 AGRICULTURAL SECTOR GROSS VALUE CONTRIBUTIONS (DAFF, 2016)**

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Gross Value (R million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal products</td>
<td>109.8 (48.8%)</td>
</tr>
<tr>
<td>Horticultural Products</td>
<td>59.9 (26.6%)</td>
</tr>
<tr>
<td>Field crops</td>
<td>59.9 (26.6%)</td>
</tr>
</tbody>
</table>

**Top 4 contributors**
- Poultry: R37.2 billion (33.9%)
- Beef: R26.8 billion (24.3%)
- Milk: R15 billion (13.7%)
- Eggs: R9.4 billion (8.6%)

**Top 5 contributors**
- Deciduous and other fruit: R16.2 billion (27%)
- Citrus fruit: R12.6 billion (21%)
- Vegetables: R11.5 billion (19.1%)
- Potatoes: R6.6 billion (11%)
- Viticulture: R4.7 billion (7.8%)

**Top 4 contributors**
- Maize: R24.6 billion (44.2%)
- Sugar cane: R7.7 billion (13.9%)
- Wheat: R5.4 billion (9.7%)
- Soya beans: R5.1 billion (9.1%)
- Hay: R4.9 billion (8.9%)

It can be established from the given diagram that the animal production sub-sector contributes to almost half of South Africa’s agricultural sector’s total gross value. The horticultural sub-sector is in the second position with a contribution of around 26.6%, and lastly, the field crops have a contribution of slightly under 25%.
Table 2-1 provides a ranking of the top ten individual agricultural products based on their contribution to 2014/2015 total agricultural sector gross value, estimated at around R110 billion. Similar to the trend observed above, five of the top-ten products are from the animal production sub-sector, three are from the horticultural sub-sector, and only two are field crops.

### TABLE 2-1: TOP 10 SOUTH AFRICAN AGRICULTURAL PRODUCTS BY PRODUCTION VALUE

<table>
<thead>
<tr>
<th>Position</th>
<th>Agricultural Product</th>
<th>Sub-sector</th>
<th>Contribution towards total gross value Value (R billion)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Poultry</td>
<td>Animal production</td>
<td>37.2</td>
<td>16.5</td>
</tr>
<tr>
<td>2</td>
<td>Beef</td>
<td>Animal production</td>
<td>26.8</td>
<td>11.9</td>
</tr>
<tr>
<td>3</td>
<td>Maize</td>
<td>Crop production</td>
<td>24.6</td>
<td>10.9</td>
</tr>
<tr>
<td>4</td>
<td>Deciduous and other fruit</td>
<td>Horticulture</td>
<td>16.2</td>
<td>7.2</td>
</tr>
<tr>
<td>5</td>
<td>Milk</td>
<td>Animal production</td>
<td>15</td>
<td>6.7</td>
</tr>
<tr>
<td>6</td>
<td>Citrus fruit</td>
<td>Horticulture</td>
<td>12.6</td>
<td>5.6</td>
</tr>
<tr>
<td>7</td>
<td>Vegetables</td>
<td>Horticulture</td>
<td>11.5</td>
<td>5.1</td>
</tr>
<tr>
<td>8</td>
<td>Eggs</td>
<td>Animal production</td>
<td>9.4</td>
<td>4.2</td>
</tr>
<tr>
<td>9</td>
<td>Sugar cane</td>
<td>Crop production</td>
<td>7.7</td>
<td>3.4</td>
</tr>
<tr>
<td>10</td>
<td>Sheep and goat meat</td>
<td>Animal production</td>
<td>6.6</td>
<td>2.9</td>
</tr>
</tbody>
</table>

(DAFF, 2016)

2.1.2 LAND SURFACE AREA UTILISED

With respect to land surface area, livestock farming is by far the largest agricultural sub-sector, with approximately 80% of agricultural land in South Africa believed to be suitable mainly for extensive livestock farming (DAFF, 2016b). The area utilised for cattle, sheep, and goat farming in South Africa comprises of approximately 590 000 km², which is almost 53% of all agricultural land in the country (DAFF, 2016b). In contrast, only 12% of South Africa’s surface area is believed to be suitable for crop production, mainly due to the challenge related to the availability of water (KPMG, 2012). High-potential arable land comprises of only 22% of total arable land. As of December 2012, 1.2 million km² is the land area of South Africa in which 1.5% of the land is under irrigation (SOUTH AFRICAN YEARBOOK 2008/9).

Within the crop production sub-sector, Table 2-2 outlines the estimated land area utilised for the farming of various field crops during the 2014/15 period. The largest area of farmland in South Africa during the 2014/15 season was dominated by maize production activities, followed by soya beans, sunflower, wheat, sugar cane, wattle bark, canola, barley, sorghum, dry beans, ground nuts, and, to a lesser extent, cotton and tobacco.

### TABLE 2-2: CONCENTRATION OF FIELD CROPS IN SOUTH AFRICA (2014/2015)

<table>
<thead>
<tr>
<th>Field Crop</th>
<th>Area planted (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>3 048 000</td>
</tr>
<tr>
<td>Soya beans</td>
<td>687 000</td>
</tr>
<tr>
<td>Sunflower</td>
<td>576 000</td>
</tr>
<tr>
<td>Wheat</td>
<td>477 000</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>382 000</td>
</tr>
<tr>
<td>Wattle bark</td>
<td>142 000</td>
</tr>
<tr>
<td>Canola</td>
<td>95 000</td>
</tr>
<tr>
<td>Barley</td>
<td>85 000</td>
</tr>
<tr>
<td>Sorghum</td>
<td>70 000</td>
</tr>
<tr>
<td>Dry beans</td>
<td>64 000</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>58 000</td>
</tr>
<tr>
<td>Cotton</td>
<td>15 000</td>
</tr>
<tr>
<td>Tobacco</td>
<td>4 900</td>
</tr>
</tbody>
</table>

(DAFF, 2016)
2.1.3 EMPLOYMENT IN AGRICULTURAL SUB-SECTORS

Formal employment in rural areas constituted to an estimated 55% of all employment within the agricultural sector in 2012 (Liebenberg & Kirsten, 2013). In terms of sub-sectoral employment, the following facts can be highlighted with regard to some of the agricultural sub-sectors in South Africa:

CROP PRODUCTION:

- In the 2009/10 production year, an estimated 8000 farm workers were employed in cotton production activities (DAFF, 2012e).
- The primary tobacco industry in South Africa employs about 8000 agricultural farm workers, while an approximated 40 000 people are dependent on the tobacco industry, mostly in the rural areas of South Africa (DAFF, 2012f).
- Wheat farmers provide work opportunities to about 28 000 people, while the wheat milling industry employ around 3 800 people (DAFF, 2012g).

HORTICULTURE:

- The citrus industry is quite labour intensive. In 2012, an estimated 100 000 people were employed in this industry, with large numbers of workers in the orchards and packing houses (DAFF, 2012c). Furthermore, an unspecified number of people are employed throughout the supply chain services such as transport, port handing, and allied services. It is further estimated that more than a million households in South Africa depend on the citrus industry for their livelihood (DAFF, 2012c).
- With respect to tomato production activities, as of 2012, the industry employed approximately 22 500 people with at least 135 000 dependants (DAFF, 2012d). Multipliers in the supply chains are the transport of the tomatoes to the fresh produce markets and processing plants, processing factories, fresh produce markets, independent traders, supermarket groups, packaging factories, informal traders, and fast food outlets (DAFF, 2012d).

ANIMAL PRODUCTION

- The beef industry is a major employer. Around 500 000 people were employed in this industry in 2012, while an estimated 2.1 million depended on the livestock industry for their livelihood (DAFF, 2012a).
- Within the poultry industry, broiler hatchery and rearing activities employed an estimated 7 035 farm staff and 562 farm managers in 2012. Processing and related feed industries employed around 18700 and 1000 people, respectively (DAFF, 2012b).

2.2 ENERGY USAGE IN AGRICULTURE

2.2.1 SECTORAL ENERGY USAGE IN SOUTH AFRICA

The consumption of energy within the South African agricultural sector is relatively low compared to that of other economic sectors. As can be established from Figure 2-2, an estimated total of 2 657PJ of energy was consumed in South Africa in 2012 (DoE 2012). Around 60 565 TJ of that energy was consumed within the agricultural sector, which is only 2% of the total energy consumed in South Africa in 2012; thereby making the agricultural sector the least direct energy consuming sector in the country. Other metrics can be used to reflect energy consumption such as ZAR/MJ. The majority of energy consumed in South Africa was utilised to support various activities in the industry and mining (35%), transport (29%), and building sectors (32%).

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Even when the energy profile is disaggregated into separate energy sources, the agricultural sector’s share of energy consumption in each of the different energy sources still remains low, relative to that of other sectors. Figure 2-3 illustrates South African sectors’ consumption of electricity, petroleum, and coal energy sources.
The following can be noted from the above:

- The agricultural sector is one of the least electricity consuming sectors in South Africa. The sector accounts for three percent of the total electricity consumed in South Africa in 2012. The majority of electricity in South Africa is used within the industry and mining, and building sectors.

- With respect to the consumption of energy generated from petroleum products, the agricultural sector only accounts for four percent of total energy consumed from petroleum products in South Africa in 2012. The majority of energy generated from petroleum products is used within the transport sector.

- The South African agricultural sector’s usage of coal for energy purposes is relatively insignificant. Out of the five sectors listed in the given diagram, the agricultural sector was the smallest sector in South Africa in terms of utilising coal for energy generation in 2012, with under one percent share.

While the agricultural sector’s direct energy consumption might seem relatively low and insignificant, consideration of indirect energy related to agriculture could result in a depiction of a completely different overall energy consumption profile.

Importantly, energy usage in agriculture cannot be ignored (Eskom, n.d.), as farming and the agricultural community is a huge contributor to South Africa’s food security. There are vast opportunities for the implementation of energy efficiency practices and renewable energy alternatives, opportunities to reduce the negative impact of climate change on the agriculture sector and minimising the vulnerability to energy price hikes.

### 2.2.2 TRENDS IN ENERGY USAGE WITHIN THE SOUTH AFRICAN AGRICULTURAL SECTOR

Data presented in the Department of Energy’s various energy balance statistics show that petroleum products, electricity, and coal are the three main energy sources utilised in the South African agricultural sector. The use of renewable energy, e.g. photovoltaics and windmills for pumping water, is quite notable within the South African agricultural sector especially in rural areas. Between 9% and 14% of energy supply in South Africa is generated from biomass (DoE 2012). In agriculture, biomass to fuel is common as food crops can be used to produced bioethanol and biodiesel, that in which can be combined with petroleum and diesel to fuel engines (Department of Environmental Affairs and Tourism 2008).

In terms of energy usage trends, Figure 2.4 illustrates the patterns of energy usage in the South African agricultural sector during the years 1992, 2002, and 2012. It can be established that the volume of total energy consumed within the South African agricultural sector has been declining between the years 1992 and 2012. An estimated energy total of 78 PJ was consumed within the South African agricultural sector in 1992, and declined to 73 PJ in 2002. Energy consumption within the agricultural sector further declined from 73 PJ recorded in 2002, to around 61 PJ in 2012.
Other key aspects to note with respect to energy usage within the South African agricultural sector include the following:

- The share of direct energy used within the agricultural sector, generated from coal and petroleum products has been declining over the past years while the share of electricity has been increasing.
- The majority of energy consumed within the agricultural sector is derived from petroleum-based products, followed by electricity and lastly coal. In 2012, around 66% of all energy consumed within the agricultural sector was from petroleum products, 34% was from electricity, while the share of energy from coal was around 0.4%.
- Figure 2-5 gives an overview of the major petroleum products used in the South African agricultural sector in 2012. It can be established that diesel fuel (gas diesel) is the major petroleum product used in the South African agricultural sector, accounting for an estimated 90% of all agricultural direct energy generated from petroleum products. Other petroleum products that are also utilised, but to a lesser extent, are kerosene (7%), petrol/motor gasoline (2%), and residual fuel (1%). Diesel and other petroleum products are used in several mechanical farm equipment such as tractors, water pumps, tillers, generators, farm vehicles, etc.

According to Department of Environmental Affairs and Tourism (2008), agricultural waste components such as cellulose, hemicellulose, starch and lignin found in biomass can be converted into fuel for heating, electricity generation and transportation, thus reducing the direct energy usage of petroleum products in South African agriculture.

**FIGURE 2-5: PETROLEUM PRODUCTS USED IN THE SOUTH AFRICAN AGRICULTURAL SECTOR (DOE 2012)**

Energy within the South African agricultural sector is used in tractors, pumped irrigation, harvesters, transport, heating, drying, refrigeration, and processing of crops (DOE n.d). Figure 2-6 provides a detailed overview of the South African agricultural sector’s general energy usage profiles based on an analysis done by the DoE. It can be established that the majority of energy within the sector goes towards traction (~67%) followed by irrigation (~8%). With regard to electricity usage in the sector, the largest share is used for irrigation (~28%) followed by water heating activities (~22%) (DOE, 2012).

**FIGURE 2-6: ENERGY USES IN SOUTH AFRICAN AGRICULTURAL SECTOR (DOE, 2012)**
Irrigation and water heating activities need to be assessed to improve energy efficiency in these areas. Managing of water applications, maintenance, design and installation are the areas where energy efficient improvements can be made (Eskom 2016). The following suggestions are made from (Eskom 2016):

- The irrigation systems should be designed in accordance to the operational needs. E.g. pressure of the system should be adequate and not release pressure that is too high or too low, pipes and pumps should be correctly sized and matched and blends and elbows should be limited.
- Maintenance of motors, pumps and pipes through servicing, fixing and replacing parts will ensure they are working efficiently thus using less energy.
- Irrigation scheduling to reduce energy consumption can reduce energy usage by 7-30% as it will apply the right amount of water at the right time for the needs of the farm.

### 2.3 WASTE PRODUCTION BY SOUTH AFRICA’S AGRICULTURE

#### 2.3.1 SOUTH AFRICA’S WASTE VOLUMES AND COMPOSITION

The local South African waste economy is estimated at R15.3 billion (~0.51% of South Africa’s 2012 GDP) (Godfrey 2015). It employs an approximated 30 000 people, the majority (~67%) of whom are in the public sector (local government) (Godfrey 2015).

An estimated 108 million tonnes of waste were generated in South Africa in 2011, which constituted of general waste (59 million tonnes), unclassified waste (48 million tonnes), and hazardous waste (1 million tonnes) (Urban Earth 2013). Slightly under 91% of all that total waste generated in South Africa in 2011 was landfilled.

**GENERAL WASTE**

Figure 2-7 shows the sources of the 59 million tonnes of general waste generated in South Africa in 2011. The highest general waste source in South Africa was the “other waste” category (61%), which primarily consists of biomass waste from industry. It was followed by non-recyclable municipal waste (14%), construction and demolition waste (8%), metals (5%), organic waste (5%), paper (3%), plastic (2%), glass (2%), and tyres (slightly under 1%). Highest rates of recycling were achieved for metals (80%), followed by paper (57%), organic waste (35%), and glass (32%).

**FIGURE 2-7: SOURCES OF GENERAL WASTE IN SOUTH AFRICA (URBAN EARTH 2013)**

The majority of biomass waste from the agriculture sector falls under the organic waste category, which refers to garden and food waste. Other waste streams from the agriculture sector, as discussed in earlier sections, also feed into the different sources of waste mentioned in the given diagram.
HAZARDOUS WASTE

With respect to hazardous waste, out of the 1.3 million tonnes of waste generated in South Africa in 2011, the majority of that waste came from miscellaneous sources (24.8%), followed by inorganic waste (22%), Tarry and Bituminous waste (19.3%), other organic waste without halogen or sulphur (15.3%), waste oils (9.1%), health care risk waste (3.5%), asbestos containing waste (2.5%), and batteries (2.5%) (Urban Earth 2013). Other sources of hazardous waste (such as organic solvents without halogens and sulphur, organic halogenated waste and solvents, Persistent Organic Pollutants (POP) waste, mercury containing waste, and gaseous waste) had contributions under one percent each. The highest recycling levels were achieved for batteries (96%) and waste oils (44%) (Urban Earth 2013).

UNCLASSIFIED WASTE

Coal fired power stations are major contributors of unclassified waste in South Africa through fly ash and bottom ash waste materials. Out of the 48 million tonnes of unclassified waste generated in South Africa in 2011, the majority was from fly ash and dust from miscellaneous filter sources (65.8%), followed by bottom ash (12%), slag (11.2%), brine (8.7%), sewage sludge (1.4%), mineral waste (0.8%), and waste of electric and electronic equipment (0.1%).

SOLID WASTE

Overall, Figure 2-8 provides a breakdown of aggregated solid waste in South Africa based on a study conducted by Van der Merwe and Vosloo in 1992. It is likely that the breakdown has somehow, slightly changed, especially considering the period in which the study was conducted as well as increased or reduced solid waste generation from the identified sources. Based on the given diagram, it is clear that the agriculture sector contributes a relatively small but significant share of solid waste in South Africa. The biggest contributor to the solid waste stream is mining waste (72.3%), followed by pulverised fuel ash (6.7%), agricultural waste (6.1%), urban waste (4.5%), and sewage sludge (3.6%) (Swiss Business Hub South Africa 2011).

FIGURE 2-8: BREAKDOWN OF SOLID WASTE IN SOUTH AFRICA (VAN DER MERWE AND VOSLOO 1992)

From the above, it can be concluded that an approximated 26% of food is lost as waste during agricultural production, followed by other significant loses in activities such as post-harvest handling and storage (24%), processing and packaging (25%), and distribution (20%). Around 5% of food waste in South Africa is generated at consumption level, i.e. when the food reaches the consumers. Overall, it is quite clear that agricultural-specific waste (i.e. agricultural production and post-harvest handling and storage) accounts for almost half of all food waste in South Africa (~4.5 million tonnes p.a.).
Figure 2-10 shows the relative contribution of individual agricultural commodity groups towards total food waste generated in South Africa. The majority of food waste in South Africa is generated from fruits and vegetables (44%), followed by cereals (26%), roots and tubers (9%), milk (8%), meat (7%), oil seeds and pulses (4%), and fish (2%). Overall, it can be established that horticultural and field crops account for the most food waste generated in South Africa. Relatively small margins of food waste are generated from the animal production sub-sector.

**FIGURE 2-10: CONTRIBUTION OF INDIVIDUAL COMMODITY GROUPS TO TOTAL FOOD WASTE IN SOUTH AFRICA (OELOFSE 2013)**

<table>
<thead>
<tr>
<th>Commodity Group</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits and Vegetables</td>
<td>44.0%</td>
</tr>
<tr>
<td>Cereals</td>
<td>26.0%</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>9.0%</td>
</tr>
<tr>
<td>Milk</td>
<td>8.0%</td>
</tr>
<tr>
<td>Fish</td>
<td>2.0%</td>
</tr>
<tr>
<td>Oil seeds and pulses</td>
<td>4.0%</td>
</tr>
<tr>
<td>Other</td>
<td>30.0%</td>
</tr>
</tbody>
</table>

It is therefore, clear that a lot of food is lost as waste in South Africa, and there is definitely need for increased interventions in order to address this challenge, which has a strong bearing on the country’s overall food security.

### 2.3.3 KEY FINDINGS

- Horticultural and crop waste are the mass of food waste. Fruits and vegetable waste are the bulk of the food waste generated within the agricultural sector.
- “Other waste” makes up general waste, the largest type of waste in South African. Other waste is made up of biomass waste, indicating that opportunities for waste-to-energy opportunities are high.

### 2.4 PRIORITY SUB-SECTORS FOR FURTHER ANALYSIS

Table 2-3 summarises the categorisation of various agricultural products in terms of energy intensity, contribution to South Africa’s agricultural sector, and waste generation. In order to determine priority sectors from the perspective of sustainable energy and waste-to-energy opportunities, the following approach was followed:

- Each of the three aspects (i.e. energy intensity, contributions to agriculture, and waste intensity) was rated on a scale of low, medium and high based on the qualitative and quantitative data presented earlier in the report.
- Activities that scored high in terms of contributions towards agricultural production and at the same time are associated with medium- to high- energy intensity were selected as priorities for advocating deployment of energy efficient and renewable energy technologies.
- Activities that have medium to high contribution towards agricultural production and at the same time are associated with medium- to high- waste generation intensity were selected as priorities for advocating deployment of waste-to-energy technologies.
### TABLE 2-3: CATEGORISATION OF AGRICULTURAL PRODUCTS IN TERMS OF ENERGY INTENSITY, GDP CONTRIBUTION AND WASTE GENERATION

<table>
<thead>
<tr>
<th>Agricultural product</th>
<th>Categorisation</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy intensity</td>
<td>SA's share in agricultural GDP</td>
</tr>
<tr>
<td>Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other cereals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower seed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticultural products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples, pears and peaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olive for oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table wine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal and animal products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pork meat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
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</tr>
</tbody>
</table>

Based on the categorisation of selected agricultural activities indicated in Table, Error! Reference source not found. The following sectors are suggested to be prioritised when advocating for deployment of renewables, energy efficient technologies, and waste-to-energy technologies:

- For opportunities to improve energy efficiency of agricultural sectors:
  - maize
  - vegetables
  - beef
  - poultry

- For opportunities to deploy waste-to-energy practices:
  - vegetables
  - deciduous fruits (apples, peaches, etc.)
  - citrus fruits
  - poultry
  - milk
  - sugar cane
  - pork meat

The recommendations above are only suggestions as to which agricultural products are advised to start with. This is based on their energy and waste intensity and the opportunities for SECP implementation; however, it is important to note that SECP implementation should not be limited to the above recommended products.
CHAPTER 3
POLICY REVIEW

KEY FINDINGS

South Africa’s promotion of key socio-economic priorities such as sustainable development, job creation, mitigation and adaptation to climate change, and promotion of food security is articulated in numerous national policies and strategic documents. From the SECP perspective, the following can be highlighted:

- National policies acknowledge renewable energy and energy efficiency as key drivers for sustainability within the economy.
- In terms of compliance, policies do raise awareness in regard to renewable energy and energy efficiency; however, they fall short on enforcement. There are many goals set and the emphasis on the need for interventions; however, these are long-term plans that fall short of implementation of short- to medium-term solutions such as assistance in implementation or incentivised mechanisms serving as transitioning tools.
- From a restriction perspective, it is cautioned that biomass should not conflict with food security.
- Regulatory policies promote the use of biofuels and encourage waste-to-energy practices.
- The following policy-related opportunities are created or envisaged to be created within the agriculture sector for deployment of SECP practices and principles:
  - Investments in energy efficiency, and renewable and cleaner energy technologies.
  - The production of bioenergy crops such as sugar cane, sugar beet, soya bean, canola, and sunflower.
  - Adoption of sustainable farming practices.

The majority of the reviewed waste-related policies and regulations aim to promote the waste management hierarchy in South Africa. The promotion of waste-to-energy initiatives is also explicitly stipulated in the reviewed policies. In particular, the National Policy on Thermal Treatment of General and Hazardous Waste specifically discusses the recovery of energy through waste management, which supports the promotion of waste-to-energy in SECP. The implementation of waste-to-energy initiatives though, is constrained by the stringent requirements for licence application, which limits a wide deployment of these practices in agriculture.

It can be argued that the lack of up-to-date information on energy usage and waste streams within agriculture in South Africa is a contributing factor resulting in the gap between existing policies and the implementation of these policies in the form of support mechanisms. If information were available, it would push for the enforcement of existing policies to be implemented and ensure compliance.
3.1 AGRICULTURAL SECTOR POLICY FRAMEWORK ANALYSIS

The following is the list of policies, strategies, plans, legislation, and regulations reviewed in the study. Policies and strategic documents:

- The National Development Plan 2030 (NDP 2012)
- Integrated Growth and Development Plan (IGDP 2012)
- Green Paper on Land Reform (2011)
- The Agriculture Policy Action Plan (APAP 2014)
- Strategic Plan for the Department of Agriculture, Forestry and Fisheries 2013/14 to 2017/18 (2013)
- Policy on Agriculture in Sustainable Development
- National Policy on Organic Production
- National Strategy on Agroecology
- White Paper on Agriculture 1995
- South African Agricultural Production Strategy 2011-2025
- Industrial Policy Action Plan
- National Climate Change Response White Paper (2011)
- Local Procurement Accord (2011)

Legislation and regulations:

- The Conservation of Agricultural Resources Act 43 of 1983
- Regulations Regarding the Mandatory Blending of Biofuels with Petrol and Diesel (2012)
- Regulations Regarding Petroleum Products Manufacturing Licences under the Petroleum Products Act 120 of 1977
- Electricity Regulation Act (Act No. 40 of 2006)
- Regulatory Rules on Network Charges for the third party transportation of energy 2012
- Consumer Protection Act 2010-2014
3.1.1 POLICY IMPLICATIONS ON SECP

THE NATIONAL DEVELOPMENT PLAN (NDP) 2030

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The NDP was formulated by the National Planning Commission, which consisted of 26 people appointed by President Jacob Zuma to advise on issues influencing long-term development. It is a broad and overarching long-term perspective policy plan, primarily, aimed at eliminating poverty and reducing inequality in South Africa by 2030.</td>
</tr>
</tbody>
</table>
| Implication on SECP | The following aspects highlighted in the NDP have implications on SECP practices in agriculture:  
• The NDP calls for increased electrification, i.e. more than 90% of the population should have access to grid or off-grid electricity by 2030. Such a commitment is beneficial for non-electrified rural farmers who could capitalise on this government vision and invest more in off-grid renewable energy technologies should there be any form of government support offered.  
• The NDP envisages an energy system where coal will contribute proportionately less to primary energy needs, while gas and renewable energy resources will play a significant role.  
• The NDP acknowledges that investments in waste-to-energy projects, among other things, can aid South Africa to becoming a zero-waste society. As a result, rural and peri-urban farmers could also try and capitalise on this government vision by initiating waste-energy-projects to support some of the farming activities.  
• The NDP acknowledges that public investment in new agricultural technologies and the development of resilient and environmentally sustainable strategies and support services for small-scale and rural farmers ensures the protection of rural livelihoods and the concurrent expansion of commercial agriculture. The implications could be around the need for farmers not only to adopt renewable energy technologies but also to consider adopting energy-conservative sustainable farming practices, where increased government support is envisaged.  
• Reduced utilisation of nitrogen fertilisers, and increased promotion of organic farming methods is explicitly highlighted in the NDP.  
• The NDP recommends for the expansion of irrigated agriculture, i.e. the 1.5 million hectares of land under irrigation could be expanded by at least 500 000 hectares. This implies more energy needs towards irrigation activities; hence the possible need for energy efficient irrigation equipment. |
NEW GROWTH PATH: ACCORD 4 (GREEN ECONOMY ACCORD)

Year 2011

Brief description The Green Economy Accord is one of the four accords signed as an outcome of social dialogue on the New Growth Path. It is an agreement between the government, businesses and organised labour, committing each to tangible targets in achieving a low-carbon based economy, inclusive of creating at least 300 000 jobs by 2020 in the green economy.

Implication on SECP The following aspects from the Accord have implications on SECP practices in agriculture:

- The commitment towards promoting energy efficiency across the economy, which came out of the Accord, relates to SECP practices in agriculture in that rural and peri-urban farmers would also be expected to invest in energy efficiency technologies.
- The government and business sector is committed to promoting bio-fuels. Under this commitment, government would provide a supportive regulatory environment to facilitate the development of a bio-fuels industry, while business supports smallholder farming schemes, communal land and co-operatives in the supply of feedstock. As a result, the implications on SECP are mainly around incentivising rural and peri-urban farmers to engage in the production of crops that can be utilised as inputs for bio-fuels. Also, bio-fuels can be utilised as a clean energy in relevant farming production activities especially considering the intensive use of diesel in South African agriculture.

NATIONAL CLIMATE CHANGE RESPONSE WHITE PAPER

Year 2011

Brief description The National Climate Change Response White Paper was developed by the Department of Environmental Affairs (DEA). It presents the government’s vision for an effective climate change response and the long-term transition to a climate-resilient and lower-carbon economy and society. The National Climate Change Response White Paper highlights a suite of sectors that need to consider climate change impacts in their planning, namely water, agriculture and commercial forestry, health, biodiversity and ecosystems, and human settlements (urban, coastal and rural).

Implication on SECP Aspects from the White Paper with implications on SECP practices in agriculture include the following:

- The White Paper recognises and acknowledges that conventional, commercial input-intensive agriculture has a range of negative environmental, social and economic externalities, which increasingly render it an unsustainable model.
- The White Paper identifies energy efficiency and demand-side management, coupled with increased investments in renewable energy as some of the most important short-term climate change mitigation measures to be followed in South Africa. The use of bio-fuels is also included as another useful mitigation measure.
- Adoption of farming-specific climate change adaptation measures, such as conservation agriculture is mentioned in the White Paper as one of the key interventions in response to challenges affecting rural human settlements.
### NATIONAL STRATEGY FOR SUSTAINABLE DEVELOPMENT AND ACTION PLAN (NSSD 1) 2011-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The NSSD 1 builds on the 2008 National Framework for Sustainable Development (NFSD) and several other initiatives launched by the business sector, government, NGOs, civil society, academia and other key role players to address issues of sustainability in South Africa. The NSSD sets out key areas that require attention in order to ensure a shift towards a more sustainable path in South Africa.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>Discussions on the need for renewable energy feed-in tariffs (REFIT) as a mechanism to promote the deployment of renewable energy, are some of the SECP-related aspects addressed in the NSSD 1. The use of REFIT is likely to incentivise rural and peri-urban farmers to invest in renewable energy projects.</td>
</tr>
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</table>

### WHITE PAPER ON AGRICULTURE

<table>
<thead>
<tr>
<th>Year</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The White Paper on Agriculture was developed by the Department of Agriculture [Forestry and Fisheries] in order to ensure equitable access to agriculture and promote the contribution of agriculture to the development of South African communities and economy at large.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>One of the agricultural goals highlighted in the White Paper is that, agricultural production should be based on the sustainable use of the natural agricultural and water resources.</td>
</tr>
</tbody>
</table>

### THE AGRICULTURE POLICY ACTION PLAN (APAP)

<table>
<thead>
<tr>
<th>Year</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The APAP was formulated by the Department of Agriculture, Forestry and Fisheries as a programmatic response to key policy documents such as the NDP, NGP, and Medium Term Strategic Framework.</td>
</tr>
</tbody>
</table>
| Implication on SECP | The APAP recognises changes in energy and fuel prices as one of the main challenges facing agricultural sub-sectors such as poultry, and fruit and vegetables. The APAP calls for urgent attention in order to make agricultural production more energy efficient.  
- The adoption of conservation agriculture is, even, recommended for some sub-sectors e.g. wheat production.  
- The promotion of Climate Smart Agriculture (CSA), through provision of incentives targeted at small holder farmers, is also strongly recommended. |
POLICY ON AGRICULTURE IN SUSTAINABLE DEVELOPMENT

**Status**
A discussion document (8th Draft)

**Brief description**
The Policy on Agriculture in Sustainable Development is being developed by the Department of Agriculture [Forestry and Fisheries] as a response to the commitments made by world leaders at the WSSD, held in Johannesburg in 2002. The policy forms part of the process of incorporating principles and objectives of sustainable development into the ethos of the agricultural sector in South Africa.

**Implication on SECP**
The Policy identifies and recommends the following strategies for policy development related to sustainable energy management in agriculture:

- Promoting sustainable use of biomass and other renewable sources of energy.
- Decreasing the depletion of non-renewable energy resources, e.g. oil, gas, and coal, and promoting methods extending their ‘life’ through recycling, using less or switching to renewable substitutes.
- Developing and implementing programmes that combine, more efficiently, and as appropriate, the use of traditional, renewable energy resources, and cleaner fossil fuel technologies, which could meet the growing need for energy services in the longer term to achieve sustainable development.
- Developing programmes aimed at promoting the production of crops needed for manufacturing of biofuels.

NATIONAL POLICY ON FOOD AND NUTRITION SECURITY

**Year**
2013

**Brief description**
The National Policy on Food and Nutrition Security was developed by the Department of Social Development and the Department of Agriculture, Forestry and Fisheries. The policy is primarily aimed at ensuring the availability, accessibility and affordability of safe and nutritious food at national and household levels.

**Implication on SECP**
The National Policy on Food and Nutrition Security recognises the rising input costs, especially electricity and fuel, as one of the challenges facing South Africa in attaining national food security.

THE INTEGRATED FOOD SECURITY STRATEGY FOR SOUTH AFRICA

**Year**
2002

**Brief description**
The Integrated Food Security Strategy for South Africa was formulated by the Department of Agriculture [Forestry and Fisheries] with a goal to eradicate hunger, malnutrition and food insecurity in South Africa over 2015.

**Implication on SECP**
Investing in productivity enhancing and environmentally sustainable agriculture and agro-processing sector technologies targeted at small-scale producers, is identified in this Strategy as one of the possible policy interventions for consideration with regard to improving household food production, trade and distribution.
NATIONAL STRATEGY ON AGROECOLOGY

**Status**

**Discussion document (4th Draft)**

**Brief description**
The National Strategy on Agroecology is being formulated by the Department of Agriculture, Forestry and Fisheries. The strategy is aimed at achieving and creating an ecologically, socially and economically sustainable South African agro-ecology sector that is globally competitive and contributes towards poverty alleviation, job creation, food security, economic development and climate change mitigation and adaptation.

**Implication on SECP**
The Strategy notes that agroecology practices minimise energy consumption by 30%-70% per unit of land by eliminating the energy required to manufacture synthetic fertilisers, fossil-based fuels and by using internal farm inputs; thus reducing fuel used for transportation. The Strategy promotes the adoption of agroecology practices in South Africa through the establishment of special incentive schemes for farmers practicing agro-ecology, e.g. setting up a special fund dedicated to the agro-ecology sector.

NATIONAL POLICY ON ORGANIC PRODUCTION

**Status**

**Discussion document (10th Draft)**

**Brief description**
The National Policy on Organic Production is being developed by the Department of Agriculture, Forestry and Fisheries. The Policy is primarily aimed at creating a broad framework for the development of a prosperous South African organic sector that is globally competitive and capable of supporting government's commitments towards poverty alleviation, job creation, rural development, food security, improved health and sustainable economic development.

**Implication on SECP**
The Policy notes that organic production minimises energy consumption by 30%-70% per unit of land by eliminating the energy required to manufacture synthetic fertilisers, fossil based fuels and by using internal farm inputs, thus reducing fuel used for transportation. The Policy envisages to utilise both pull and push strategies to promote organic production. Special incentive schemes, such as public sector procurement and the use of a common national logo for organic products, are currently being proposed.

BIOFUELS INDUSTRIAL STRATEGY OF THE REPUBLIC OF SOUTH AFRICA

**Year**

2007

**Brief description**
The Biofuels Industrial Strategy presents the South African government’s approach to biofuels and the creation of such an industry. The strategy was formulated with a primary objective of creating jobs in the energy-crop and biofuels value chain, and bridging between the first and second economy. It is about rural development and the provision of opportunities to the rural poor by creating a market for their produce that would otherwise not exist.

The Strategy initially aims for the bio-fuels to achieve a market penetration of 2% of road liquid transport fuels. The Strategy further recommends that the following blending levels be achieved: for Biodiesel B2 or 2% blending requirement and for Bioethanol E8 or 8% blending requirement.

**Implication on SECP**

According to the Strategy, sugar cane and sugar beet will be used for the production of bio-ethanol, while soya bean, canola and sunflower will be used for the production of bio-diesel. The use of maize for the production of bioethanol was excluded due to food security concerns. As a result, the implications on SECP practices in agriculture are that the Strategy incentivises rural and peri-urban farmers to produce more of energy crops such as sugar cane, sugar beet, soya bean, canola, and sunflower. It could also result in the increased use of clean energy, through bio-fuels, in agricultural production activities that are mainly dependent on diesel fuel.
SUSTAINABLE ENERGY CONSUMPTION AND PRODUCTION (SECP) IN AGRICULTURE

WHITE PAPER ON ENERGY POLICY

<table>
<thead>
<tr>
<th>Status</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The White Paper on Energy Policy was developed by the Department of Energy (DOE) in order to clarify the government's position regarding the supply and consumption of energy in South Africa.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>The White Paper acknowledges that many agricultural products, by-products, and residues can serve as raw materials for processing into modern bio-fuels, suitable for the operation of fuel-driven technologies at high efficiencies and for combined heat and electric power generation. According to the White Paper, such biofuels include briquettes, charcoal, biogas, producer gas, ethanol and bio-diesel fuel. Furthermore, residues from processing some of these bio-fuels include fertilisers and soil conditioners, which are key inputs in agriculture as well. Other SECP related aspects from the White Paper include:</td>
</tr>
<tr>
<td></td>
<td>• The government's commitment to facilitate the sustainable production and management of solar power and non-grid electrification systems, such as the further development of home solar systems (SHS), solar cookers, solar pump water supply systems, solar systems for schools and clinics, solar heating systems for homes, hybrid electrification systems, wind power; largely targeted at rural communities.</td>
</tr>
<tr>
<td></td>
<td>• Energy efficiency is identified as the main demand-side issue in the agriculture sector. The White Paper recognises that mechanisation, fertilisers, and pesticides are energy-intensive technologies. As a result, these, need to be balanced with environmental protection, especially through the utilisation of energy efficient, productive, profitable, and environmentally responsible farming systems.</td>
</tr>
</tbody>
</table>

WHITE PAPER ON RENEWABLE ENERGY

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The White Paper on Renewable Energy was developed by the DOE as a supplement to the government's commitment to support the development and implementation of renewable energy projects made in the White Paper on Energy Policy (1998). The White Paper sets a 10 000GWh target for renewable energy contribution towards the final energy consumption in the country by 2013.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>The White Paper cautions that biomass production for energy should not compete and/or conflict with food production.</td>
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</tbody>
</table>

3.1.2 REGULATORY IMPLICATIONS ON SECP

REGULATIONS REGARDING THE MANDATORY BLENDING OF BIOFUELS WITH PETROL AND DIESEL

<table>
<thead>
<tr>
<th>Status</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promulgation status</td>
<td>Promulgated: The Department of Energy announced in 2013 that the regulations would come into effect in October 2015.</td>
</tr>
<tr>
<td>Brief description</td>
<td>The regulations regulate the mandatory blending of bio-ethanol or bio-diesel with liquid transport fuels to produce a biofuel blend that may be sold in South Africa. Section 3 (5) of the regulations stipulates that all petrol and diesel supplied to a petroleum blending facility must allow for the blending of biofuels, with a minimum concentration of 5% for biodiesel and 2% for bioethanol.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>The regulations create a demand for energy crops such as sugar cane, sugar beet, soya bean, canola, and sunflowers. They also allow for the use of clean biofuel energy in agricultural production activities such as traction.</td>
</tr>
</tbody>
</table>
## REGULATIONS IN TERMS OF SECTION 12L OF THE INCOME TAX ACT, 1962, ON THE ALLOWANCE FOR ENERGY EFFICIENCY SAVINGS

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promulgation status</td>
<td>Promulgated in 2013</td>
</tr>
<tr>
<td>Brief description</td>
<td>These regulations were first developed by the Department of Energy in 2011 under the National Energy Act of 2008. In 2013, the National Treasury promulgated these regulations under the Income Act of 1962 and further amended them in March 2015. The regulations were developed in order to establish a tax incentive for those that can demonstrate energy efficiency savings. They guide relevant energy efficiency stakeholders on how to claim allowances for energy savings.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>Tax-paying rural and peri-urban farmers could utilise the tax incentive scheme stipulated in the regulations by means of investing in energy efficiency and claiming tax deductions based on the energy savings.</td>
</tr>
</tbody>
</table>

## SECTION 12B OF THE INCOME TAX ACT NO. 58 OF 1962

<table>
<thead>
<tr>
<th>Year</th>
<th>Most recent amendments: 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promulgation status</td>
<td>Promulgated</td>
</tr>
<tr>
<td>Brief description</td>
<td>Section 12B of the Income Tax Act No. 58 of 1962, as amended, provides for an accelerated capital allowance for movable assets used in the generation of renewable energy, e.g. solar, wind, hydro or biomass. The Section allows for a deduction on a 50/30/20 basis over three years in respect of any qualifying asset owned by the taxpayer. The Section requires the qualifying asset to be brought into use for the purposes of the claimant’s trade; for example, in the case of agriculture, the asset should be for the purposes of supporting agricultural related activities.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>Tax-paying rural and peri-urban farmers could utilise the incentive scheme and invest in relevant renewable energy technologies that support agriculture-related activities.</td>
</tr>
</tbody>
</table>

## REGULATORY RULES ON NETWORK CHARGES FOR THIRD-PARTY TRANSPORTATION OF ENERGY

<table>
<thead>
<tr>
<th>Status</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promulgation status</td>
<td>Promulgated</td>
</tr>
<tr>
<td>Brief description</td>
<td>These regulatory rules were developed by NERSA, and are meant to guide Independent Power Producers (IPPs) and renewable energy generators on the costs involved in network access and transportation of electricity, rules and methodologies to facilitate transmission and distribution system access. The regulatory rules allow for the wheeling of energy, subject to the generator receiving approval from NERSA to sell to a third party and the signing of the network service provider’s Connection and Use-of-System Agreement. Section 12.2 of the regulatory rules stipulates that generators connected at below 11kV shall not be allowed to wheel energy.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>Rural or peri-urban farmers could consider investing in sizeable renewable energy projects and wheel excess power to third party buyers.</td>
</tr>
</tbody>
</table>
3.1.3 KEY FINDINGS

The policy review revealed:
- Policies prioritise the focus on addressing socio-economic challenges such as poverty and unemployment.
- Policies lack in medium-term targets for energy access; there are only long-term plans, which are focused on access to grid electricity and there is minimal focus on off-grid electricity (UNEP, 2013).

It can be argued that the lack of available information on energy usage within agriculture in South Africa is a contributing factor, resulting in the gap between existing policies and the implementation of these policies in the form of support mechanisms. If information was available, it would push for the enforcement of existing policies to be implemented and ensure compliance. Nonetheless, the following policy-related opportunities are created or envisaged to be created within the agriculture sector for deployment of SECP practices and principles:
  - Investments in energy efficiency, and renewable and cleaner energy technologies.
  - The production of bioenergy crops such as sugar cane, sugar beet, soya bean, canola, and sunflower.
  - Adoption of sustainable farming practices.

3.2 WASTE SECTOR POLICY FRAMEWORK ANALYSIS

Waste is the mandate of the National Department of Environmental affairs, but waste-related policies also involve other departments, since waste has been identified as a new emerging and cross-cutting sector.

3.2.1 POLICY IMPLICATIONS ON SECP

The following are prominent waste-related policies that have some implications on using agricultural waste in generating energy products or energy inputs.

WHITE PAPER ON INTEGRATED POLLUTION AND WASTE MANAGEMENT FOR SOUTH AFRICA

<table>
<thead>
<tr>
<th>Status</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The White Paper developed by the Department of Environmental Affairs sets out the government's position with regard to pollution and waste management in South Africa.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>The White Paper emphasises the importance of preventing pollution and controlling waste discharges at source, something that directly aligns with practices around establishing waste-to-energy facilities on rural farms in order to control agricultural waste.</td>
</tr>
</tbody>
</table>

NATIONAL WASTE MANAGEMENT STRATEGY

<table>
<thead>
<tr>
<th>Status</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The National Waste Management Strategy, developed by the Department of Environmental Affairs, is a legislative requirement of the Waste Act. The purpose of the Strategy is to achieve the objects of the Waste Act. One of the primary intentions of both the Waste Act and the National Waste Management Strategy is to implement the waste management hierarchy.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>Implementing the waste management hierarchy in agriculture favours the adoption of sustainable farming methods, which are more aligned to the zero-waste concept. Energy recovery, including biogas projects and methane gas from landfills, is only considered as an alternative option for waste types that cannot be re-used or recycled.</td>
</tr>
</tbody>
</table>
INTEGRATED WASTE MANAGEMENT: RESEARCH AND TRAINING

NATIONAL POLICY ON THERMAL TREATMENT OF GENERAL AND HAZARDOUS WASTE

<table>
<thead>
<tr>
<th>Status</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The policy outlines the government’s stance on thermal treatment as a suitable waste management strategy.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>One of the aims of the policy is to promote waste management options that allow for the recovery of energy and raw materials from waste, together with the effective treatment thereof, in order to reduce the pressure on certain non-renewable resources.</td>
</tr>
</tbody>
</table>

MINIMUM REQUIREMENTS FOR HANDLING, CLASSIFICATION AND DISPOSAL OF HAZARDOUS WASTE

<table>
<thead>
<tr>
<th>Status</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>The Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste forms part of the Waste Management Series, produced by the Department of Water Affairs &amp; Forestry. The Minimum Requirements provide steps required when classifying hazardous waste, as well as its handling and disposal.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>One of the recommended treatment options includes incineration, which could be combined with power generation.</td>
</tr>
</tbody>
</table>

3.2.2 REGULATORY IMPLICATIONATIONS ON SECP

THE NATIONAL ENVIRONMENTAL MANAGEMENT: WASTE ACT (ACT NO. 59 OF 2008)

<table>
<thead>
<tr>
<th>Status</th>
<th>Produced in 2008 and amended in 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promulgation status</td>
<td>Promulgated</td>
</tr>
<tr>
<td>Brief description</td>
<td>One of the primary intentions of the Waste Act is to implement the waste management hierarchy in South Africa. Certain parts of the Act empower the Minister to determine and gazette waste management activities that require a licence. The promulgated Amendment No. 921 of 2013 provides a list of waste management activities that may have a detrimental effect on the environment and hence, require a waste management licence to be issued prior to undertaking the activity.</td>
</tr>
<tr>
<td>Implication on SECP</td>
<td>The need for a licence might constrain rural farmers who would want to engage in medium to large scale waste-to-energy projects on their farms especially those who handle above-set-threshold volumes of waste and other streams of waste that require a licence. However, this is unlikely for most small scale rural farmers who are likely to be handling relatively small volumes of internally generated agricultural waste.</td>
</tr>
</tbody>
</table>

3.2.3 KEY FINDINGS

The majority of the reviewed waste-related policies and regulations are aimed at promoting the waste management hierarchy in South Africa. The promotion of waste-to-energy initiatives is also explicitly stipulated in the reviewed policies. The waste management policies and regulations fall short of implementation of renewable energy and energy efficiency practices. The policies discuss:

- The National Policy on Thermal Treatment of General and Hazardous Waste specifically discusses the recovery of energy through waste management, which supports the promotion of waste-to-energy in SECP.
- Markets in South Africa are not developed enough for green products, particularly organic food markets.
CHAPTER 4
SECP TECHNOLOGIES

KEY FINDINGS

Transitioning from conventional agriculture to sustainable agriculture is a long-term process that requires a gradual approach. SECP practices (i.e. energy efficiency and renewable energy – including bioenergy solutions) offer a sustainable solution that can be employed, while agricultural practices move towards sustainable agriculture. There is a wide range of energy efficiency and renewable energy technological solutions that can be adopted in agriculture to lessen the over-reliance on fossil fuels. The majority of these technologies are mature and well-established.

The diverse nature of the available renewable energy and energy efficiency technologies allows for the provision of sustainable energy solutions to cater for each related energy need in agriculture; i.e. lighting, ventilation, refrigeration, transport, drying, heating, irrigation, etc. The review of various technologies employed in agriculture for the purpose of reduced or more efficient use of energy highlighted the following:

- Energy efficiency is broad and is not necessarily restricted to the implementation of physical and tangible energy efficient technologies. In fact, there are numerous energy efficiency opportunities that farmers can tap into, some of which are cost-free and entail adoption of certain behavioural practices as well as proper maintenance of already existing equipment and technologies. Sustainable agricultural practices such as composting and crop rotations can also be perceived as energy efficiency practices.
- Considering the variability of power produced by popular renewable energy technologies such as solar and wind, the use of hybrid systems, which sometimes incorporate fossil fuel powered generator sets, is also a highly recommended SECP option in agriculture.
- Anaerobic digestion technologies appear to be the most widely adopted small-to-medium scale energy solution in agriculture among the various bioenergy systems reviewed, followed by gasification plants.
- The utilisation of small-to-medium-scale bioenergy conversion technologies such as pyrolysis and fermentation in agriculture is very limited. Moreover, the feasible commercial utilisation of pyrolysis technologies for bioenergy purposes using feedstock from crops and other agricultural organic waste is yet to be established. Within the agricultural sector, this technology has mostly been utilised to produce biochar, for agricultural soil enhancement applications; but the technology is still faced with economic and reliability issues.

One of the major weaknesses of most renewable energy technologies, e.g. solar, wind and hydro, is the high capital/initial investments; hence the need for relevant financial support mechanisms to assist farmers acquire such technologies. Based on some of the reviewed case studies, programmes that package and complement energy efficiency or renewable energy technologies, together with some innovative and flexible end-user financial assistance mechanisms appear to be quite effective and critical for most small scale farmers in rural areas.
4.1 TRANSITION TOWARDS SUSTAINABLE AGRICULTURE

The promotion of sustainable agricultural practices by key UN agencies such as the FAO forms part of the global development agenda. Sustainable agriculture seeks to contribute to all four pillars of food security, i.e. availability, access, utilisation, and stability, in a manner that is environmentally, economically and socially responsible over time (FAO, 2014). In other words, for agricultural practices to be considered sustainable, they should meet the agricultural-related needs of present and future generations, while ensuring profitability, environmental health, and social and economic equity (FAO, 2014).

It is imperative to note that sustainable agricultural practices are not restricted to certain agriculture sectors, but encompass all agriculture sectors; that is, crops, livestock, forestry, aquaculture, fisheries, etc. There are broad and various sector-specific sustainable agricultural practices that can be pursued. Examples of sustainable agricultural practices that could be implemented within the crop and animal production (livestock) sectors include the following amongst others:

• Conservation agriculture
• Judicious use of organic and inorganic fertilisers
• Improved water productivity, precision irrigation
• Integrated pest management
• Improved resource use efficiency
• Improved soil moisture management
• Appropriate cropping systems; crop rotations, crop diversity
• Managed grazing
• Balanced and precision animal feeding and nutrition
• Zero waste systems

Considering the distinctiveness of the aforementioned sustainable farming practices from the current conventional farming approaches, it can be posited that transitioning towards sustainable agriculture should be a long-term process, one that does not transpire overnight. Considering the multiplicity and interrelatedness of the sustainable farming techniques to be implemented, the transition should be gradual, on-going, smooth, and not rushed. Intermediate agricultural practices should be considered as part of the transitioning process. SECP practices serve as one such transitioning pathway towards the long-term adoption of sustainable agriculture. In the meanwhile, SECP practices in agriculture that encompass the implementation of renewable energy, energy efficiency and waste-to-energy solutions should be widely promoted and rolled out.

The following sub-sections provide detailed discussions on the various SECP technologies that could be considered for implementation within the agricultural sector grouped under energy efficiency, renewable energy, and bioenergy technologies.

4.2 ADOPTION OF ENERGY EFFICIENCY PRACTICES

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

Energy audits and life cycle assessments, discussed in the succeeding paragraphs, are some of the tools that are used to promote the implementation of energy efficiency practices and renewable energy technologies.

4.2.1 ENERGY AUDIT

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). In other words, the main goals of an energy audit can be presented as follows (Powering Agriculture, 2016a):

• Understanding how energy is used within the system or process, and where it is wasted.
• Finding alternative measures to reduce energy losses and improve the overall performance.
• Performing a cost-benefit analysis to identify energy efficiency measures that are best to implement.

Energy audits can be executed in different levels, for example (Powering Agriculture, 2016a):

• A simple level audit: which includes a brief site inspection as well as assessing the broad energy input and output of a system, in order to identify low cost energy saving opportunities.
• Medium level audits: include an in-depth analysis of energy costs, energy usage, and system characteristics along with on-site energy demand measurements in order to identify energy efficiency measures that are more capital intensive and need to be aligned with the financial budget plan of the site.
Most sophisticated level (referred to as an investment grade audit): includes an additional continuous monitoring of system data and process characteristics.

Overall, an energy audit can be divided into the following four different phases (Powering Agriculture, 2016a):
1. Review of energy use
2. Site assessment
3. Energy and cost analysis
4. Audit report

CASE STUDY: ENERGY AUDITS IN THE KENYAN FLOWER INDUSTRY (POWERING AGRICULTURE, 2016A)

The flower production sub-sector is one of the largest contributors to national GDP within the agricultural sector in Kenya. The sub-sector is constituted of large-, medium- and small-scale producers, many of which have already incorporated technologies such as drip irrigation, automatic greenhouse ventilation systems, pre-cooling, cold storage facilities and artificial lighting to increase day length. Other producers have also installed renewable energy technologies such as rooftop PV installations, solar thermal and biogas plants.

Nevertheless, energy audits conducted at a number of flower producing facilities still identified major potential for improving energy efficiency, especially considering that flower production activities are energy-intensive, with an approximated average of 10 to 20% of total operating costs resulting from energy costs. There are substantial energy requirements for water pumping, lighting, refrigeration, heating and sanitary processes, and greenhouse farming.

Conducted energy demand assessments revealed that water pumping for irrigation (67%) constituted the largest share of electrical energy demand, followed by applications such as refrigeration (13%), greenhouses (11%), and lighting (9%). With regard to thermal energy, the audits revealed that thermal energy demand appears when hot water is used to warm seedling beds for better cultivation.

Overall, based on the energy audits, several energy efficiency measures were recommended. Amongst others, these include the use of high-efficiency motors and pumps, LED lighting, better cold curtains, variable speed drives, and instituting an energy management system.

4.2.2 LIFE-CYCLE ASSESSMENT

According to the UNEP, a Life Cycle Assessment (LCA) “is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle” (UNEP, 2016). In other words, LCA should be understood as a tool that identifies, quantifies, and evaluates the total potential environmental impact of production processes or products, from procurement of raw materials (the ‘cradle’), to production and utilisation (the ‘gates’), and their final storage (the ‘grave’), as well as for determining ways to repair damage to the environment (Skowrońska & Filipek, 2014).

Nowadays, the LCA is the most commonly performed assessment, with the International Organisation for Standardisation (ISO) having developed LCA-specific standards, e.g. ISO 14040 describing the framework for LCA and ISO 14044 describing the procedure to carry out the LCA (Powering Agriculture, 2016a). ISO outlines the four key phases of LCA as follows (UNEP, 2016):

- **Goal and Scope Definition**: the products or services to be assessed are defined, a functional basis for comparison is chosen and the required level of detail is defined.
- **Inventory Analysis**: of extractions and emissions, the energy and raw materials used, and emissions to the atmosphere, water and land, are quantified for each process, then combined in the process flow chart and related to the functional basis.
- **Impact Assessment**: the effects of the resource used and emissions generated are grouped and quantified into a limited number of impact categories which may then be weighted for importance.
- **Interpretation**: results are reported in the most informative way possible, and the need and opportunities to reduce the impact of respective products or services on the environment are systematically evaluated.
The primary purpose of LCA could be to steer decision-makers towards more sustainable products and services (The Green House, n.d.). Furthermore, LCA results could still be utilised by producers in a variety of marketing, design and operational contexts. Overall, energy efficiency can be argued to be one of the critical constituents of LCA.

**CASE STUDY: LCA OF MILK PRODUCTION IN THE WESTERN CAPE (THE GREEN HOUSE, N.D)**

The Green House conducted an LCA research paper commissioned by the WWF, aimed at understanding the impact of milk production along its full supply chain in the Western Cape, as well as identifying the key points of intervention for improvement. The study results were presented at a public workshop held in Cape Town on the 25th of May 2011.

The assessment following the next approach:

- **Step 1:** Defining the system. The first step of the study was to clearly define the system, which entail the production and supply of fresh milk to the consumer; i.e. fresh milk produced in the Western Cape and sold within the greater Cape Town area. The system incorporated stages of milk production on the farm, through to processing, distribution, retail and consumption. Furthermore, the life cycle of products used in the milk value chain was also included, e.g. the manufacture and disposal of milk packaging. Transport aspects were also considered; i.e. the transport of milk through its value chain, as well as transport used for all materials in the various processes.

- **Step 2:** Data collection. The next step involved deciding on a data collection strategy and identifying relevant data sources. Data sources included site-specific sources (dairy farms, dairy processes and a major retail chain), South African agricultural statistics, and the Green House’s proprietary LCI database.

- **Step 3:** Metrics for assessment. The ultimate step was deciding the metrics against which the milk supply chain would be assessed. Standard life cycle impact assessment indicators such as global warming potential (carbon footprint), acidification potential, eutrophication potential and fossil fuel depletion were selected. A particular component of the study further incorporated into the LCA study was to develop water and biodiversity indicators relevant to the South African context.

Figure 4-2 is a snapshot of the carbon footprint and water footprint of fresh milk production in the Western Cape, derived from the study.

**FIGURE 4-2: CARBON AND WATER FOOTPRINT OF FRESH MILK PRODUCTION IN THE WESTERN CAPE**
The CSA clearly revealed that the carbon footprint ‘hotspot’ of milk production was at the farm stage (51-59%). Other life cycle stages (i.e. processing, packaging, distribution, retail, consumer), together, accounted for about a third of the total GHG emissions over the supply chain; thus offering additional options for intervention rather than just focusing on the dairy farm itself. The GHG emissions associated with milk packaging, although it tends to receive a lot of attention, was relatively insignificant, with a carbon footprint equivalent to about 1.5 tablespoons of the milk inside the bottle. According to the study, the emphasis of packaging development should thus, be less on the weight or type of materials, but ensuring that every drop of the contents is ultimately consumed.

4.2.3 ENERGY EFFICIENCY TECHNOLOGIES

OVERVIEW

A technology is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input; for example, when a compact fluorescent light (CFL) bulb uses less energy (one-third to one-fifth) than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient (OECD/IEA, 2015).

Improving energy efficiency within the agricultural sector helps reduce energy demand and its associated costs. This also plays a significant role in reducing reliance on fossil fuels thus contributing towards GHG emission reduction. In other words, the benefits of implementing energy efficiency schemes to farmers include the following among others (Carbon Trust, 2006):

- Reduced costs and increased profitability
- Improved crop quality
- Increased sales from customers encouraged to purchase more ‘green’ produce
- Enhanced business credentials through helping the environment

As will be established in the subsequent subsections, energy efficiency in the context of this study can be implemented in different agricultural sub-sectors as well as in various ways e.g.:

- Having a more energy efficient technology replacing a conventional lesser energy efficient technology, e.g. replacing a hot water electric geyser with a solar water geyser.
- Incorporating additional energy saving technologies in order to realise some energy savings, e.g. incorporating sensors for lighting and air-conditioning equipment, using double glazed windows and insulation in houses, etc.
- A change in behavioural practices; for example, utilising composting instead of extensive reliance on inorganic fertilisers.

APPLICATION IN FIELD CROP PRODUCTION

There are numerous energy efficiency technologies and behavioural practices applicable to the field crop production sub-sector as can be established from Table 4-1. Available energy efficiency technologies and practices can be utilised to reduce energy usage in field crop applications such as irrigation, refrigeration, machinery and transport. It is also worth noting that sustainable agricultural practices such as crop rotations and composting, amongst others, can also be viewed as energy efficiency practices with a positive indirect impact on energy usage within the field crop production sub-sector especially considering that they lessen the demand for energy intensive fertilisers.
TABLE 4-1: ENERGY EFFICIENCY PRACTICES APPLICABLE TO FIELD CROP PRODUCTION

<table>
<thead>
<tr>
<th>Energy demand</th>
<th>Recommended energy efficiency technologies and behavioural practices</th>
</tr>
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<tbody>
<tr>
<td>Fertilizer use</td>
<td>• Use of cover crops and manures</td>
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<td></td>
<td>• Nitrogen-fixing crops in rotations</td>
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<tr>
<td></td>
<td>• Composting</td>
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<tr>
<td></td>
<td>• Integrated pest management (IPM)</td>
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<td></td>
<td>• Precision farming/application</td>
</tr>
<tr>
<td>Irrigation (and fertigation)</td>
<td>• Efficient irrigation pumps including variable speed motors</td>
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<tr>
<td></td>
<td>• Using gravity where possible</td>
</tr>
<tr>
<td></td>
<td>• Varying irrigation rates by using automatic regulation control systems</td>
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<tr>
<td></td>
<td>• Proper pump-sizing</td>
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<tr>
<td></td>
<td>• Upgrading to more efficient irrigation systems e.g. from wheel lines to pivot or linear sprinkler systems, or drip irrigation in row crops</td>
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<tr>
<td></td>
<td>• Frequent management/maintenance of irrigation systems</td>
</tr>
<tr>
<td>Lighting</td>
<td>• Maximise on natural daylight by utilising translucent materials</td>
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<tr>
<td></td>
<td>• Energy saving lighting technologies e.g.:</td>
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<td></td>
<td>o LED</td>
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<td>o CFLs</td>
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<td>o T5 fluorescent</td>
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<td>o induction lamps</td>
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<tr>
<td></td>
<td>• Replacing electromagnetic ballasts with electronic and dimmable ballasts</td>
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<td></td>
<td>• Efficient automatisation of lighting matching real demands</td>
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<td></td>
<td>o Timers</td>
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<tr>
<td></td>
<td>• Cleaning dust off reflective surfaces of light fixtures to help maintain light output</td>
</tr>
<tr>
<td>Refrigeration (cold storage)</td>
<td>• Precooling produce with cold water before putting it into refrigerated areas</td>
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<td></td>
<td>• Improving insulation of the refrigerated cold storage area e.g. cold room curtains</td>
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<td></td>
<td>• Insulation on all pipe work should be in good condition</td>
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<tr>
<td></td>
<td>• Reducing infiltration of warm air through the doors, cracks, and other openings</td>
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<tr>
<td></td>
<td>• Regular maintenance and servicing of refrigeration equipment</td>
</tr>
<tr>
<td></td>
<td>• Utilising energy-efficient compressors, heat exchangers, and refrigerants</td>
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<tr>
<td></td>
<td>• Preventing and detecting refrigerant leakage</td>
</tr>
<tr>
<td></td>
<td>• Ensuring refrigerators are full but not overloaded</td>
</tr>
<tr>
<td>Crop drying and other storage</td>
<td>• Use energy efficient dryers e.g. solar dryers</td>
</tr>
<tr>
<td>Machinery and farm vehicles</td>
<td>• Excellent humidity control of dryers</td>
</tr>
<tr>
<td></td>
<td>• Using fuel efficient vehicles and machinery</td>
</tr>
<tr>
<td></td>
<td>• Efficient automation (efficient electric drives and motors, as well as automate monitoring and control systems) for production and processing</td>
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<td></td>
<td>• Correct gear and throttle selection</td>
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<td></td>
<td>• Proper tyre inflation</td>
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<td></td>
<td>• Selecting optimum truck size for the load</td>
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<td>• Route optimisation</td>
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<td>• Regular vehicle maintenance</td>
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<td></td>
<td>• Reduced idling</td>
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<tr>
<td></td>
<td>• Reduced-till or no till cropping systems</td>
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<tr>
<td></td>
<td>• Overlap reduction systems e.g. auto-steer, obstacle isolation, proper equipment sizing</td>
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<tr>
<td></td>
<td>• Variable Speed Drives – in milling, mixing, sieving, conveying, ventilation and drying processes.</td>
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</table>
Having looked at the various energy efficiency technologies and practices that could be incorporated into the field crop production sub-sector, two case studies are presented below that illustrate how:

- in Nicaragua, farmers are being encouraged to adopt low pressure drip irrigation as an energy efficiency technology to reduce energy costs in crop production,
- in the Democratic People’s Republic of Korea have utilised no tillage cropping systems as well as crop rotations as energy saving tools.

**CASE STUDY 1: EFFICIENT LOW PRESSURE DRIP IRRIGATION IN NICARAGUA (REEEP, 2015A)**

Low-pressure drip irrigation could increase efficiency, reduce water and fertiliser use, extend growing seasons and overall, improve productivity. The irrigation system delivers smaller amounts of water to plant roots thus positively impacting on agricultural output. While this irrigation system is ideal for smallholder farmers; in Nicaragua, a lack of finance as well as a lack of understanding and risk aversion from both farmers and lenders - inhibited the uptake of this irrigation system.

In light of the above, iDEal Tecnologías, a Colorado-based wholesaler of low-cost drip irrigation systems, is addressing the aforementioned barriers to low-pressure drip irrigation technology uptake in Nicaragua. iDEal Tecnologías is offering a specialised micro drip irrigation system that lowers overall cost, as well as auctioning a strategy to cultivate a retailer network of technicians who can both sell and conduct after-sales service.

The iDEal specialised micro drip irrigation is believed to have the following direct impacts for farmers:

- Cost savings in fuel, fertilisers and labour
- Increase in food production (30%)
- Decrease of food wastage (10%)
- Water savings (up to 80%)
- Attractive payback time - 6 months to 2 years
- Agricultural advisory services

**CASE STUDY 2: CONSERVATION AGRICULTURE IN THE DEMOCRATIC PEOPLE’S REPUBLIC OF KOREA (FAO, 2012)**

The Democratic People’s Republic of Korea engaged the FAO to provide the country with some technical assistance in the introduction of conservation agriculture to address agricultural production related challenges. Following the involvement of the FAO, the following practices were implemented:

- Soil tillage was eliminated
- Permanent soil cover was introduced
- Crop rotations

These practices resulted in a reduction in fertiliser requirements and significant fuel savings. The impact of conservation agriculture and no tillage practices for Korea was assessed by measuring the fuel consumption per hectare and per season on three farms between the years 2003 and 2005, and the following results were reported:

- Input savings of 30% to 50%
- An average of 15.5 kg fuel per ha was saved

**APPLICATION IN HORTICULTURAL PRODUCTION**

Similar to the field crop production sub-sector, energy efficiency technologies and practices can also be applied to the horticulture sub-sector as shown in Table 4-2. While most of the energy demand goes towards applications similar to those of the field crop production sub-sector, it should still be noted that certain other energy demand applications such as greenhouse farming, space heating and cooling, lighting, and hot water generation are more applicable to the horticultural sub-sector. As a result, there are also a myriad of energy efficiency technologies and practices to reduce energy usage for such applications (i.e. greenhouse farming, space heating and cooling, lighting, hot water generation) as outlined in the table below.
### TABLE 4-2: ENERGY EFFICIENCY PRACTICES APPLICABLE TO HORTICULTURAL PRODUCTION

<table>
<thead>
<tr>
<th>Energy demand</th>
<th>Recommended energy efficiency technologies and behavioural practices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fertilizer use</strong></td>
<td>• Use of cover crops and manures:&lt;br&gt;• Nitrogen-fixing crops in rotations:&lt;br&gt;• Composting:&lt;br&gt;• Integrated pest management (IPM)&lt;br&gt;• Precision farming/application</td>
</tr>
<tr>
<td><strong>Greenhouse</strong></td>
<td>• Foundation and sidewall insulation&lt;br&gt;• Thermal blankets/screens&lt;br&gt;• Greenhouse poly film with an infrared inhibitor&lt;br&gt;• Double covering on sidewalls and end walls&lt;br&gt;• Reducing air leaks by using door closers, weather stripping (doors, vents, fan openings) and lubricating louvres&lt;br&gt;• Clean glass regularly&lt;br&gt;• Minimising traffic in and out of the greenhouse to avoid heat losses</td>
</tr>
<tr>
<td><strong>Irrigation (and fertigation)</strong></td>
<td>• Efficient irrigation pumps including variable speed motors&lt;br&gt;• Using gravity where possible&lt;br&gt;• Varying irrigation rates by using automatic regulation control systems&lt;br&gt;• Proper pump-sizing&lt;br&gt;• Upgrading to more efficient irrigation systems e.g. from wheel lines to pivot or linear sprinkler systems, or drip irrigation in row crops&lt;br&gt;• Frequent management/maintenance of irrigation systems</td>
</tr>
<tr>
<td><strong>Lighting</strong></td>
<td>• Maximise on natural daylight by utilising translucent materials&lt;br&gt;• Energy saving lighting technologies e.g.:&lt;br&gt;  o LED&lt;br&gt;  o CFLs&lt;br&gt;  o T5 fluorescent&lt;br&gt;  o Induction lamps&lt;br&gt;• Replacing electromagnetic ballasts with electronic and dimmable ballasts&lt;br&gt;• Efficient automatisation of lighting matching real demands&lt;br&gt;  o Timers&lt;br&gt;• Cleaning dust off reflective surfaces of light fixtures to help maintain light output</td>
</tr>
<tr>
<td><strong>Space heating and cooling</strong></td>
<td>• Use adequate insulation&lt;br&gt;• Avoiding opening doors and windows when heating is in operation&lt;br&gt;• Variable speed drives on ventilating systems&lt;br&gt;• Energy efficient ventilation fans&lt;br&gt;• Use climate control equipment: timers, sensors and thermostats.&lt;br&gt;  o These should be tested, cleaned and calibrated regularly</td>
</tr>
<tr>
<td><strong>Refrigeration (cold storage)</strong></td>
<td>• Precooling produce with cold water before putting it into refrigerated areas&lt;br&gt;• Improving insulation of the refrigerated cold storage area, e.g. cold room curtains&lt;br&gt;• Insulation on all pipe work should be in good condition&lt;br&gt;• Reducing infiltration of warm air through the doors, cracks, and other openings&lt;br&gt;• Regular maintenance and servicing of refrigeration equipment&lt;br&gt;• Utilising energy-efficient compressors, heat exchangers, and refrigerants&lt;br&gt;• Preventing and detecting refrigerant leakage&lt;br&gt;• Ensuring refrigerators are full but not overloaded</td>
</tr>
</tbody>
</table>
Energy demand

Recommended energy efficiency technologies and behavioural practices

| Machinery and farm vehicles | • Using fuel efficient vehicles and machinery  
|                           | • Efficient automation (efficient electric drives and motors, as well as automate monitoring and control systems) for production and processing  
|                           | • Correct gear and throttle selection  
|                           | • Proper tyre inflation  
|                           | • Selecting optimum truck size for the load  
|                           | • Route optimisation  
|                           | • Regular vehicle maintenance  
|                           | • Reduced idling  
| Hot water applications | • Solar water heating or heat pump systems for hot water requirements  
|                            | • Using on-demand hot water systems rather than storage tanks  
|                            | • Boiler combustion efficiency  
|                            | • Insulating boilers, hot water tanks and the associated valves and flanges (pipe joints)  

Having looked at the various energy efficiency practices in horticultural production, the following paragraphs provide a case study on how variable speed drives (VSDs) can be utilised in the horticultural sub-sector as an energy efficiency promoting technology.

**CASE STUDY: VARIABLE SPEED DRIVES: REDUCING ENERGY COSTS IN HORTICULTURE (ESKOM INTEGRATED DEMAND MANAGEMENT, 2015)**

A Variable Speed Drive (VSD), also known as Variable Frequency Drive (VFD) or Adjustable Speed Drive, is a device that can adjust the frequency to regulate and adapt motor speed in order to match the actual demand required by the system or application it is driving, resulting in a reduction in energy consumption. VSDs play a significant role in lowering energy use and reducing operating costs in the horticultural sector by improving the energy efficiency of electric motors that drive pumps and irrigation and ventilation systems. It is believed that a pump or fan running at half speed consumes only one eighth of the power compared to one running at full speed, which means a small increase in speed requires a lot more power.

- Reducing a pump or fan speed by 20% can reduce energy consumption by more than 50%
- 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

Besides energy savings, VSDs are also beneficial in that they deliver accurate control, hence less mechanical wear; thus reducing maintenance and extending the life expectancy of systems.

- In the case of an irrigation system, a VSD can be used to adapt the speed according to the respective water and pressure requirements of the various sizes of land, which will prevent the motor from running at full speed and all the excess energy dissipated by the pump's pressure regulator.
- In the case of a ventilation system for a greenhouse, a VSD allows fan systems that adapt to changes in the outdoor environment.

Application in animal and animal products

Similar to the other sub-sectors of crop and horticultural production, the animal and animal products sub-sector is also constituted of multiple opportunities for energy efficiency. Table 4-3 outlines some of the energy efficiency technologies and practices that can be applied within this particular sub-sector.
<table>
<thead>
<tr>
<th>Energy demand</th>
<th>Recommended energy efficiency technologies and behavioural practices</th>
</tr>
</thead>
</table>
| Irrigation (and fertigation)  | • Efficient irrigation pumps including variable speed motors  
| of paddocks                   | • Using gravity where possible  
|                               | • Varying irrigation rates by using automatic regulation control systems  
|                               | • Proper pump-sizing  
|                               | • Frequent management/maintenance of irrigation systems  
|                               |                                                                                                                                   |
| Lighting                      | • Utilise natural daylight by making use of translucent materials, e.g. skylights  
|                               | • Energy saving lighting technologies, e.g.:  
|                               |   o LED  
|                               |   o CFLs  
|                               |   o T5 fluorescent  
|                               |   o induction lamps  
|                               | • Replacing electromagnetic ballasts with electronic ballasts  
|                               | • Use dimmable ballasts  
|                               | • Efficient automatisation of lighting matching real demands:  
|                               |   o Timers  
|                               |   o Photo sensors  
|                               |   o Motion detectors  
|                               | • Using moisture resistant lamp fixtures in animal houses  
|                               | • Cleaning dust off reflective surfaces of light fixtures to help maintain light output  
|                               |                                                                                                                                   |
| Space heating and cooling     | • Utilise automatically controlled natural ventilation systems  
|                               | • Use adequate insulation  
|                               | • Variable speed drives on ventilating systems  
|                               | • Energy efficient ventilation fans  
|                               | • Use timers, sensors and thermostats.  
|                               |   o These should be tested, cleaned and calibrated regularly  
|                               |                                                                                                                                   |
| Refrigeration (cold storage)  | • Pre-cooling produce with cold water before putting it into refrigerated areas  
|                               | • Improving insulation of the refrigerated cold storage area, e.g. cold room curtains  
|                               | • Insulation on pipe work should be in good condition  
|                               | • Reducing infiltration of warm air through the doors, cracks, and other openings  
|                               | • Regular maintenance and servicing of refrigeration equipment  
|                               | • Utilising energy-efficient compressors, heat exchangers, and refrigerants  
|                               | • Preventing and detecting refrigerant leakage  
|                               | • Ensuring refrigerators are full but not overloaded  
|                               |                                                                                                                                   |
| Machinery and farm vehicles   | • Using fuel efficient vehicles and machinery  
|                               | • Efficient automation (efficient electric drives and motors, as well as automate monitoring and control systems) for production and processing  
|                               | • Correct gear and throttle selection  
|                               | • Proper tyre inflation  
|                               | • Selecting optimum truck size for the load  
|                               | • Route optimisation  
|                               | • Regular vehicle maintenance  
|                               | • Reduced idling  
|                               |                                                                                                                                   |
| Hot water applications        | • Solar water heating or heat pump systems for hot water requirements  
|                               | • Using on-demand hot water systems rather than storage tanks  
|                               | • Boiler combustion efficiency  
|                               | • Insulating boilers, hot water tanks and the associated valves and flanges (pipe joints)  
|                               | • Heat recovery – from the condenser unit of the refrigeration cycle to heat water for sterilising equipment and supporting electrical element geysers during peak periods of demand for hot water  
|                               |                                                                                                                                   |
Having looked at the various energy efficiency practices that can be considered for the animal and animal products sub-sector, the following is a case study on how a poultry farmer in the Western Cape, South Africa, made use of some of the aforementioned energy efficient lighting technologies and realised enormous energy savings.

**CASE STUDY: ENERGY EFFICIENT LIGHTING AT THE KROMME RIVIER POULTRY FARM IN SOUTH AFRICA (ESKOM INTEGRATED DEMAND MANAGEMENT, 2013)**

A Kromme Rivier poultry farm in the Western Cape, South Africa, cycled 13 000 broiler chickens in phases through eight 15 000 chicken sheds. Each of the eight sheds was illuminated with 32 60w incandescent light bulbs. Furthermore, there were also two external mercury vapour floodlights on the farm.

Following some advice and an energy audit from an energy efficiency project developer, the Kromme Rivier poultry farm did a lighting retrofit at a cost of approximately R70 700, and comprising of the following:

- Replacing 256 X 60w incandescent globes with 6W LEDs
- Replacing 2 X 125W Mercury vapour floodlights with 20W Light LEDs

As a result, the retrofit achieved the following:

- Reduction in energy usage of 51 226kWh per annum.
- Savings in energy cost of R60 053 per annum.

### 4.3 ADOPTION OF MODERN RENEWABLE ENERGY TECHNOLOGIES

There are myriad of renewable energy sources that could be utilised for electricity generation and other energy demands. The following are some of the renewable energy sources and technologies commonly applied within the agricultural sector.

#### 4.3.1 SOLAR PHOTOVOLTAICS (PV)

**TECHNOLOGY OVERVIEW**

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. When sunlight is absorbed by solar cells made up of these semi-conductor materials, it causes electrons to flow through an electrical circuit, thereby generating electric current (Powering Agriculture, 2016a). Most PV solar cells are made from either crystalline silicon or thin-film semiconductor material (Solar Energy Industries Association, 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. Solar PV technologies have their strengths as well as their weaknesses. The following are some of the strengths and weaknesses of these technologies (UNIDO, n.d.):

- **Strengths:**
  - PV is a mature technology with high reliability and long lifetimes. Power output warranties from PV panels now commonly for 25 years
  - Automatic operation with very low maintenance requirements
  - No fuel required (no additional costs for fuel nor delivery logistics)
  - Modular nature of PV allows for a complete range of system sizes as application dictates
  - Low environmental impacts compared to conventional energy sources
  - The solar system is an easily visible sign of a high level of responsibility, environmental awareness, and commitment
  - Solar users are less affected by rising prices for other energy sources

- **Weaknesses:**
  - Performance is dependent on sunshine levels and local weather conditions
  - Storage/back-up usually required due to fluctuating nature of sunshine levels e.g. no power production at night
  - High capital/initial investment costs
  - Specific training and infrastructure needs
  - Energy intensity of silicon production for solar PV cells
  - Provision for collection of batteries and facilities to recycle batteries is required
  - Use of toxic materials in some PV panels

Within the agricultural sector, there are multiple applications for solar PV. The following sub-sections outline some of the common applications of solar PV in various agricultural sub-sectors.
APPLICATION IN FIELD CROP AND HORTICULTURAL PRODUCTION

The integration of solar PV technologies into field crop and horticultural production sub-sector applications is not something new. Solar PV has been relied on for crop and horticultural applications such as irrigation, lighting, agro-processing machinery, amongst others, for quite some time. Table 4-4 outlines some of the common applications that are related to field crop and horticultural sub-sectors, where solar PV technologies are being utilised. From the table below, it is quite clear that most of the solar PV technologies currently being utilised within the field crop and horticultural sectors play a significant role in minimising the reliance on grid electricity as well as the use of petroleum products such as diesel, petrol, kerosene, etc.

TABLE 4-4: SOLAR PV USES IN THE FIELD CROP AND HORTICULTURAL SUB-SECTORS

<table>
<thead>
<tr>
<th>Status</th>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>PV-driven pumps for irrigation</td>
<td>Petroleum products, grid electricity</td>
</tr>
<tr>
<td></td>
<td>Solar PV powered tractors and mowers for traction.</td>
<td>Grid electricity</td>
</tr>
<tr>
<td></td>
<td>It must, however, be noted that this application is</td>
<td></td>
</tr>
<tr>
<td></td>
<td>still emerging and has not been fully rolled out in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>most parts of the world.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PV powered sprayer for crop spraying</td>
<td>Petroleum products</td>
</tr>
<tr>
<td></td>
<td>Solar PV lanterns for pest control (solar insecticidal lamp)</td>
<td>Grid electricity</td>
</tr>
<tr>
<td></td>
<td>– i.e. to attract moths away from field</td>
<td></td>
</tr>
<tr>
<td>Post-harvest handling</td>
<td>Solar PV powered greenhouses – for lighting, temperature controls, irrigation, etc.</td>
<td>Grid electricity, coal, petroleum products</td>
</tr>
<tr>
<td></td>
<td>Off-grid solar PV powered cold storage for fresh produce refrigeration</td>
<td>Petroleum products, grid electricity</td>
</tr>
</tbody>
</table>
The following are case studies with detailed information on how some of the aforementioned solar PV technologies are being utilised within the field crop and horticultural sub-sectors globally.

**CASE STUDY 1: SOLAR PV POWERED IRRIGATION SYSTEM TARGETED AT SMALLHOLDER FARMERS IN KENYA**

Futurepump, a partnership of the non-profits iDE and PRACTICA Foundation, developed a model that enables smallholder farmers in Kenya to adopt sustainable irrigation solutions with a proprietary solar powered irrigation pump, combined with an end-user flexible finance programme (REEEP, 2015a). The finance programme allows for the targeted small holder farmers to pay for the irrigation system once they start realising economic benefits from irrigating their land (REEEP, 2015a). The use of solar powered irrigation systems in Kenya is envisaged to reduce the volume of usage of petroleum products, such as diesel.

**CASE STUDY 2: OFF-GRID SOLAR PV POWERED COLD STORAGE IN UGANDA**

In Uganda, Station Energy developed a solar PV powered cold room that provides refrigeration and freezing for fresh products of any type in isolated areas (REEEP, 2015a). The technology is mainly targeting agricultural cooperatives and fishermen associations. This type of technology is envisaged to assist in reducing waste and improving food security, as well as alleviating the GHG emissions from fossil fuel-powered alternatives.

Solar PV technologies within the animal and animal products sub-sector, either as standalone or hybrid technologies, are also quite prevalent. Various applications within the animal and animal products sub-sectors that require electricity from the grid or from petroleum products can also be powered by solar PV technologies. Table 4-5 outlines some of the common uses of solar PV in the animal and animal products sub-sector.
### TABLE 4-5: SOLAR PV USES IN THE ANIMAL AND ANIMAL PRODUCTS SUB-SECTOR

<table>
<thead>
<tr>
<th>Value chain</th>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Animal production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PV powered lighting for poultry and livestock. Lighting in poultry could also be used for heating</td>
<td>Grid electricity, petroleum products, coal</td>
</tr>
<tr>
<td></td>
<td>PV powered pumping for livestock watering</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td></td>
<td>PV powered electric fencing for grazing management</td>
<td>Grid electricity</td>
</tr>
<tr>
<td></td>
<td>PV powered system for poultry hatching i.e. egg incubators</td>
<td>Grid electricity</td>
</tr>
<tr>
<td></td>
<td>PV cooling for veterinary uses</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td></td>
<td>PV powered mechanical ventilation in livestock buildings, storage sheds</td>
<td>Grid electricity</td>
</tr>
<tr>
<td><strong>Post-harvest handling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PV powered dairy/meat processing refrigeration (solar chillers)</td>
<td>Grid electricity, petroleum products</td>
</tr>
</tbody>
</table>
The following is a case study on how solar PV technologies are being utilised to power dairy refrigeration in Bangladesh.

**CASE STUDY: SOLAR PV POWERED DAIRY REFRIGERATION IN BANGLADESH**

Enerplus is working with a dairy firm in Bangladesh called PRAN Dairy to retrofit existing diesel-powered cooling units with solar PV powered units (REEEP, 2015a). The company is also building new collection centres incorporating renewable energy (REEEP, 2015a). As a result, the market for dairy cooling could avoid close to 12,000 tonnes of CO2 annually by 2030 by shifting from diesel gensets to solar PV and other renewable sources such as solar thermal, biomass gasifiers, biogas, etc. (REEEP, 2015c). According to Enerplus, the direct impact for dairy processors include (REEEP, 2015c):

- 15% saving in energy expenses
- Stable power supply
- Stable energy price
- Increased milk collection
- Opportunity to expand milk collection to off-grid regions
- Better milk quality
- Replaced R22 by Montreal Protocol conforming refrigerants
- Reducing MCCs’ environmental impact on rural (reduce noise generated by gensets)

**APPLICATION FOR OTHER FARM USES**

There are many other farm-related facilities that could benefit from the use of solar PV power. Table 4-6 outlines how solar PV can be utilised to power some of the energy demands for farm buildings such as residences, offices, etc.

**TABLE 4-6: SOLAR PV USE FOR OTHER FARM ACTIVITIES**

<table>
<thead>
<tr>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV for off-grid electricity generation to power multiple energy demands for farm buildings:</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
</tr>
<tr>
<td>Cooking</td>
<td></td>
</tr>
<tr>
<td>Entertainment</td>
<td></td>
</tr>
<tr>
<td>Office appliances</td>
<td></td>
</tr>
<tr>
<td>Water pumping</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td></td>
</tr>
<tr>
<td>Grid electricity, petroleum products, coal, biomass</td>
<td></td>
</tr>
</tbody>
</table>
Case study: Solar PV home systems in rural Kenya (Kerea, 2012)

Around 300,000 rural households in Kenya had solar home systems in 2012. Solar electricity use in rural Kenya is dominated by a rural middle class that is comprised of small business owners, rural professionals such as school teachers, civil servants, pastors, and other better-off small holder cash crop farmers.

Solar PV systems are widely used for household applications such as television, radio, cell phone charging, and lighting. Modern and low cost lighting systems comprising of small solar PV and LEDs have also been widely adopted in rural Kenya, with an estimated 70,000 low cost LED based lighting products having been purchased in 2010/2011.

4.3.2 SOLAR THERMAL

TECHNOLOGY OVERVIEW

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, i.e. flat plate collectors and concentrating collectors (Powering Agriculture, 2016a). 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 e.g. power production, cooking, drying, etc.

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). The following sub-section outlines the various applications of solar thermal technologies in agriculture.

APPLICATION IN FIELD CROP AND HORTICULTURAL PRODUCTION

Solar thermal technologies can be utilised in field crop and horticultural production for various purposes such as irrigation, heating and cooling, and drying of produce. By utilising solar thermal technologies, conventional energy sources such as grid electricity, coal, and petroleum fuels can be displaced or minimised. Table 4-7 gives a snapshot of some of the solar thermal technologies applicable to the field crop and horticultural production sub-sector.

<table>
<thead>
<tr>
<th>Value chain</th>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Solar thermal pumps for irrigation</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td></td>
<td>Solar thermal heating to warm greenhouses at night</td>
<td>Grid electricity, coal, petroleum products</td>
</tr>
</tbody>
</table>
The following are case studies detailing the use of solar thermal technologies for irrigation and refrigeration applications within the field crop and horticultural sub-sectors.

**CASE STUDY 1: THE SUNFLOWER SOLAR THERMAL PUMP FOR IRRIGATION IN KENYA (REEEP & FAO, 2014)**

<table>
<thead>
<tr>
<th>Pump aspect</th>
<th>Description</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water yield</td>
<td>5-20,000 litres/day</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>Pumping depth</td>
<td>0-15m</td>
<td></td>
</tr>
<tr>
<td>Lifetime</td>
<td>~20 years</td>
<td></td>
</tr>
<tr>
<td>Initial capital costs (2013)</td>
<td>~USD 400</td>
<td></td>
</tr>
</tbody>
</table>

**Value proposition for smallholder farmers**
- Increased income
- Resilience and food security in the dry season
- Decreased manual work (compared to manual pumps)
- Decreased long term operating costs (compared to diesel engine pumps)

**General barriers for uptake of the technology by smallholder farmers**
- Slightly higher upfront costs (compared to engine pumps)
- Slightly higher technology risk (compared to manual and engine pumps) lack of access to finance

The Sunflower solar thermal pump (or steam pump) mainly targets commercial smallholder farmers in developing countries. The pump consists of the following three main parts:
- a parabolic collector: which captures and concentrates sunlight on a boiler in the focal point in order to produce steam that drives a steam engine;
- a steam engine: which converts pressurised steam into mechanical movement thus driving a water pump;
- a water pump: which draws water from a well.
CASE STUDY 2: THE SUNCHILL™ OFF-GRID REFRIGERATION SOLUTION FOR SMALLHOLDER FARMERS

SunChill™ is a novel, low-cost, and low-maintenance off-grid solar thermal refrigeration solution that enables increased field crop and horticulture agricultural productivity by reducing spoilage, especially during the post-harvest handling value chain stage. The refrigeration technology, targeted at smallholder farmers, transforms 50ºC solar thermal energy into 10ºC refrigeration using solid refrigerants and local, non-precision components (Powering Agriculture, 2016a). Rebound Technologies, the company behind the SunChill™ technology, completed the testing of the SunChill™ prototype in April 2015 and have since deployed its members to test the technology in field conditions in Mozambique (Powering Agriculture, 2016b).

APPLICATION IN ANIMAL AND ANIMAL PRODUCTS

Solar thermal technologies can also be used to displace or minimise the reliance on conventional energy sources in the animal and animal products sub-sector, such as grid electricity, petroleum based fuels, coal, and biomass. Table 4-8 highlights some of the solar thermal energy uses in animal and animal products sub-sector.

<table>
<thead>
<tr>
<th>Value chain</th>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Solar process space heating and cooling technologies for air conditioning livestock shelters and poultry houses</td>
<td>Grid electricity, petroleum products, coal, biomass</td>
</tr>
<tr>
<td>Processing</td>
<td>Solar thermal technologies to produce hot water for milking parlours and other meat processing applications</td>
<td>Grid electricity, petroleum products, coal</td>
</tr>
<tr>
<td></td>
<td>Solar dryers for meat drying</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td></td>
<td>Solar absorption refrigeration and freezers for preserving livestock and poultry products</td>
<td>Grid electricity, petroleum products</td>
</tr>
</tbody>
</table>
The following is a case study on how solar water heating has been applied as a strategy to reduce operational costs from energy, in Costa Rica’s thriving dairy sector.

**CASE STUDY: SOLAR WATER HEATING IN THE COSTA RICAN DAIRY SECTOR (ASHDEN, 2015)**

Costa Rica has a thriving dairy sector, which produces all the milk and milk-products consumed locally and those for export markets. Over 2,000 dairy farms in Costa Rica are affiliated to the Dos Pinos cooperative, one of the largest enterprises in Costa Rica. Dos Pinos buys about 80% of Costa Rica’s milk from its members. The enterprise has put in place very high standards for quality and hygiene, which lead to excellent dairy products but also entail high costs. One significant cost is electricity or bottled gas to provide hot water. This is required for washing milking equipment to prevent milk from becoming contaminated, and also used for other purposes like making up calf food.

One local solar business, Enertiva, identified an opportunity to reduce the cost of electricity, by using solar energy for heating water on dairy farms, which involves installation of an evacuated-tube design of solar water-heater with an integrated hot water tank on the roof of a dairy. Enertiva calculated that the cost of a solar water-heater could be paid back within a year through savings on electricity. The company also realised that solar water-heating also displaces fossil-fuel generation of electricity, helping Costa Rica towards its ambitious target of becoming carbon neutral by 2021.

Accordingly, Enertiva tailors the solar water heating system to suit respective dairies’ requirements. The system also comes with an automated thermostatic mixer and backup immersion heater to make sure that water is always supplied at the right temperature, and a timer to link with the particular milking schedule.

The installed cost is around US$1,200 for the most popular solar water-heater, which has 20 tubes (4 m² area) and a 200 litre tank. To further boost the uptake of the solar water heaters, Dos Pinos took up a solar loan scheme to assist its members. The cooperative provides loans to its farmers to buy solar water heaters at an annual interest rate of 14%, and promotes the loan programme through its network of agricultural supply stores and advisors.

As a result, between 2009 and April 2015, Enertiva had installed a total of 378 solar water heaters in 337 dairy farms. Benefits to the dairy farmers are reported as follows:

- Solar water heaters save money for the farmers who were already washing equipment with hot water. Enertiva estimates that a typical 60-cow dairy uses about 450 kWh per month to heat water, so saves about US$120 per month.
- 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%.
- Farmers in remote parts of Costa Rica can now also produce better quality products by keeping equipment cleaner, and also reduce their use of detergent. Even farmers who already used hot water noted reduced bacterial counts in their milk, probably because extra cleaning is carried out when the hot water is ‘free’.

**APPLICATION FOR OTHER FARM USES**

Solar thermal technologies can also be utilised for different other applications within a farm setting. There are several ways in which solar thermal technologies can be used in areas such as farm residences, offices and other related buildings. Table 4-9 outlines the various other applications for solar thermal energy within a farm. It can be established that solar thermal energy, among other uses, can be used to generate electricity, cook food, heat water for various purposes, air condition spaces in farm buildings, and even to pasteurise and distillate water for human consumption.
TABLE 4-9: SOLAR THERMAL TECHNOLOGIES FOR OTHER FARM USES

<table>
<thead>
<tr>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrated solar power technologies for electricity generation to power multiple energy demands for farm buildings and other general farm operations</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>Solar thermal water heaters for hot water production in farm buildings</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>Solar thermal water heaters for heating swimming pools at farm houses</td>
<td>Grid electricity</td>
</tr>
<tr>
<td>Solar thermal air-conditioners for heating and cooling farm buildings</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>Solar cookers for cooking applications</td>
<td>Grid electricity, petroleum products, biomass</td>
</tr>
<tr>
<td>Solar thermal technologies for water pasteurisation, distillation to produce fresh water to be consumed in farm residences</td>
<td>Grid electricity</td>
</tr>
</tbody>
</table>
The following is a case study on how solar thermal geysers can be utilised for domestic purposes.

**CASE STUDY: DOMESTIC SOLAR THERMAL CASE STUDY (SOLAHART, N.D)**

Sondela Nature Reserve is situated in Limpopo, South Africa, and it is a popular inland holiday resort. In 2012, a tragic veld fire gutted the nature reserve and other surrounding areas, burning down 60 chalets. The Sondela management used the rebuilding of the 60 chalets as an opportunity to make the nature reserve more sustainable and green. As part of greening the facilities, Sondela installed solar thermal water heaters. The nature reserve needed a solar water heating solution that would require little maintenance, reduce the resort’s high electricity consumption and reduce its carbon footprint. Sixty Solahart 302J were installed to cater for the 60 x 6 sleeper chalets; i.e. one system on each of the chalet, with each chalet requiring 300L of water to be heated to 58-60ºC per day. Consequently, Sondela is now experiencing savings of up to 87% on hot water heating costs per month. According to the technology provider, the nett result of the saving is that the installed solar water heaters’ maintenance costs are lower, the risk of damages caused by burst geysers is eliminated, and the carbon footprint is reduced.

**4.3.3 WIND ENERGY**

**TECHNOLOGY OVERVIEW**

The governing principle of wind energy is based on the transformation of wind flows into rotational movements (Powering Agriculture, 2016a). The rotational force derived from the rotational movements can be used either directly for mechanical energy (e.g. in irrigation pumps, for grinding, and other machinery), 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. Recently, wind turbines from 0.3 kilowatts and others of up to six megawatts have become reliable and cost effective globally (FAO & USAID, 2015).

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 CO2-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, which may be on a large or small (mini-grid) scale• 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

In general, the following are the strengths and weaknesses of wind energy systems (UNIDO, n.d.):

- **Strengths:**
  - Technology is relatively simple and robust, with lifetimes of over 15 years without major new investment
  - Automatic operation with low maintenance requirements
  - No fuel required (no additional costs for fuel nor delivery logistics)
  - Low environmental impacts relative to conventional energy sources
  - Mature, well-developed technology in developed countries

- **Weaknesses:**
  - Site-specific technology (requires a suitable site)
  - Variable power produced therefore it requires storage/back-up
  - High capital/initial investment costs
  - Cranage and transport access problems for installation of larger systems in remote areas
Having discussed the general aspects relating to wind technologies, the following subsections highlight the application of wind energy in agriculture.

**WIND POWER FOR MECHANICAL USES**

Table 4-10 shows how wind power can be utilised to drive machines in agriculture. When windmill technologies are used for pumping water, or when wind powered grain mills are utilised for agro-processing activities, this could lessen the demand for grid electricity as well as that for petroleum products like diesel which are normally used to power generator sets.

**TABLE 4-10: WIND-POWERED AGRICULTURAL MACHINES**

<table>
<thead>
<tr>
<th>Application</th>
<th>Displaced conventional energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windmills are used for pumping water, which can be used for the following farm activities:</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>o Irrigation of crops</td>
<td></td>
</tr>
<tr>
<td>o Watering livestock</td>
<td></td>
</tr>
<tr>
<td>o Supplying drinking water to be used in farm buildings/residences</td>
<td></td>
</tr>
<tr>
<td>Wind powered grain mills for processing grain and animal feeds</td>
<td>Grid electricity, petroleum products</td>
</tr>
</tbody>
</table>

The following is a case study on two local Kenyan manufacturers that produce wind pumps and wind turbines for the local Kenyan market.

**CASE STUDY: WIND PUMPS AND WIND TURBINES IN KENYA (ENERGYPEDIA, 2015)**

Bobs Harries Engineering Limited (BHEL) and Crafts skills Enterprises are two companies that pioneered the local manufacturing of wind pumps and wind generators in Kenya. BHEL manufactures wind pumps for water pumping, which bear the brand name ‘Kijito’. 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. On the other hand, Crafts skills Enterprises started working on wind power machines in 2001, and has since designed wind turbines that:

- operate on bearings
- are rugged
- strong against windstorms
- utilise any slight breeze

The bearings take five to six years to replace and their spare parts are locally available. The wind turbines have charge controllers that enable them to regulate themselves during high wind speeds. Around ninety percent of materials used to manufacture these wind turbines are sourced locally, except for the magnets which are the only imported components.

With respect to the impacts, 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 proved 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.
WIND POWER FOR ELECTRICITY GENERATION

As can be established from Table 4-11, wind energy can also be utilised to generate electricity, which powers various agricultural applications.

TABLE 4-11: WIND ENERGY FOR ELECTRICITY GENERATION

<table>
<thead>
<tr>
<th>Application</th>
<th>Displaced conventional energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind turbines for electricity generation. Wind turbines can meet the electricity needs of an entire farm or can be targeted to specific applications that utilise electricity, e.g.:</td>
<td>Grid electricity, petroleum products</td>
</tr>
<tr>
<td>o General farm building energy demands</td>
<td></td>
</tr>
<tr>
<td>o Irrigation and animal watering systems</td>
<td></td>
</tr>
<tr>
<td>o Greenhouse lighting and temperature controls</td>
<td></td>
</tr>
<tr>
<td>o Heating and cooling of animal and poultry shelters</td>
<td></td>
</tr>
<tr>
<td>o Electric fence charging</td>
<td></td>
</tr>
<tr>
<td>o Farm lighting</td>
<td></td>
</tr>
<tr>
<td>o Powering agro-processing equipment</td>
<td></td>
</tr>
<tr>
<td>o Refrigeration and drying of farm produce</td>
<td></td>
</tr>
<tr>
<td>o Etc.</td>
<td></td>
</tr>
</tbody>
</table>

Wind turbines for electricity generation. Wind turbines can meet the electricity needs of an entire farm or can be targeted to specific applications that utilise electricity, e.g.:

- General farm building energy demands
- Irrigation and animal watering systems
- Greenhouse lighting and temperature controls
- Heating and cooling of animal and poultry shelters
- Electric fence charging
- Farm lighting
- Powering agro-processing equipment
- Refrigeration and drying of farm produce
- Etc.

GRID ELECTRICITY, PETROLEUM PRODUCTS

The following is a case study on small wind turbine products offered by one of the local South African manufacturers of wind technologies, Kestrel.

CASE STUDY: 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.
4.3.4 MICRO-HYDRO ENERGY

TECHNOLOGY OVERVIEW

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). Hydropower plants vary in size, with plants available from very small sizes of only few kilowatts to multi-gigawatts. Small hydropower plants have high potential to be integrated into agricultural value chains (Powering Agriculture, 2016a). These small hydropower plants utilise a simple energy generation principle where water from streams or rivers runs through a turbine, which then rotates and turns machinery/equipment (e.g. pumps, mills, etc.), or a generator to produce electricity (Powering Agriculture, 2016a). In other words, hydropower simply involves the use of energy of moving water to power machinery or to produce electricity.

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

The following are some of the notable strengths and weaknesses of small hydropower systems (UNIDO, n.d.):

### Strengths:
- Hydropower technologies are relatively simple and robust with lifetimes of over 30 years without major investment
- Overall costs can, in many cases, undercut all other alternatives
- Automatic operation with low maintenance requirements
- No fuel required (no additional costs for fuel nor delivery logistics)
- Low environmental impacts relative to conventional energy sources
- Power is available at a fairly constant rate and at all times, subject to water resource availability

### Weaknesses:
- Very site-specific technology
- Small hydropower systems using small streams have limited maximum power, which cannot expand if the energy needs grow
- Droughts and changes in local water and land use can affect power output
- Although power output is generally more predictable, it may fall to very low levels or even zero during dry seasons
- High capital/initial investment costs
- Engineering skills required may be unavailable or expensive to obtain locally

Having noted the general aspects relating to hydropower technologies, the following are some of the applications of hydro energy in agriculture.

HYDRO-POWER FOR MECHANICAL USES

Table 4-12 outlines how hydropower can be utilised to drive agricultural machines resulting in energy savings from the reduced use of grid electricity and petroleum products.

<table>
<thead>
<tr>
<th>Application</th>
<th>Displaced conventional energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower has been previously utilised to generate mechanical energy to power farm machinery such as grinding mills and water pumps for irrigation.</td>
<td>Grid electricity, petroleum products</td>
</tr>
</tbody>
</table>

The following case study on Nepal shows how some countries utilise hydropower to support agriculture-related activities such as grain processing.
CASE STUDY: PICO HYDROPOWERED AGRICULTURAL MILLS IN NEPAL (REEEP, 2015B)

Agriculture is Nepal’s principal sector, contributing around 38% of the country’s GDP, as well as employing over 70% of the population. The majority of the farmers are mostly subsistence farmers, prone to challenges such as limited access to new farming technologies, inputs, and extension services. Furthermore, Nepal is an energy-poor country, having no known fossil fuel reserves of any type and also characterised of a terrain that is extremely difficult to build energy infrastructure.

Faced with such challenges, Nepalese farmers have, for centuries, relied on the country’s vast hydropower potential. The farmers use traditional water mills, known as ghattas, to process their farming produce; e.g. to grind maize and wheat. However, the traditional water mills are not efficient and limited in terms of processing activities, producing only up to 0.5kW and managing 10-20kg of grain per hour.

Against this backdrop, the Clean Energy Development Bank (CEBD) and SNV have since developed an innovative programme that offers a pico hydropower unit (i.e. an improved and efficient version of the water mill), capacity building and targeted financing envisaged at improving the livelihoods of local Nepalese farmers.

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. According to CEBD and SNV, the direct benefits of the improved water mills for Nepalese farmers and food-processing micro-enterprises are as follows:

- Up to 50% increased wheat and grain processing capacity
- A 70% decrease of agricultural waste
- A 30% reduction in cost of production
- Increased income
- Diversification of processing activities

REEEP also estimates that the replacement of traditional water mills and the displacement of diesel generators by the improved water mills could result in Nepal avoiding up to 60 000 tCO2 annually.

HYDROPOWER FOR ELECTRICITY GENERATION

TABLE 4-13 PROVIDES DETAILED INFORMATION ON HYDROPOWER FOR ELECTRICITY GENERATION.

<table>
<thead>
<tr>
<th>Application</th>
<th>Displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower for electricity generation. Similar to other renewable energy resources discussed earlier, 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.):</td>
<td></td>
</tr>
<tr>
<td>o Large-hydro: more than 100MW and usually feeding into a large electricity grid</td>
<td></td>
</tr>
<tr>
<td>o Medium-hydro: 15-100MW and usually feeding into a grid</td>
<td></td>
</tr>
<tr>
<td>o Small-hydro: 1-15MW and usually feeding into a grid</td>
<td></td>
</tr>
<tr>
<td>o Mini-hydro: Above 100kW but below 1MW in either standalone schemes or integrated systems feeding into a grid</td>
<td></td>
</tr>
<tr>
<td>o Micro-hydro: From 5kW up to 100Kw, usually providing power for a small community or rural industry away from the grid</td>
<td></td>
</tr>
<tr>
<td>o Pico-hydro: from a few hundred watts up to 5kW</td>
<td></td>
</tr>
<tr>
<td>Grid electricity, petroleum products</td>
<td></td>
</tr>
</tbody>
</table>


Displaced: Grid electricity, petroleum products.
The following case study provides an example of a pico-hydro system technology that can be utilised to meet certain agricultural electricity demand.

CASE STUDY: THE SMART HYDROPOWER (IN-STREAM TURBINE) (POWERING AGRICULTURE, 2016A)

The Smart Hydropower turbine was developed to produce a maximum amount of electricity with the kinetic energy of flowing waters. The technology is also known as “zero-head” or “in-stream” turbine mainly because it is powered by kinetic energy and not by potential energy. As such, no dams and/or height differences are necessary for the operation of this hydropower technology; the course of a river remains in its natural state and no major investments in infrastructure are required. Because the amount of kinetic energy (velocity) varies from river to river, the capacity of an in-stream turbine ranges from a minimum of a few watts to a maximum of 5 kW.

4.3.5 HYBRID RENEWABLE ENERGY SYSTEMS

TECHNOLOGY OVERVIEW

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). Hybrid renewable energy systems could be a combination of renewable energy sources, which when integrated, could overcome limitations inherent in either; or a combination of conventional energy sources (e.g. fossil fuel-fired generators) with renewable energy sources. 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
- Solar-wind-diesel

Together, hybrid systems provide a more reliable and cost-effective power system than what is possible with either, for example, wind, solar or diesel alone (Powering Agriculture, 2016a). The following are the other notable examples of advantages of hybrid energy systems, among others:

- They can be installed in remote areas isolated from the utility grid
- They could result in reductions for the size of diesel engines and battery storage systems, which could save the fuel as well as reduce pollution
- Reduced environmental impacts
- They improve the load factors and help saving on maintenance and replacement costs
- They could reduce the cost of electricity (i.e. when the integration of diesel systems with renewable power generation occurs)

With respect to the disadvantages, hybrid energy systems are relatively expensive and could also be difficult to combine together, especially where more than two energy sources are involved (Solar Power Notes, 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, e.g. irrigation, electric fencing, lighting, refrigeration and drying systems, space ventilation systems, agro-processing, etc.

The following case study shows how a farmer in South Africa is making use of a solar/wind hybrid energy system in order to meet some of the energy demands at his farm in the Eastern Cape.

CASE STUDY: HYBRID WIND-SOLAR GENERATION IN SOUTH AFRICA (FARMER’S WEEKLY, 2013)

Luke Bell is a livestock farmer from Moltano 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.

4.4 ADOPTION OF BIOENERGY TECHNOLOGIES

Bioenergy generally entails energy derived from a wide variety of material of plant or animal origin. 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 4-3 is an outline of the various conversion processes that can be utilised to beneficiate biomass into different forms of energy.

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:

- Physical/Mechanical: e.g. drying, size reduction, densification, etc. (UNIDO, n.d.).
- Thermochemical processes: e.g. pyrolysis and gasification (Powering Agriculture, 2016a)
- Biochemical: e.g. anaerobic digestion and fermentation (Powering Agriculture, 2016a)
- Other processes: e.g. transesterification (Powering Agriculture, 2016a)

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 in agriculture to produce bioenergy 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.

In general, the strengths and weaknesses of bioenergy conversion systems and the resultant end-products can be presented as follows (UNIDO, n.d.):

- **Strengths:**
  - Conversion technologies are available in a wide range of power levels at different levels of technological complexity
  - Conversion can be to gaseous, liquid or solid fuel state
  - They promote high utilisation of resources since waste products within the agricultural value chain can be used to generate power
  - Low environmental impacts

- **Weaknesses:**
  - Production can create land use competition
  - Often large areas of land required
  - Production can have high fertiliser and water requirements
  - May require complex management systems to ensure constant supply of resource, which is often bulky adding complexity to handling, transport and storage
  - Resource production may be variable depending on local climatic/weather effects, e.g. drought
  - Likely to be uneven resource production throughout the year

It is imperative to reiterate that bioenergy is vital, both as a waste management tool, and as a source of renewable energy. End energy products such as liquid fuels, gas, and electricity play a significant role in agriculture, particularly around lessening the overreliance on unsustainable conventional energy sources such as diesel. Similar to earlier-discussed renewable energy technologies, bioenergy can also be utilised to power various agricultural applications; thus, displacing conventional fuels.

The following sub-sections discuss some of the various earlier-mentioned conversion technologies used to benefit bioenergy in greater detail.

### 4.4.1 PYROLYSIS

**CONVERSION TECHNOLOGY OVERVIEW**

Pyrolysis is an endothermic thermal decomposition process, which utilises high temperatures, mostly around 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. A gas turbine, engine, or boiler can be utilised to convert syngas into electricity.

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). It should be noted that the composition of the end-products varies, depending on the pyrolysis method used, and process conditions such as the applied temperatures (EREF, 2013).

There are many technologies in pyrolysis, and the following are some of the most common:

- **Plasma pyrolysis:** Two high voltage probes create an electrical arc in a field of low pressure gas, which causes the gas molecules to lose an electron and become ionised; the resulting hot, ionised gas is referred to as a “plasma.” When a combination of organic and inorganic waste is introduced into the plasma field, the intense heat breaks the waste products’ molecules into simpler compounds. These gaseous products are then scrubbed to remove contaminants, and burned or used directly in a gas turbine to produce electricity. The resulting products from the gas combustion are carbon monoxides, hydrogen and carbon dioxides from the organic waste and a glassy slag residue from the inorganic waste. The plasma arc itself operates at a temperature of 3,871°C (i.e. 7,000°C).
INTEGRATED WASTE MANAGEMENT: RESEARCH AND TRAINING

- Catalytic pyrolysis: which entails the introduction of fine metallic substances or oxides in the process to increase temperature chock.
- Flash pyrolysis: where the biomass must be ground into fine particles and the insulating char layer that forms at the surface of the reacting particles must be continuously removed.

To date, there is no known commercially profitable standalone pyrolysis plant that specialises in oil production.

In the current carbon emission prevention rationale, pyrolysis of fossil fuel-based products such as tires, plastics and synthetic rubbers is not a good option. Recycling of “cold” products such as pellets or powders, which can be re-moulded into usable products, is the best option.

APPLICATION IN AGRICULTURE

These applications are not feasible in agriculture, but can be used when large amount of continuous waste is available. They require highly engineered and built combustion chambers, which have not yet been scaled to sizes adaptable for domestic use. Only pyrolysis of organic products into bio-char and its derivatives can find applications.

4.4.2 GASIFICATION

CONVERSION TECHNOLOGY OVERVIEW

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). Typical raw materials used in gasification are coal, petroleum-based materials, and organic materials. The feedstock is prepared and fed, in either dry or slurried form, into a sealed reactor chamber called a gasifier. In the case of agriculture, biomass feedstock is heated in a gasifier to a high temperature of above 700°C, with limited oxygen to produce syngas. Most commercial gasification technologies do not use oxygen. All gasification technologies require an energy source to generate heat and begin processing.

Syngas, produced from gasifiers, can either be combusted to produce steam in a boiler for electricity or heat for thermal applications. It can also be chemically transformed through catalytic processes (e.g. Fischer-Tropsch) into methanol, ethanol, etc. (EREF, 2013).

APPLICATION IN AGRICULTURE

Modern engineering designs have converted the size of gasifiers into small units useable by small enterprises for disposal of waste. The heat from gasifiers can also be used to produce steam, which in turn, can be utilised for agricultural applications such as, for example, within the dairy industry, sterilisation and pasteurisation.

The following is a case study on how farming communities in the state of Bihar in India are being powered by electricity generated from biomass gasification plants.

CASE STUDY: HUSK POWER SYSTEMS IN BIHAR, INDIA (UNDP , 2013)

Husk Power Systems (HPS) is a private organisation providing electricity to about 200 000 people across 300 villages in the state of Bihar in India. The organisation installed around 80 biomass gasification plants, which use rice husk as the main raw material to produce electricity. All HPS biomass gasification plants are located in the rice belt of northern India where rice husk is a plentiful agro residue. 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.

Most of the biomass gasification plants are 25–100 kW in capacity, and each uses about 330 kg/day or 50–60kg/hr of rice husk to generate power for six hours a day. A typical HPS biomass gasification plant can serve two to four villages, approximately 500 households within a radius of 1.5 km, depending on size and population.

The total landed cost of a 32 kW plant, including distribution system, is less than US$ 1 000 per kW. The cost of producing 32 kW of electricity per month is Rs 22 000, which includes cost of raw material, salaries, and maintenance. As a by-product, HPS sells ash residue and rice husk char to local incense stick manufacturers and other customers.

4.4.3 ANAEROBIC DIGESTION

CONVERSION TECHNOLOGY OVERVIEW

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.). The methane gas can be utilised to produce electricity or heat.

Within the agriculture sector, there is a wide range of small- to medium-sized biogas reactors that can be used on a farm. These are anaerobic treatment technologies that produce a digested slurry (that can be utilised as a fertiliser) and biogas (for energy applications). They are typically designed to produce biogas at household or community level in rural areas. Installation of such small scale biogas reactors is technologically simple with low energy and space requirements. Factors to consider before installation include (Powering Agriculture, 2016a):

- Size: large, medium, small, micro
- Cost: capital investment required
- Level of technology
- Operation and Maintenance requirements
- Terrain: space available, geotechnical studies, etc.
- Waste characteristics: total solids concentration
- Climate: temperature, rainfall

**APPLICATION IN AGRICULTURE**

Biogas can be utilised either directly for cooking and lighting or for the production of heat through a gas heater system, as well as for cogeneration of electricity and heat (CHP) through a cogeneration unit. It can also be upgraded to natural gas or fuel gas quality. As a result, anaerobic digesters can displace conventional energy sources commonly used on farms, such as grid electricity and petroleum products.

With respect to large farms or agro-processing sites, it should be noted that bio-digesters vary in size, but should be built on the rationale dictated by the availability, type and quality of the feed stock and the analysis in energy needs of the farm/site.

The following are a case studies on farm size anaerobic digesters supplied by a local South African biogas company, BiogasSA; and a pay-as-go biogas technology programme for farmers in Kenya.

**CASE STUDY 1: FARM SIZE DIGESTERS IN SOUTH AFRICA (BIOGASSA, 2016)**

BiogasSA offers two anaerobic digestion technology solutions targeted at the farming sector, i.e., the large Biobag and the Floating Digester.

**THE LARGE BIOBAG**

According to BiogasSA, it can provide customised biobags of up to 50m³ in size, costing around R14 000 to R42 000 per kit, with an estimated payback period of between two and three years, if the technology is self-installed by the farmer. The Biobag Kit comes complete with the actual PVC digester, gas pipes and fittings, in-line gas pressure pump, desulfuriser, safety valve, moisture trap and complete installation and operation manual. It is important to note that there are no generic solutions for these biobags as well as other digester solutions since there are too many variables to consider before installations, e.g., type of feedstock, quantity, temperature, mixing, heating, geographical location, etc.

Nonetheless, the large biobags can typically generate enough biogas to provide energy for the staff accommodation (i.e. stoves for cooking, gas lights, space heating, water heating and potentially enough biogas to run a small generator to provide electricity to charge cell phones and run TV’s). Alternatively, the generated biogas could be used to run a generator and produce electricity to power the farmer’s house. As a rough estimate, a 50m³ biobag digester could potentially produce 25m³ of biogas from the daily manure production from:

- 200 grown pigs
- 35 cattle
- 3500 chickens
- 700kg vegetable waste

Also, as a rough estimate for indication purposes, 1m³ of biogas could provide the following energy support:

- One-hour cooking time on a 2-plate biogas stove
- 20min hot water from a 6l/min biogas geyser
- 15 hours lighting on single biogas light
- 1.5kWh of electricity by running a biogas generator

**THE FLOATING PLUG FLOW DIGESTER**

This medium sized anaerobic digestion solution is currently being developed. It is built from either concrete or brick & mortar, covered by a ‘floating’ type gas dome. It is designed to allow for self-installation by the farmer in order keep the costs as low as possible. The main digester is a rectangular construction with an inlet and outlet manhole very similar to those of the above mentioned Biobag installation, just on a much larger scale. The edge of the dome is anchored in a water channel that runs around the structure, which also serves as gas trap.
This type of structure allows for practical installation of both heating as well as mixing options as pipes can easily be installed through the concrete or brick walls. The solution has been piloted at an Aids Clinic in Johannesburg, while another 100m³ Floating Digester was also installed for the Cane Growers Association in Durban.

Case Study 2: Takamoto Pay-As-You-Go Biogas in Kenya (Powering Agriculture, 2016a)

The company Takamoto has introduced an innovative Pay-as-you-go financing scheme for small-scale biogas systems used for cooking in Kenya. Traditionally, a family-sized biogas system in Kenya would cost US$1 000-US$1 500, but with the Pay-as-you-go scheme, installation is as low as US$100. Once the systems are installed, farmers feed the systems with animal waste (typically from the family cows), and when they are ready to use the biogas, they simply add credit via their mobile phones and the system switches on. These systems are advantageous because most farmers can afford them without taking out loans and paying high installation fees, and Takamoto maintains the system for life.

4.4.4 Fermentation

Conversion Technology Overview

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 remark that Cassava is the starchy crop with the highest energy content per acre; however, it has not been considered in the ethanol production equation.

Application in Agriculture

The produced ethanol can be utilised as a farm transport and machinery fuel, especially as an additive to petrol; thus resulting in a decrease in consumption of fossil fuels. The resultant fuel can also be utilised to power an engine and produce electricity thus supporting all electricity-related applications on a farm.

4.4.5 Transesterification

Conversion Technology Overview

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 purposes (Powering Agriculture, 2016a).

Application in Agriculture

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, nontoxic, 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. After the cost of converting it to biodiesel has been added, the price is too high to compete with petroleum diesel. Waste vegetable oil can often be obtained for free or already treated for a small price. One disadvantage of using waste oil is it must be treated to remove impurities like free fatty acids (FFA) before it can be converted into biodiesel.

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 STUDY: 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. The dairy farmer began experimenting with farm-scale biodiesel production in 2008 following an increase in diesel prices. The farmer began planting oilseed sunflowers on a portion of his 214 acres as well as installing biodiesel processing equipment.

The small-scale biodiesel production facility at the farm is a 74.3 square meter insulated and heated building that houses an oil press, a BioPro 190 automated biodiesel processor, a methanol recovery system, and a set of dry-wash columns for cleaning the fuel. The clean oil at the top of each settling tank is added to the BioPro 190 processor along with lye, methanol, and sulfuric acid. 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.

The finished biodiesel is stored in about 950l pallet tanks. 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. The farmer has since switched from purchasing diesel for five tractors and one truck to making his own biodiesel. 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.
CHAPTER 5
SECP PRACTICES IN SOUTH AFRICA

KEY FINDINGS

Twenty-four associations and agricultural businesses were engaged with and profiled to create an insight into SECP practices in South Africa. It was revealed that the current adoption of the SECP practices in the country is in the emerging stage and is yet to reach a high uptake among agricultural MSMEs. Many associations indicated that they will also take time and significant effort to change the conventional agricultural mindset of farmers and their behavioural tendencies to embrace sustainable agriculture.

Notwithstanding the above, there are a number of agricultural businesses that have successfully championed the deployment of renewable energy and energy efficient technologies making strong business cases for their wide adoption in the sector. The major motivator for farmers adopting SECP practices and shifting towards sustainable agriculture is the anticipated cost savings, which can reduce operational costs and increase agricultural MSMEs competitiveness, followed by the need to reduce their carbon footprint in preparation for the Carbon Tax Bill promulgation.

It should be noted though, that implementation of renewable energy technologies and energy efficient practices comes at a cost. At the same time, knowledge about incentives and funding available to finance the deployment of renewable energy and energy efficient technologies is very limited among farmers and associations, which most likely also contributed to the limited uptake of these technologies in the country at the moment.

SOLAR PV

Solar PV appears to be the most common alternative means of electricity generation implemented by farmers in South Africa using renewables. It reduces their reliance on the grid and sensitivity to electricity price hikes; therefore, resulting in electricity savings for agricultural businesses. It is also the most feasible solution recommended by agricultural associations within South Africa. The average payback period of this technology experienced by farmers’ ranges between three and five years.

Farmers though highlighted a number of challenges when implementing this technology, which included:
- Theft of Solar PV panels
- High costs of battery banks if a large storage capacity is required
- Sourcing of funding for the investment in solar panels

It should also be noted that investing in solar panels is a viable means of renewable energy generation; however, one should consider implementing a hybrid renewable energy system to go completely off-grid as an investment in battery banks to meet a full off grid capacity required to run a farm is usually not financial feasible.
VARIABLE SPEED DRIVES (VSD’S)

VSD is an energy efficient technology that is commonly used among South African farmers. It is usually installed onto irrigation systems to minimise the waste of electricity, but it also allows reduction in the maintenance and repair costs of pumps and motors. VSDs as an energy efficient measure should be used in conjunction with other energy efficient solutions.

BIO-DIGESTERS

The use of bio-digesters is common in the farms producing animals and animal product sub-sectors in South Africa; however, the implementation of bio-digesters on South African farms for energy generation is not as common as solar PV technology. Nonetheless, bio-digesters allow reduction in electricity usage from the grid, which translates into notable savings on the farm’s utility bills. It also offers opportunities for production of various products and energy from waste that can be re-used on the farm (i.e. compost and organic fertilisers). The payback period for bio-digesters, though, is much higher than that for solar PV technologies and averages between eight to 12 years. Furthermore, incentives and funding available for installation of bio-digesters on farms are limited in South Africa; thus, further constraining its wider adoption and deployment in the country. Some other challenges associated with the use of bio-digesters include requirements for extensive management of variable input to determine how much biogas is produced.

LED’S

Energy efficient lighting technologies are common among South African farmers; this is particularly the case for poultry farms that make use of LEDs. Depending on the size of LEDs, they can potentially save about nine times on an electricity bill if they replace incandescent light bulbs (which are currently being phased out in the country) or two times on the electricity bill if they replace compact fluorescent lights (CFLs). Often ignored due to the initial cost, LEDs as a replacement can contribute to marginal savings on electricity costs depending on lighting requirements. Considering the longer lifespan of LEDs and the significant potential monthly savings on utility bills, the payback period though averages a few months.

5.1 OPPORTUNITIES FOR SECP IN AGRICULTURE

Sustainable agriculture is concerned with food security, environmental health, and social interests through the conservation of natural resources. The concepts of sustainable agriculture revolve around zero-waste, biofuels, water and energy efficiency. It is changing the conventional agricultural approach to farming by shifting towards greener practices through the use of innovative technology. The zero-waste theory is centred around agro-ecology and the integration of Biosystems focused on waste management, fuel generation, aquaculture, agriculture, food processing and water use (Coastal & Environmental Services, 2010).

SECP is aligned with the notions around sustainable agriculture, specifically speaking waste management, water and energy efficiency and fuel generation as it proposes alternative renewable energy and energy efficient practices as a transition from conventional to sustainable agriculture. The previous chapter outlined numerous renewable energy and energy efficient technologies that can potentially be deployed in the agricultural sector and specifically in crop production, horticulture and production of animal and animal products.

The engagement with 24 different associations and agricultural MSMEs suggests that not all of the technologies mentioned in the previous chapter are widely adopted in South Africa. The most common practices currently observed are outlined in the table below and are discussed in greater detail further in this chapter.
TABLE 5-1: RENEWABLE ENERGY AND ENERGY EFFICIENCY TECHNOLOGIES THAT ARE ADOPTED IN SOUTH AFRICA

<table>
<thead>
<tr>
<th>Status</th>
<th>Application</th>
<th>Conventional energy displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable energy technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar PV for cooling</td>
<td>Hydro-electric turbines</td>
<td>Bio-digester (cogeneration)</td>
</tr>
<tr>
<td>Biogas plants</td>
<td>Solar PV for heating</td>
<td>Solar PV for pack houses</td>
</tr>
<tr>
<td>Solar thermal water heaters</td>
<td>Solar PV for lighting</td>
<td>Solar PV for cooling</td>
</tr>
<tr>
<td>Solar PV for irrigation</td>
<td>Anaerobic digestion from food waste</td>
<td>Anaerobic digestion from animal waste</td>
</tr>
<tr>
<td>Solar PV for powering machinery</td>
<td>Solar PV for refrigeration vehicles</td>
<td>Solar PV for borehole pumps</td>
</tr>
<tr>
<td>Solar PV for electric fencing and gates</td>
<td>Anaerobic digestion from cattle manure</td>
<td>Gasification from invasive wood trees</td>
</tr>
<tr>
<td><strong>Energy efficiency technologies and solutions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power factor correction capacitors on motors</td>
<td>Shade cloths on greenhouses</td>
<td>LED for lighting in poultry</td>
</tr>
<tr>
<td>Variable speed drives for irrigation</td>
<td>Eskom energy saving initiatives</td>
<td>LED for farming houses</td>
</tr>
</tbody>
</table>

5.2 CROP PRODUCTION PRACTICES TO REDUCE ENERGY USAGE

In crop production, activities that are reliant on sustainable supply of energy are harvesting operations, soil tillage, crop management, pumping irrigation, fertiliser inputs, packaging and transport (Blignaut, 2014). Many of these activities can be performed using renewal energy sources or offer opportunities for the use of energy efficient technologies.

In order to determine the current practices in South Africa, with respect to the use of renewables and energy efficient technologies in the crop production sub-sectors, the following table outlines the case studies that were studied. Their profiles and experience in deployment of renewable energy and energy efficient technologies are profiled further in this section.

TABLE 5-2: ANALYSED CASE STUDIES WITHIN THE CROP PRODUCTION SUB-SECTOR

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Nature of business</th>
<th>Technology/Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>South African Cane Growers Association (SASA)</td>
<td>Sugarcane Farm</td>
<td>Biogas plants from cane leaves</td>
</tr>
<tr>
<td>De Rustica Oliva Farm</td>
<td>Olive Farm</td>
<td>Solar PV for cooling</td>
</tr>
<tr>
<td>Rooibos Ltd</td>
<td>Rooibos Tea Farm</td>
<td>Solar PV</td>
</tr>
<tr>
<td>Olyvenbosch Farm</td>
<td>Olive Farm</td>
<td>VSD’s for irrigation and solar PV panels</td>
</tr>
</tbody>
</table>
Case Study: South African Cane Growers Association (SASA)

**Sugarcane Farms**

**Practice: Biogas plants from cane leaves**

**Case Study Overview**

The South African Cane Growers Association (SASA) promotes sustainable agriculture amongst their members as a green initiative and a measure to lower the operating costs of the farmers. SASA promotes minimum tillage and soil conservation, one of the focal areas relevant to SECP is the promotion of renewable energy and energy efficiency. SASA encourages farmers to invest in biogas plants and utilise cane leaves to create methane gas that can be used to run tractors. There is currently a farmer in the Northern Coast who has a biogas plant with the assistance of SASA.

**Feasibility/Challenges**

- SASA assists members looking to save energy by potentially implementing renewable energy and energy efficiency projects.
- Changing the behaviour and mindsets of farmers from conventional agricultural views to transitioning to sustainable agriculture is a challenge for SASA.
- Sourcing of funding is another constraint farmers experience with implementing these projects and cash flow.
- The impact of the drought has created resistance from farmers, it will take 5 years for farmers to get past the negative financial impact the drought has had on their supply, their primary focus is on supply at the moment.

**Financial Implications**

According to SASA, the majority of the farmers are not aware of financial incentives and how to access it. SASA is only aware of one funding opportunity, which was offered by Dragons Den.

**Benefits**

- Reduces the carbon footprint of cane growers by preventing the release of GHG emissions, promotion of methane gas for fuel and electricity is a much cleaner alternative
- SASA is focused on helping farmers save costs through sustainable farming practices
- SASA assists in the implementation of projects and helps minimize the costs of implementation

**Payback Period**

SASA can assist in working out the payback period for farmers.
### Case Study: De Rustica Oliva Farm

**Olive Farm**

**Practice:** Solar for cooling

**Case Study Overview**
De Rustica Farm has invested in Solar PV panels to meet the electricity demand required for the cooling of their olive storage rooms and provide electricity for their irrigation pumps. In addition, De Rustica Farm is looking at installing VSD’s on their irrigation pumps to save electricity. The Solar PV panels host a capacity of 20kwh.

**Feasibility/Challenges**
The Solar PV panels meets peak demands through summer. De Rustica’s total monthly electricity bill is R60,000-R70,000, using Solar PV to generate energy provides a minor monthly saving of R3,000 per a month thus the need to implement additional energy efficient practices in conjunction with Solar to reduce their monthly electricity bill further. Hence, De Rustica’s potential installation of VSD’s.

**Financial Implications**
The Solar PV panels costed R450,000 and were installed by contactors in the area. De Rustica Farm paid for this themselves, and did not look to banks or financial incentives for funding.

**Benefits**
- Installing Solar PV panels on the farm has generated savings of R3,000 a month on their electricity bills
- The Solar PV panels meet the peak demand times in summer

**Payback Period**
The payback period is 4-5 years as stated by De Rustica farm.

### Case Study: Rooibos Ltd

**Rooibos Tea Farm**

**Practice:** Solar PV

**Case Study Overview**
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 (Colthorpe, 2013).

**Feasibility/Challenges**
One of the requirements for Rooibos to supply the USA and the EU is that they reduce their GHG emissions to mitigate the effects of climate change (Colthorpe, 2013). Implementation of rooftop Solar PV system has an expected reduction of 840.5 tonnes in their carbon dioxide emissions (Colthorpe, 2013).

**Financial Implications**
Cost of the investment was not provided.

**Benefits**
- Lowers Rooibos’s carbon footprint and improves their image as a low-carbon footprint supplier
- SolarWorld guarantees system performance for 25 years, mitigating maintenance and repair costs associated with poorly installed panels
- Reduces exposure to rising Eskom electricity tariffs

**Payback Period**
The payback period was not identified.
Case Study: Klipopmekaar Rooibos Farm

Rooibos Tea Farm | Practice: Solar thermal water heaters and Solar PV for irrigation

Case Study Overview

High input costs in crop production are a result of extensive crop irrigation required in the sector (Sunworx 2016). Klipopmekaar Farm has invested in Solar PV panels to power their 3kwh water pump. Their guesthouse has 8 Solar PV panels on the roof which they use to run their household, some of the houses on the farm run completely off grid. The power is used to heat water for some of the houses which are installed with solar water heaters.

Feasibility/Challenges

Solar has been a feasible solution for Klipopmekaar Farm, as a result they are considering investing in additional Solar PV panels so they can feed electricity into the grid. However, this will only be done once Eskom provides a rebate for them to do so.

Financial Implications

Klipopmekaar Farm funded the panels themselves, they did receive non-financial assistance with the project from the Green Alliance.

Benefits

Savings on their electricity bill was the biggest benefit Klipopmekaar Farm indicated

Payback Period

The payback period is 3-4 years.

5.3 HORTICULTURAL PRACTICES TO REDUCE ENERGY USAGE

Greenhouses within the horticultural sub-sector consume the largest amount of energy; 90% of the energy is used during the heating process in the greenhouses creating GHG emissions. As a result, carbon dioxide is created, which pollutes the air (Carbon Trust, 2016). Conventional greenhouse practices releasing significant amounts of GHG emissions are not sustainable in the long-run. With the proposed Carbon Tax Bill coming into effect, many farmers are looking to reduce their carbon emissions to avoid tax implications.

A farmer operating in horticultural farming could potentially reduce their energy usage on a farm by using energy efficient machinery and equipment to improve their irrigation systems and greenhouse maintenance systems. In horticulture, shade cloths, speed drives, and lighting can be used to save on electricity and energy costs.

In order to determine the current SECP practices among horticultural producers in the country, the following case studies were reviewed:

5-2: ANALYSED CASE STUDIES WITHIN THE CROP PRODUCTION SUB-SECTOR

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Nature of business</th>
<th>Technology/Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murludi farm in the Western Cape</td>
<td>Fruit farm</td>
<td>Hydro-electric turbines</td>
</tr>
<tr>
<td>Murludi farm in the Western Cape</td>
<td>Fruit farm</td>
<td>Power factor correction capacitator on motors</td>
</tr>
<tr>
<td>Jomajoco a Lettuce farm in Tarlton</td>
<td>Lettuce farm</td>
<td>Shade cloths on greenhouses and speed drives on irrigation pumps</td>
</tr>
</tbody>
</table>
Case Study: The South African Subtropical Growers’ Association (Subtrop)

**Nature of business:** Avocado and macadamia growers

**Technology/Practice:** Solar power generation and Eskom energy saving initiatives

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Case Study: Harvest Fresh Vegetable farm

**Nature of business:** Vegetable farm

**Technology/Practice:** Solar PV

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Case Study: Oldenburg Vineyards Wine vineyard

**Nature of business:** Wine vineyard

**Technology/Practice:** Solar for lighting

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Case Study: Greenway Farms Rugani carrot farm

**Nature of business:** Rugani carrot farm

**Technology/Practice:** Anaerobic digestion in a biodigester

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Case Study: Southern Farms Grape farm

**Nature of business:** Grape farm

**Technology/Practice:** Solar PV

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Case Study: Ceres Fruit Growers Fruit farm

**Nature of business:** Fruit farm

**Technology/Practice:** Solar for cooling

---

Case Study: Murludi farm in the Western Cape

**Practice:** Hydro-electric turbines

---

**Case Study Overview**

Hydro-power in agriculture is becoming a viable means of electricity generation, it has evolved as an energy cost saving solution that reduces the reliance on the grid to generate electricity; thus mitigating the risk of power outages effecting farming operations (Eskom, 2016). Kobus van der Westhuizen, owner of the Murludi fruit farm in the Western Cape has often struggled with the impact frequent power cuts have had on his business. He has lost thousands of Rands due to power failures, resulting in machinery breakdowns (Kriel, 2015). At the end of 2013, he decided to install a hydro-electric turbines consisting of 4 units as a solution to his problems.

**Feasibility/Challenges**

Kobus’s Murludi farm is located below the springs in the Witzenberg mountain range. Using water from the spring to generate electricity was feasible for alternative energy production. Furthermore, it also promotes minimum water waste as the excess water after going through the hydro-electric turbine is then returned back into the spring.

**Financial Implications**

An additional investment was required to mitigate the risk of electricity fluctuations caused by variations in the water flow supply. Battery banks were purchased by Kobus to prevent machinery getting damaged, it prevents the costly replacement and repairing of equipment (Kriel, 2015).

**Benefits**

- 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 (Kriel, 2015)
- The turbines can meet the demand of up to 124kWh during fruit season and the unit can deliver 29kWh in total
- Kobus also managed to reduce his Eskom electricity consumption by 22 000kWh in 2015 (Kriel, 2015)
- Savings maintenance of his equipment are benefits he has gained
- 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 (Kriel, 2015).

**Payback Period**

The payback period is indicated to be 5 years; this will come from energy savings and savings on maintenance and repair costs (Kriel, 2015).
Case Study: Murludi farm in the Western Cape

Rooibos Tea Farm  |  Practice: Solar thermal water heaters and Solar PV for irrigation

**Case Study Overview**

A power factor correction capacitor within agriculture can be used for equipment used in farming operations as an energy efficient measure to reduce the electricity usage when operating the equipment and motors. In addition to the hydro-electric turbines, Kobus experienced issues with mechanical failure and breakage of compressors, a common malfunction on motor operated equipment on farms that results from leakages in electric networks. This was a costly situation Kobus found himself in annually. He installed a power factor correction capacitor which limited the amount of energy lost and ensured that there was a constant supply of electricity provided through the magnetic field on the induction motor (Kriel, 2015).

**Feasibility/Challenges**

Investment in a power factor correction capacitor reduced costly expenses such as repairing compressors and equipment and also reduced productivity loss from the compressors and equipment not working.

**Financial Implications**

The cost of the power capacitor was not included.

**Benefits**

As well as reducing Kobus’s electricity bills by using less power, his investment in this motor has shifted the farms maximum electricity demand from 130kWh to 87kWh which means he avoids the R18,000 fine he was paying for using too much electricity (Kriel, 2015).

**Payback Period**

The payback period for Kobus’s investment is only a year, which comes from the annual repair/replacement savings on compressors or electrical equipment. A replacement compressor costs R33,000 to replace.
Case Study: Jomajoco a Lettuce farm in Tarlton

<table>
<thead>
<tr>
<th>Lettuce farm</th>
<th>Practice: Shade cloths on greenhouses and speed drives on irrigation pumps</th>
</tr>
</thead>
</table>

Case Study Overview

The application of energy efficient and water efficient technologies are based around saving energy whilst increasing yields, so production is not compromised. Johan van den Bosch is one of the country’s leading greenhouse producers with his lettuce and herb farm in Tarlton, and he participates in the customer Woolworth’s Farming for the Future programme (Claassen, 2014). He has installed a shade cloth on his greenhouse and a speed drive on his irrigation pumps to save energy on the farm. In addition, Johan has partnered with Dutch suppliers as well as the Embassy of the Kingdom of Netherlands to use his farm as a training facility for other farmers to learn how to use advanced technology which promotes sustainable agriculture. He also installed a VSD on his 22kW borehole pump to ensure the pump runs at 31A instead of 41A (Claassen, 2014).

Feasibility/Challenges

A shade cloth is a woven piece of fabric that sits a few feet above the plants or is installed over the top of a greenhouse structure to protect the plants by shading out a percentage of the sun (Claassen, 2014). Depending on the conditions of a specific greenhouse, a shade cloth can be designed to a thickness that would be suitable, the installation of the shade cloth is fairly simple and cost effective. Traditional greenhouse systems rely on a combination of heaters, fans, and ventilation devices to control the humidity and temperature so it stays at a constant rate; however, this is heavily reliant on electricity and is a costly investment (Baley, 2014). Shade cloths can reduce the dependency on expensive traditional greenhouse systems.

Financial Implications

A speed drive costed Johan R40,000 to purchase (Claassen, 2014).

Benefits

- Reduces the reliance of inputs required for open-field production and avoids overheating in the greenhouse during summer
- Shade cloths on greenhouses reduce the amount of electricity required to run open-field activities such as crop rotation, tractors, rippers and ploughs (Claassen, 2014)
- Shade cloths allow for control of temperature and keep the greenhouse cool
- Allows growing lettuce all year without worrying about the impact of weather conditions in summer

Payback Period

The payback period for his speed drive device was only four months, as it costed R40,000 to buy and the monthly electricity savings equate to R10,000 as a result of the system (Claassen, 2014).
Case Study: The South African Subtropical Growers’ Association (Subtrop)

| Avocado and macadamia growers | Practice: Solar power generation and Eskom energy saving initiatives |

Case Study Overview
Agricultural farms boast perfect conditions for solar power generation because of the amount of sunlight they receive. Unused land, rooftops, solar powered drying systems and solar powered heat generation for greenhouses can reduce electricity consumption and the reliance of grid electricity (Soventix, 2014). The South African Subtropical Growers Association (Subtrop) promotes sustainable agricultural practices and renewable energy practices amongst its members. They promote organic farming, cover cropping, biological/eco-friendly pesticides, compost tea fertilisation, mulching, solar power generation, Eskom energy saving initiatives for the agricultural sector and macadamia husks for heat-drying in processing plants. Subtrop discusses the benefits of transitioning to renewable energy and energy efficiency solutions through study groups and farmer days which target their members and they enlist energy experts to explain the benefits and the technology. Avocado and macadamia growers have implemented macadamia husk heat generation and solar power for electricity generation in avocado pack houses.

Feasibility/Challenges
- Associations have limited awareness of incentives available
- One of the challenges faced by members has been identified as lack of knowledge of funding or incentive programmes
- Associations experience difficulties persuading growers of the benefits of transiting to sustainable agriculture

Financial Implications
Information on the financial implications involved was not provided by Subtrop; however, Subtrop did acknowledge sourcing funding for renewable energy and energy efficiency projects was difficult for the members.

Benefits
- Better pest control
- Irrigation water savings
- Better soil health
- Cost savings and avoidance of being impacted by load shedding and electricity tariff hikes
- Reduction in cable theft

Payback Period
Subtrop did not provide information on the payback period of the member’s investments.
Case Study: Harvest Fresh

Vegetable farm | Practice: Solar power

Case Study Overview
Harvestfresh Farms are currently looking at implementing Solar technology on their farm. This is currently in the planning stage and they are going through a German company to do the installation. They have expressed that they cannot rely on Eskom, thus they are quite serious about implementing Solar PV on their farm.

Feasibility/Challenges
An energy audit will possibly be conducted to determine energy savings and identify whether Solar would provide adequate electricity generation for the farm.

Financial Implications
Due to the project still being in the planning stage, the financial implications could not be identified as yet.

Benefits
Harvestfresh expressed the following potential benefits that led to the potential implementation of Solar PV technology on their farm:
- Harvestfresh is a part of Woolworths Holding Limited. Woolworth's promotes the Farming for the Future approach, which is centred around growing food sustainably (reference)
- Renewable energy will reduce their carbon footprint
- Harvestfresh’s reliance on Eskom will decrease
- Mitigation of price hike sensitivity

Payback Period
No payback period has been identified at this stage as the project is still in the planning stage.
## Case Study: Olderburg Vineyards

**Wine vineyard**

**Practice: Solar for lighting**

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### Case Study Overview

Oldenburg Vineyards use Solar PV panels to generate energy in which they use for lighting, offices, wine tasting centre, guesthouses and irrigation pumps. In addition, they feed electricity generated into the grid. They have 119 panels in which they have invested in. They are looking at investing in more Solar PV panels for their new wine vineyard, which will be covered in Solar PV panels.

### Feasibility/Challenges

- One of the challenges expressed was theft of the panels, preventable measures had to be taken to ensure panels do not get stolen
- The Solar PV panels are still linked to the grid so when Eskom is offline it still creates challenges
- Oldenburg Vineyards have not invested in batteries as they are too expensive at this stage, they cannot store electricity generated from the panels due to this

### Financial Implications

Eskom was supposed to provide a rebate for the installation of the Solar panels; however, Oldenburg Vineyards have been waiting 4 years for this and still have not received any form of rebate.

### Benefits

- They generate 73,948 kwh from the unit, Eskom power can generate 95,000 kwh
- Eskom electricity costed R173,000 per annum, with Solar panels they are now saving on that cost
- During midday, the Solar panels can accommodate 85% of the electricity demand

### Payback Period

The payback period is unknown at this stage.
### Case Study: Greenway Farms

**Carrot farm**  
**Practice: Anaerobic digestion in a bio-digester**

| Practice | Greenway Farms  
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Anaerobic digestion in a bio-digester</td>
<td>Greenway Farms</td>
</tr>
</tbody>
</table>

#### Case Study Overview

Greenway Farms is focused on sustainable agriculture and nature conservation; they apply sustainable practices in their carrot production. They have a biogas plant on their farm, they feed carrot pulp waste into their bio-digester and use the methane gas to fuel their boilers in their carrot juice factory. They are considering implementing a second bio-digester to cogenerate.

#### Feasibility/Challenges

The biggest challenge Greenway Farms faced was the regulatory requirements that came with implementing a methane plant. Before setting up the bio-digester, an economic impact assessment had to be conducted, engineering certificates produced and government laws adhered to. Greenway Farms say that their experience in implementing a methane gas plant was difficult because the government offered little support, instead over regulated requirements and restrictions made the process timeous and costly.

#### Financial Implications

Greenway Farms also experienced difficulties with funding, the financial proposal was completed by the Industrial Development Corporation (IDC). They applied for loans but opted out of this route and the security perquisites were higher than what most other loans asked for. In addition, there were a lot of additional audit requirements and costs involved.

#### Benefits

The initial start-up costs of a bio-digester are expensive; however, the long-term benefits are electricity savings.

#### Payback Period

The payback period is indicated by Greenway Farms to be between 8-10 years.
### Case Study: Southern Farms

**Grape farm**  
Practice: Solar for houses

#### Case Study Overview

Southern Farms are grape producers looking at implementing Solar PV panels. At this stage, the project is still in the planning stage and they’re conducting energy audits to determine feasibility, energy usage and potential savings. They are looking to use solar power for electricity generation to run irrigation operations, pack houses, pumps and labour houses.

#### Feasibility/Challenges

Southern Farms see Solar PV panels to be a feasible solution over other renewable energy means given their location in the Northern Cape and the high sun density. However, one challenge identified that Solar would provide a solution for electricity costs but would not provide a solution for fuel.

#### Financial Implications

Funding sources and financial implications will be looked at after the energy audit is completed; however, they will look into incentives as possible means for funding.

#### Benefits

- Reduces their carbon footprint
- Savings on their electricity bill
- Greener image

#### Payback Period

No payback period has been identified as yet.

### Case Study: Ceres Fruit Growers

**Fruit farm**  
Practice: Solar for cooling

#### Case Study Overview

Ceres Fruit Growers boasts one of the largest agricultural rooftop Solar PV system within South Africa. The large fruit producer invested in 4,060 SW250 polycrystalline panels (Colthorpe, 2013). The area of Ceres Fruit Growers is 54 hectares which has 100 cold storage units.

#### Feasibility/Challenges

No challenges were identified in the article. The implementation of the Solar PV is helping many farms reduce their carbon footprint before the Carbon Tax Bill comes into effect.

#### Financial Implications

The financial implications were not indicated.

#### Benefits

- The Solar technology contributes to 6% of Ceres's annual electricity consumption (Colthorpe, 2013)
- Reduces the impact of rising electricity tariffs
- Reduces the carbon footprint of Ceres by over 1,622 tonnes each year for the next 25 years (Colthorpe, 2013)

#### Payback Period

No payback period was identified in the article.
5.4 ANIMAL AND ANIMAL PRODUCT PRACTICES TO REDUCE ENERGY USAGE

Fossil fuels in animal and animal products are a major input in livestock activities such as production, processing, transport and storage (Veermäe, 2012). The demand for animal and animal products is continually growing; therefore, leading to the increase in energy consumption by the sector (Veermäe, 2012).

In order to determine the current practices of South African farmers in the animal and animal products sub-sectors aimed at reducing the use of fossil fuels and saving on their energy bills, the following case studies were studied.

**TABLE 5-4: ANALYSED CASE STUDIES WITHIN THE ANIMAL AND ANIMAL PRODUCTS SUB-SECTOR**

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Nature of business</th>
<th>Technology/Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>The South African Mohair Growers’ Association (SAMGA)</td>
<td>Animal products</td>
<td>Solar pumps and solar irrigation pumps</td>
</tr>
<tr>
<td>Biogas SA</td>
<td>Organic waste</td>
<td>Biogas plants</td>
</tr>
<tr>
<td>Humpheries Boerdery Piggery</td>
<td>Pig farming</td>
<td>Solar for heating and irrigation</td>
</tr>
<tr>
<td>Humpheries Boerdery Piggery</td>
<td>Pig farming</td>
<td>Anaerobic digestion in a biogas digester from animal waste</td>
</tr>
<tr>
<td>Camphill Village Farm</td>
<td>Dairy and vegetable farming</td>
<td>Solar PV- thin film for heating and powering machinery</td>
</tr>
<tr>
<td>Red Barn Free Range Chickens</td>
<td>Poultry farming</td>
<td>Solar for borehole pumps and irrigation</td>
</tr>
<tr>
<td>Belnori Boutique Cheesery</td>
<td>Animal products- goat cheese</td>
<td>LED lighting</td>
</tr>
<tr>
<td>Enaleni Farm</td>
<td>Meat and poultry farming</td>
<td>LED lighting and Solar electric fencing and gates</td>
</tr>
<tr>
<td>Uilenkraal Farm</td>
<td>Dairy farm</td>
<td>Anaerobic digestion from cattle manure (bio-digester)</td>
</tr>
<tr>
<td>Coredale Farms</td>
<td>Poultry farming</td>
<td>Gasification wood from invasive alien trees</td>
</tr>
</tbody>
</table>
Case Study: The South African Mohair Growers’ Association (SAMGA)

Animal products  Practice: Solar pumps and solar irrigation pumps

Case Study Overview

The uses of solar pumps and solar irrigation are sustainable agricultural practices. The investment costs are relatively low for these energy efficient technologies and have reduced over the years. They also require low if are of good quality and installed properly (FAO, 2015). The environmental benefits cannot be ignored as solar pumps and irrigation contribute to climate change and reduce the GHG emissions. SAMGA promotes the use of solar technology amongst its members because as they believe it is a viable source of alternative electricity generation, in addition they promote other sustainable agricultural practices such as zero waste. On-farm assessments are provided to educate their members on solar technology and encourage them to use it.

Feasibility/Challenges

- SAMGA is not aware of incentives or financial assistance available for their members
- A challenge identified by Mohair was theft of equipment
- About 50% of members in the association have invested in renewable energy and energy efficiency solutions
- Angora goat farmers are said to be very conservative farmers making it difficult to change their view on conventional farming practices

Financial Implications

No specific information is given on the cost; however, it is expressed by the association that the cost of solar technology is relatively low with a reasonable payback period.

Benefits

- Solar electricity generation is an alternative to avoid reliance on the grid
- SAMGA sees solar power as a more cost effective option
- SAMGA states solar is easy to install
- Reduces the dependency on labour

Payback Period

SAMGA identifies the payback period for investing in solar to be 3-5 years; that is why it is promoted amongst their members because the payback time frame works.
## Case Study: Biogas SA

**Animal products** | **Practice: Solar pumps and solar irrigation pumps**

### Case Study Overview

Biogas SA promotes organic waste utilisation to its members through various platforms. They also engage with the Department of Agriculture to promote waste management. The two options they have developed for as solutions are:

- Large Biobags
- Floating Digeste

### Feasibility/Challenges

- The solution is feasible for abattoirs in particular as waste management regulations for landfill waste is becoming stricter
- Biogas SA states they struggle with financial assistance for biogas plants
- No generic solution for biogas as there are a lot of variables which determine the amount of biogas produced

### Financial Implications

A biogas plant becomes financially viable after a 350kWe plant upward, in addition the cost of setting up a biogas plant is expensive due to the electricity tariffs, operating costs and capital costs (Biogas SA, 2016).

### Benefits

- Biogas can be used as a fuel to run generators (Biogas SA, 2016)
- Floating Digeste and Biobags can be installed and constructed by a farmer themselves, thus lowering the cost

### Payback Period

According to Biogas SA, (2016), the payback period for a biogas plant is 5-8 years. The payback period for a large Biobag is 2-3 years.
Case Study: Humpheries Boerdery Piggery

Pig farming - Practice: Solar for heating and irrigation

Case Study Overview

Within agriculture, Solar PV systems can reduce the input costs of electricity therefore reducing the electricity bills of farmers. It can also serve as electricity generation for feeders, ventilation, heating, cooling, irrigation and many other processes (Sunworx 2016). The deployment of a Solar PV system on a farm is not complex, it requires a roof to install panels or an open piece of land where panels can be installed. Maintenance of the panels are also simple. It can also be seen as an investment for farmers to either feed electricity into the grid or increase the value of their property as renewable energy technology is popular due to the increasing electricity prices hikes. Solar panels are used for electricity generation, heating and on irrigation pumps on Humpheries Boerdery Piggery farm.

Feasibility/Challenges

Piggery farms require heating at night, particularly in winter. With the amount of batteries that Humpheries Boerdery Piggery farm, have their capacity only allows for storage of electricity for up to 2-3 hours at night, which they use for heating on their breeding site. When load shedding occurs, it is just as expensive because it takes a lot of electricity to charge the batteries. Solar power is feasible for use during the day, if there are large amounts of electricity required throughout the night it maybe not be suitable if the storage capacity of the batteries is limited.

Financial Implications

Investment in batteries is required to store electricity. To run electricity throughout the whole night and solely rely on solar for electricity generation it would require a lot of batteries; therefore, for it would be expensive and charging the batteries would increase electricity bills.

Benefits

- Capacity of electricity in the evenings is 60-70kWh at night
- Solar PV panels are used to generate electricity for multiple uses on the piggery farm

Payback Period

The payback period was not indicated.
**Case Study: Humphries Boerdery Piggery**

<table>
<thead>
<tr>
<th>Pig farming</th>
<th>Practice: Anaerobic digestion in a bio-digester from animal waste</th>
</tr>
</thead>
</table>

**Case Study Overview**

Humphries Boerdery Piggery had a bio-digester in which they fed pig manure, washed water and solids and used the methane gas as fuel for the generator. This has been stopped due to the methane gas affecting the generator’s engine. After the waste has been put into the digester, the water is reused on the farm. They are currently looking at investing in a bio-digester again to use the gas emitted for fuel and electricity again; however, they have acknowledged it will take time as an impact assessment will first need to be conducted so the digester is successful this time.

**Feasibility/Challenges**

Before Humphries Boerdery Piggery makes use of a bio-digester to generate energy again, they have indicated that they need to ensure the correct process is followed so the methane gas does not affect the engine.

**Financial Implications**

The financial implications for installing a bio-digester was not indicated. Although when speaking to Humphries Boerdery Piggery incentives were discussed; however, there were concerns raised as to whether or not funding would be provided for the full cost.

**Benefits**

The generator ran on methane gas from the bio-digester and was able to generate 60kwh in the day and 20kwh at night. The overall capacity was 70kwh.

**Payback Period**

The payback period was not shared.
Case Study: Camphill Village Farm

Dairy and vegetable farming  Practice: Solar PV- thin film for heating and powering machinery

Case Study Overview

Camphill Village Farm has been using solar technology for the past 2 years to run their operations, although they still rely on Eskom the idea is to go completely off grid. They use solar power for their pasteurizers, heating of water, milking machines and pumping of water. Initially the solar plant was a 20kwh plant it now has a capacity of 60kwh. 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.

Feasibility/Challenges

Using a new thin film technology allows for the production of energy to be steady even during overcast days. The overall long-term goal of Camphill Village is to be completely off-grid, in the interim dependency on Eskom still remains a challenge. An energy audit was conducted for the project to determine feasibility and savings.

Financial Implications

Camphill Village Farm did receive funding for the solar project implementation, they do not want to disclose the beneficiary. Although, their website does indicate that phase one of the project was supported by German based Rays of Hope Foundation who sourced funding for components and technology from BAE, Dehn, First Solar, Hanel Projects, Lahmeyer International, Leschaco, Q3, Schletter, Sieckmann Engineering, SMA Solar Technology, Solardura, Southern Sun Solar and UFE (Camphill Village West Cost, 2015).

Benefits

- In summer they save R14,000 a month as a result for solar electricity generation
- R8,000 a month is saved in winter as a result for solar electricity generation
- Over the next 20 years the anticipated savings on electricity costs are R1.44 million (Camphill Village West Cost, 2015)
- Reduction in Camphill Village Farm’s carbon footprint
- Capacity to produce 28 000 litres of dairy products from the Solar PV plant

Payback Period

The anticipated payback period is 5 years for the implementation of the Solar PV panels.
**Case Study: Red Barn Free Range Chickens**

### Poultry farming Practice: Solar for borehole pumps and LED lighting

#### Case Study Overview

Red Barn Free Range Chickens installed 32 Solar PV panels on the roof of their processing area as a result of the pressure faced from electricity price hikes. The Solar PV panels provide electricity to run all of the fridges and provide electricity for the borehole pumps. In addition, they have invested in LED lighting throughout the whole farm. There are plans to install additional Solar PV panels to provide electricity for the additional pumps and geysers on the farm.

#### Feasibility/Challenges

One of the challenges faced by Red Barn Free Range Chickens was finding an experienced Solar PV installer in George who could install a 3 phase system.

#### Financial Implications

Red Barn Free Range Chickens paid for the solar panels themselves and were not aware of incentives offered. For future installation of additional panels, they are eager to look at incentives that are available.

#### Benefits

- 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
- Long-term savings are 20-25% savings on their electricity bills as they hope to go completely off grid

#### Payback Period

Red Barn Free Range Chickens sees this project as a long-term project and the payback period is anticipated to be 10 years.

**Case Study: Belnori Boutique Cheesery**

### Animal products- goat cheese Practice: LED lights

#### Case Study Overview

Belnori has installed LED lighting on their farm and they are looking at installing Solar PV panels on their refrigeration vehicles. Monthly meetings are held to see where they can cut costs, electricity being one of the focal areas.

#### Feasibility/Challenges

One of the challenges they currently face is a generator that is heavily reliant on fuel, they are looking at cutting costs in this area as well.

#### Financial Implications

LED lights cost between R100-150 each.

#### Benefits

- Less use of Eskom electricity with the LED lights resulting in savings on their electricity bills
- LED lights last long

#### Payback Period

The payback period was not indicated by the farmer.
### Case Study: Enaleni Farm

<table>
<thead>
<tr>
<th>Meat and poultry Farm</th>
<th>Practice: LED lighting and Solar electric fencing and gates</th>
</tr>
</thead>
</table>

#### Case Study Overview
Enaleni farmers are small scale agro-ecological farmers who have invested in LED lighting for their housing facilities and solar powered gates and fences for their animals. Enaleni Farm did use a bio-digester to generate gas; this did not work because it was a moulded digester made from recycled plastic so the gas kept leaking and there were numerous attempts to seal it properly in which were not successful. They promote zero-waste through the utilisation of animal manure waste used as liquid manure which is put back onto the land.

#### Feasibility/Challenges
Challenges occurred with the maintenance of the bio-digester once installed.

#### Financial Implications
The cost of the LED lights was between R100-R150. This was funded by the farm themselves and they are not aware of incentives that assist with funding for energy efficient practices.

#### Benefits
The initial cost of investing in LED lighting is expensive but the long-term savings are the reduction in their electricity bills.

#### Payback Period
The payback period was not provided by the farmer.
Case Study: Uilenkraal Farm

**Dairy farm**

**Practice: Anaerobic digestion from cattle manure (bio-digester)**

---

**Case Study Overview**

Uilenkraal farm has implemented a bio-digester which use cattle manure as fuel to generate electricity for their farm (Claassen, 2015). Inspired by the European implementation of biogas plants fuelled from cow manure, Uilenkraal farm sort to a local engineering company in the Western Cape South Africa to design a low-cost rectangular tent-like structure suitable for the specific needs of their farm (Claassen, 2015). The biogas fuels their 2 generators, resulting in a production capacity of 200kWh a day for each generator.

**Feasibility/Challenges**

The bio-digester is a feasible long-term solution as the bio-digester has a 30-year lifespan due to its design. A key challenge identified by Uilenkraal farm, was that there are not many farmers who produced a sufficient amount of biogas and have a large enough electricity demand to justify investing in a biogas plant, a solution in which he believes will motivate biogas is compensation from Eskom to feed electricity into the grid (Claassen, 2015). Uileenkraal farm produces double the amount of biogas needed daily, as a result the excess biogas is burnt off from a flare stack, in essence is wasted (Claassen, 2015). Another challenge commonly associated with bio-digesters are the controlling of variables, parameters and inputs in order to ensure quality and stability.

**Financial Implications**

Investment in the plant costed R10 million (Claassen, 2015).

**Benefits**

- Potential use of compost from the bio-digester for on farm crops
- 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 (Claassen, 2015)
- No moving parts in the bio-digester allows for simplistic maintenance

**Payback Period**

The payback period is 10 years.
### Case Study: Coredale Farms

**Practice:** Gasification wood from invasive alien trees

**Poultry farming**

**Case Study Overview**

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 due escalating gas bills. The gas boilers have a capacity of 130kWh, which meets the demands to dry and heat out the litter (Kriel, 2015). Coredale Farm uses the technology to burn wood on an open fire, which is then used to heat the water in a donkey boiler then the gases being burnt through the process is used to heat water. Coredale Farms is looking at implementing other renewable energy technologies to form a hybrid renewable energy system operating completely off grid.

**Feasibility/Challenges**

A wood gasification boiler is a more affordable solution for broiler houses than bio-digestors and it is easier to control and manage.

**Financial Implications**

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 (Kriel, 2015).

**Benefits**

- Reduces humidity levels in broiler houses
- The process in wood gasification is an indirect generation of heat, therefore it does not consume oxygen and water is not generated as a by-product (Kriel, 2015)
- Provides a better ventilation environment for chickens to grow as a result of improved capacity in Coredale Farms newer machines (Kriel, 2015)
- Heating costs for chicken decreased from R1,88/chicken to 6c/chicken
- Only 10% of energy is lost during the gasification process
- Remaining ash is used as compost for the farm

**Payback Period**

The payback period for this system was 2 years, and this came from the savings as a result of reduced heating costs (Kriel, 2015).
CHAPTER 6 SUPPORT MECHANISMS AND INITIATIVES

KEY FINDINGS

This chapter provides an overview of support mechanisms and initiatives in the form of financial assistance, non-financial assistance, or tools for the implementation of renewable energy and energy efficiency projects and solutions. Below is a list of mechanisms that can be seen in this chapter. An investigation was undertaken to analyse the nature of assistance, the spatial coverage, target industries and sub-sectors, background on the mechanism/initiative, features of note, eligibility criteria and the application process.

FINANCIAL MECHANISMS

Numerous financial mechanisms were identified to be available in South Africa to assist with deployment of renewable energy technologies and energy efficient practices. These are available in the form of loans, tax incentives, rebates, and grants. Most of these mechanisms do not specify technology that is eligible for financial assistance and are not specific to the agricultural sector. However, knowledge of these as well as accessing these mechanisms appears to be one for the biggest bottlenecks, suggesting that financial support in practice is not very well developed. Generally, the following can be highlighted:

Banks
- Some banks offered tailored solutions
- Rebates were offered by ABSA and Nedbank
- Low interest rates
- Eligibility determined by credit ratings

Government Organisations
- Additional non-financial assistance is provided such as energy audits, technical expertise not limited to these benefits
- Proven energy savings are required in some instances
- It was found that eligibility criteria’s and application processes were extensive and target larger-scale farmers
- Small-scale farmers may not be able to produce the required information such as business plans, cash flows and other documentation required nor have the skill set to construct them
- Timeous application processes are a constraint for some financial offering
- Eligibility is dependent on the projects contribution to the countries environmental goals, the economy and the overall financial viability of the project

Non-governmental Organisations
- Highly competitive
- Limited funding is available
- Eligibility criteria can be difficult to meet

It appears that smaller agricultural businesses are likely to have the biggest challenges in accessing financial support. Small-scale farmers wanting to access funding independently may experience difficulties in terms of eligibility. Therefore, a farmer should consider going through an association to access funding for their projects to increase their probability of success. In addition, it should be noted that the support mechanisms available within South Africa are not technology-specific in terms of focus.
NON-FINANCIAL MECHANISMS

Programmes promoting renewable energy and efficiency projects were limited within South Africa and are concentrated on advisory service offerings rather than incentives for farmers to shift to SECP practices. They fall short in assisting farmers in the actual implementation of the projects. However, the technical expertise and energy audits offered could provide beneficial support for a farmer in the early stages of project implementation where it is applicable.

TOOLS

Pre-Assessments for renewable energy and energy efficiency projects to determine economic and financial feasibility are crucial. They can assist a farmer in calculating savings and determining the costs associated with the project. Various tools are available for farmers to utilise in order to assist them in decision making regarding the use and purchase of various renewable energy technologies and energy efficient practices. From the investigation is was established that:

- The majority of tools available are developed by the FAO and offer assistance in promotion of sustainability within agriculture
- Many of the tools available can be accessed through the internet and are free
- Portals are available that provide informative support channels for farmers

6.1 FINANCIAL MECHANISMS

Capital for investment in infrastructure for renewable energy projects and investment in energy efficiency solutions for a farmer may be a constraint in the implementation of renewable energy and energy projects due to the costs associated. Therefore, SECP implementation within agriculture is highly dependent on the financial offerings available to fund the projects.

Types of financial assistance available can be in the form of the below:

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

Financial mechanisms specific to sustainable agriculture, renewable energy, or energy efficiency were included in this section as they target farmers transitioning from conventional agricultural practices to SECP practices.
6.1.1 ENERGY EFFICIENCY FUND (GEEF)

<table>
<thead>
<tr>
<th>Program</th>
<th>Green Energy Efficiency Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>The Industrial Development Corporation (IDC) and the German Development Bank (KfW)</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Financial assistance by the means of funding</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>The fund is currently only available to South African businesses who operate exclusively in South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Funding is provided to private sector businesses in the below industries: (Industrial Development Corporation, n.d.)</td>
</tr>
<tr>
<td></td>
<td>• Green industry:</td>
</tr>
<tr>
<td></td>
<td>o Renewable energy</td>
</tr>
<tr>
<td></td>
<td>o Energy efficiency</td>
</tr>
<tr>
<td></td>
<td>o Pollution mitigation</td>
</tr>
<tr>
<td></td>
<td>o Waste management and recycling</td>
</tr>
<tr>
<td></td>
<td>o Biofuels</td>
</tr>
<tr>
<td></td>
<td>• Agricultural value chain:</td>
</tr>
<tr>
<td></td>
<td>o Agro-processing</td>
</tr>
<tr>
<td>Overview</td>
<td>The Green Energy Efficiency Fund is a fund that is available for the deployment of self-use renewable energy projects and energy efficiency projects. The fund was implemented in line with the Industrial Policy Action Plan (IPAP2) and the New Growth Path (Industrial Development Corporation, n.d.).</td>
</tr>
<tr>
<td>Features of note</td>
<td>+ Additional benefits of the funding are weekly pre-screenings completed onsite to track energy usage</td>
</tr>
<tr>
<td></td>
<td>+ It covers a diverse range of energy efficiency, renewable energy and waste management projects</td>
</tr>
<tr>
<td></td>
<td>+ Validation checks are done on energy efficiency to reduce the risk of not obtaining the anticipated return on investments</td>
</tr>
<tr>
<td></td>
<td>+ Reduction in the exposure to increasing electricity price hikes</td>
</tr>
<tr>
<td></td>
<td>+ Technological support available for energy assessments and energy audits</td>
</tr>
<tr>
<td></td>
<td>+ Assistance in selecting the appropriate equipment for sustainable energy savings</td>
</tr>
<tr>
<td></td>
<td>+ Increased production efficiency and capacity resulting in enhanced product quality</td>
</tr>
<tr>
<td></td>
<td>+ Contribution towards growing a green economy and to South Africa’s sustainable development goals</td>
</tr>
<tr>
<td></td>
<td>+ Improved business image and value</td>
</tr>
<tr>
<td></td>
<td>+ Loans between R1m to a maximum of R50m are at prime less 2%</td>
</tr>
<tr>
<td></td>
<td>+ Increased company profitability through energy efficiency</td>
</tr>
<tr>
<td></td>
<td>+ Vulnerability to electricity prices hikes will be reduced</td>
</tr>
<tr>
<td></td>
<td>+ Application time for determining eligibility is 5 days</td>
</tr>
</tbody>
</table>

- The GEEF fund only has one constraint in which the farmer has to pay a raising fee of 1% and a 0.5% fee per annum |
- Extensive requirements that follow upon approval of the application, such as business plans, cash flows, and financial models, may be difficult for a small farmer to produce if not equipped with skills in this area
6.1.1 ENERGY EFFICIENCY FUND (GEEF)

<table>
<thead>
<tr>
<th>Program</th>
<th>Green Energy Efficiency Fund</th>
</tr>
</thead>
</table>
| Eligibility Criteria | To qualify for assistance, the below applies:  
  • the project needs to be for the implementation of energy efficient mechanisms that will be financially sustainable for the business in the long term, or potential implementation of self-use renewable electricity in replacement of electricity grids, essentially the implementation of off-grid electricity  
  • prioritisation is given to companies that have the below:  
    • R51-million turnover, or  
    • R55-million assets, or  
    • 200 employees  
If applying, the business needs to be South African-registered and operating within South Africa funding will be provided to projects in the interest of replacing fossil fuel with renewable resources within their operation |
| How to Apply | • An application form needs to be completed to qualify for the Green Energy Efficiency Fund, this is available via the website and the IDC Regional Offices  
  • An executive summary with the project background information and a justification for the funding will also need to be submitted  
  • The application will then be assessed and approved or declined based on whether the project is deemed viable |

6.1.2 12 L TAX

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>SARS</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Financial assistance by the means of claims backs of tax deductions</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>In accordance with the South African Income Tax Act, 1962</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Targeted industries are the agricultural sector, specifically peri-urban and rural farmers who wish to implement or are currently partaking in renewable energy practices within South Africa (National Treasury, 2013).</td>
</tr>
<tr>
<td>Overview</td>
<td>A tax incentive mechanism to encourage efficient utilisation of electricity for tax paying energy efficient role players who can demonstrate savings, as a result of implementing of energy efficient solutions. This includes cogeneration, waste-to-heat recovery and energy efficient practices (National Treasury, 2013).</td>
</tr>
</tbody>
</table>
### 6.1.2 12 L TAX

**Program**  

#### Features of note

+ Incentivises energy efficient solutions  
+ Offers 95 cents per kWh for verified energy savings

- Renewable energy is not covered by the incentive at this stage, however this is being revised  
- Only available for tax-payers  
- Cannot be used with any other concurrent benefits  
- The process in determining qualification of this benefit can be a lengthy one as going through 2 channels (M & V professionals and SANEDI) may take long. In addition, there needs to be 12 months of proven energy savings  
- The 35% energy savings for eligibility of the tax rebate maybe a high percentage for smaller scale farmers to achieve within their operations in a 12-month period

#### Eligibility Criteria

Energy generation needs to meet the below requirements:

- cannot be generated through a captive power plant unless there is a 35% proven improvement in regards to energy efficiency (National Treasury, 2013)

#### How to Apply

The following steps need to be followed when applying:

- Must be registered with the South African National Energy Department Institute (SANEDI)  
- Required to undergo an assessment by a measurement and verification professional who will produce a report of the energy savings for the respective year

- The report compiled needs to be submitted to SANEDI.  
- If SANEDI approves based on standard compliance and accurate energy savings recorded, an energy saving certificate will be produced, only if SANEDI deems fit  
- The energy saving certificate can then be presented to SARS for the tax deduction rebate
6.1.3 12 B TAX

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>SARS</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Capital allowance for moveable assets purchased for renewable energy purposes</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>In accordance with the South African Income Tax Act, 1962</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Focused on renewable energy</td>
</tr>
<tr>
<td>Overview</td>
<td>An incentive for one paying tax, the benefit is a 50</td>
</tr>
</tbody>
</table>
| Features of note | + Any improvements and foundations are included in the cost of the asset  
+ 100% allowance in the first year is possible, opposed to the 50|30|20 |
- Incentive excludes: Buildings and assets leased  
- If the asset was used within the year for other purposes in which are not for the purpose of renewable energy, these are not claimable |
| Eligibility Criteria | According to Straton Electrical (2016), to be eligible for the incentive:  
• renewable energy needs to be generated by the following means: wind power, solar power, hydropower (producing 30 watts or less of energy) and biomass  
the asset needs to be owned by the farmer(s) |
| How to Apply | Contact SARS for further information on how to apply for the incentive |
6.1.4 COMMERCIAL RENEWABLE ENERGY FINANCING OFFERING

<table>
<thead>
<tr>
<th>Program</th>
<th>Commercial Renewable Energy Financing Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Nedbank</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Funding model for the purpose of implementing renewable energy and energy efficiency projects for farmers pursuing greener operations</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>Targets farmers within South Africa only</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agricultural sector</td>
</tr>
<tr>
<td>Overview</td>
<td>A model providing financial assistance to farmers to save on electricity costs, reduce carbon emissions and also mitigate the risk of reoccurring power cuts by investing in off-grid operations to make farming more sustainable and profitable (Creamer Media, 2015).</td>
</tr>
</tbody>
</table>
| Features of note                             | + Existing clients may qualify for a 7% rebate provided that they are credit worthy (subject to availability at the time)  
+ New clients who produce energy savings of 15% or more qualify for a 7% rebate if requesting a loan for the purchase of machinery and equipment  
+ Existing clients will also benefit from longer payback periods, again provided they are credit worthy  
+ Other consulting services are provided such as surveys, workshops and consulting advice for a set period of time  
- A 7% rebate is subject to availability; current market conditions may impact the eligibility of (Nedbank, 2015). |
| Eligibility Criteria                         | The financing option is open to new and existing clients who are farmers |
| How to Apply                                 | Apply online via the following 3 options:  
• Visit a nearest Nedbank branch  
• Contact the local Agri Business Manager  
• Send an email to agriculture@nedbank.co.za |
### 6.1.5 Clean Energy Project Funding/Renewable Energy Funding

<table>
<thead>
<tr>
<th><strong>Program</strong></th>
<th>Clean Energy Project Funding/Renewable Energy Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>ABSA and the French Development Agency (AFD)</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Loans of up to R100 million for energy efficiency and renewable energy projects</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Absa clients within South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>Commercial businesses in the agricultural industry is one of the focal sectors</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>ABSA focuses on sustainable practices to promote climate change, they are offering funding solutions as a reward mechanism to promote energy efficiency and renewable energy projects.</td>
</tr>
</tbody>
</table>
| **Features of note** | 7% rebates provided on loans
| | Reduces greenhouse gas emissions through sustainable farming activities
| | Funding for renewable energy projects to farmers wanting to generate renewable energy for their own consumption and is not limited to energy generated for the purpose of feeding it into the grid, however funding is also available for this
| | Loan facility has a minimum amount of R10 million (ABSA, 2012).
| | Priority is given to existing ABSA clients |
| **Eligibility Criteria** | ABSA (2012) states that in order to qualify for a loan, the below applies:
| | the following types of renewable energy projects are eligible for funding: biogas, solar power, wind power and solar water-heaters
| | energy efficiency projects which involve retrofitting/modifications, manufacturing processes, on-site heat and electricity generation, efficient lighting and rehabilitation of power distribution systems. |
| **How to Apply** | Visit and ABSA branch and speak to a consultant |
### 6.1.6 THE WWF NEDBANK GREEN TRUST

<table>
<thead>
<tr>
<th>Program</th>
<th>The WWF Nedbank Green Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>WWF-SA and Nedbank</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Investment funding for 7 focus areas</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>The funding incentive is concerned with mainly but not limited to South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agriculture and renewable energy</td>
</tr>
</tbody>
</table>

**Overview**

According to (Morkel, 2016), the Green Trust was implemented to:
- promote the maintenance of the ecological assets in South Africa
- ensure the ecological system is in line with the economic and social goals of South Africa
- mitigate the risks of climate change effects (Morkel, 2016).

**Features of note**

+ Focuses on renewable energy opportunities to fight climate change
+ Investment of up 3 million every 3 years

- Time frame for the funding is 3 years, unless circumstances are exceptional.

**Eligibility Criteria**

The criteria for project funding is quite specific and be seen below:
- proposed project needs to meet the guidelines online as per Green Trust Environmental outcomes
- eligibility is based on whether the funding falls into one of the 7 focal areas, in this case Footprint which is focused on energy and commodities (crops, meat, fish and wood)
- according to the Project Funding Criteria Mix the project should be focused on Climate Change opportunities through low-carbon projects and renewable energy projects (Morkel, 2016).

Feasibility of the project is determined in terms of resources, time and expertise.

**How to Apply**

Applications must be submitted via the below website:
http://www.wwf.org.za/what_we_do/green_trust/

Below are the deadlines:
Monday 15 August 2016 and Friday 9 December 2016
6.1.7 LENDING SOLUTIONS- FNB

<table>
<thead>
<tr>
<th>Program</th>
<th>Lending Solutions- Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>FNB</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Financial assistance by the means of a loan</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>Offered to South African farmers</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agricultural sector is the main focus with support to farmers</td>
</tr>
<tr>
<td>Overview</td>
<td>FNB provide loans and overdrafts to farmers for infrastructure, livestock and crops. They also provide loans for expanding production capacity, production projects, agricultural property and moveable assets (FNB, 2016).</td>
</tr>
<tr>
<td>Features of note</td>
<td>+ Analysis is conducted on the business and a tailored solution is provided by the bank</td>
</tr>
<tr>
<td></td>
<td>- FNB does not offer a 7% rebate on loans for farmers, a disadvantage compared to ABSA and Nedbank who do</td>
</tr>
<tr>
<td>Eligibility Criteria</td>
<td>Loans and overdrafts require the below to prove capacity and motivate the approval of the loan:</td>
</tr>
<tr>
<td></td>
<td>• Budgets</td>
</tr>
<tr>
<td></td>
<td>• Cash flows</td>
</tr>
<tr>
<td>How to Apply</td>
<td>There are 3 ways to apply for a loan, or an overdraft facility:</td>
</tr>
<tr>
<td></td>
<td>• Apply via the website</td>
</tr>
<tr>
<td></td>
<td>• Request a call back</td>
</tr>
<tr>
<td></td>
<td>• Visit the nearest branch</td>
</tr>
<tr>
<td></td>
<td>In addition, the following documentation will need to be submitted:</td>
</tr>
<tr>
<td></td>
<td>• Personal details</td>
</tr>
<tr>
<td></td>
<td>• Business details and mandates</td>
</tr>
<tr>
<td></td>
<td>• Business plans, budgets and cash flow forecasts to support the loan + to substantiate the loan amount</td>
</tr>
</tbody>
</table>
### 6.1.8 MICRO AGRICULTURAL FINANCIAL INSTITUTIONS OF SOUTH AFRICA SCHEME

**Program** Micro Agricultural Financial Institutions of South Africa Scheme (MAFISA)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Department of Agriculture Forestry and Fisheries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Assistance</td>
<td>Financial services provided</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>South African citizens</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Small holder producers in Agriculture</td>
</tr>
</tbody>
</table>

#### Overview

The MAFISA scheme provides loans for the purpose of purchasing implements, small equipment, production inputs, feed and breeding livestock (DAFF, 2015).

#### Features of note

+ Financial assistance specific for the agricultural industry
+ Applications as an individual, group or entity welcomed

- Loan size is only for R500,000, which is lower than other loans available (DAFF, 2015)

- Repayment terms are determined by the income of cycle of the expertise

#### Eligibility Criteria

- South African citizen with an ID document
- Proof of repayment capacity and a good credit history
- Be from a historically disadvantaged group
- With income of < R20,000 a month coming from other than farming source
- Needs to be for the agriculture, forest or fisheries sectors
- SARS tax threshold should not be exceeded in terms of turnover

#### How to Apply

Steps to apply for the loan:

- Contact the local agricultural extension officer or participating intermediary for application forms
- The form then needs to be completed, should assistance be required the local Agricultural Extension Offer may assist
- All the required documentation as per the application needs to be submitted.
- Application is then to be submitted to the local accredited intermediary

Contact MAFISA: 012 319 7263 / 6825 / 7216
PortiaMahl@daff.gov.za
ElizabethKh@daff.gov.za
6.1.9 FARMING INCENTIVE

<table>
<thead>
<tr>
<th>Program</th>
<th>Farming Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>The Land Bank</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Bank specialising in agricultural finance solutions</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>South African farming community</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Commercial farmers or agri-businesses</td>
</tr>
</tbody>
</table>

**Overview**

The Land Bank of South Africa specializes in products and financial services for the agricultural sector and offer the following services (Land Bank, 2015):

- medium term loans
- instalment sale finance
- establishment loans
- short term (seasonal) loans
- loans for renewable energy projects within the agricultural sector fall under loans for infrastructure

**Features of note**

+ Interest is capitalised monthly and the rate is competitive
+ Repayment arrangements are based on income stream making it easier for farmers. For example, if income is earned on an annual basis, then annual instalments will be made; income earned on a monthly basis will allow for monthly instalments and income earned on a quarterly basis will allow for quarterly instalments
+ Maximum loan term is up to 25 years
+ Monthly bank charges are minimal

- FNB does not offer a 7% rebate on loans for farmers, a disadvantage compared to ABSA and Nedbank who do

**Eligibility Criteria**

To qualify for a loan, the eligibility criteria differs based on the type of farming involved, for example, poultry, livestock, etc. However, the below are some of the standard requirements:

- the farm of the farmer will serve as security for the loan which is payable over 10 years
- a business plan is required with all the supporting documentation as per checklist from the Sales and Account Management Consultant
- once approved, the bank will require all the invoices from the supplier for the purpose of the loan

**How to Apply**

The following steps are recommended to be followed when applying for a loan:

- Determine the funding needs- the amount required and what the amount is for
- Personal details submitted with a legal form and the nature of the business indicated, tax clearance certificate, proof of residence, bank statements, business plan or project feasibility study, type of commodity and owner(s) names
- Type of loan, the amount required, purpose of the loan and description of the collateral offered
- Submit all required documentation
- A checklist can be obtained from a Sales and Account Management Consultant assigned, they will help in understanding what needs to be submitted and how many copies required etc.
6.1.10 THE GREEN FUND

<table>
<thead>
<tr>
<th>Program</th>
<th>The Green Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>The Department of Environmental Affairs (DEA) and the Development Bank of</td>
</tr>
<tr>
<td></td>
<td>Southern Africa (DBSA)</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Provide catalytic finance to facilitate investment in green initiatives</td>
</tr>
<tr>
<td></td>
<td>(Department: Environmental Affairs and Development Bank of South Africa, 2014)</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Based on the Green Economy initiative within South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and</strong></td>
<td>Private sector SMEs focused on the below areas:</td>
</tr>
<tr>
<td><strong>Sub Sectors</strong></td>
<td>• Renewable energy</td>
</tr>
<tr>
<td></td>
<td>• Sustainable agriculture</td>
</tr>
<tr>
<td></td>
<td>• Energy efficiency</td>
</tr>
<tr>
<td></td>
<td>• Alternative fuels</td>
</tr>
<tr>
<td></td>
<td>• Cleaner production</td>
</tr>
<tr>
<td></td>
<td>• Rural energy (off-grid)</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>The fund focuses on promoting a low-carbon green economy supporting investment,</td>
</tr>
<tr>
<td></td>
<td>development and research for projects or programs. It addresses energy</td>
</tr>
<tr>
<td></td>
<td>efficiency through its investments promoting resource efficiency.</td>
</tr>
<tr>
<td><strong>Features of note</strong></td>
<td>+ A diverse range of financial support such as equity, loans and grants</td>
</tr>
<tr>
<td></td>
<td>+ Pursues foreign investment and local investment in support of the South</td>
</tr>
<tr>
<td></td>
<td>African green economy goals, not limited to financial support</td>
</tr>
<tr>
<td></td>
<td>+ In line with policy frameworks set by the government for climate change and</td>
</tr>
<tr>
<td></td>
<td>renewable energy</td>
</tr>
<tr>
<td></td>
<td>+ Green interventions to promote suitability and climate policies</td>
</tr>
<tr>
<td></td>
<td>+ Focus on green cities and towns, a low carbon economy and environment</td>
</tr>
<tr>
<td></td>
<td>and natural resource management, all sustainable practices (Department:</td>
</tr>
<tr>
<td></td>
<td>Environmental Affairs and Development Bank of South Africa, 2014)</td>
</tr>
<tr>
<td></td>
<td>- The fund has been exhausted on projects and is currently unavailable.</td>
</tr>
<tr>
<td></td>
<td>Additional funding is in discussion for 2017; the fund is not a short term</td>
</tr>
<tr>
<td></td>
<td>solution for farmers</td>
</tr>
<tr>
<td><strong>Eligibility Criteria</strong></td>
<td>The following needs to be met when sending an application for funding</td>
</tr>
<tr>
<td></td>
<td>(Department: Environmental Affairs and Development Bank of South Africa, 2014):</td>
</tr>
<tr>
<td></td>
<td>• the project needs to fall under one of the focal areas of the fund</td>
</tr>
<tr>
<td></td>
<td>• project requirements that need the assistance of the Green Fund</td>
</tr>
<tr>
<td></td>
<td>• potential for the project to be extended to other sites and implemented at</td>
</tr>
<tr>
<td></td>
<td>a larger scale continuing to contribute to a green economy</td>
</tr>
<tr>
<td><strong>How to Apply</strong></td>
<td>When funding is available again, requests to the public for applications will</td>
</tr>
<tr>
<td></td>
<td>be on the website below</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.sagreenfund.co.za">www.sagreenfund.co.za</a></td>
</tr>
</tbody>
</table>
6.1.11 INSPIRED EVOLUTION FUND

<table>
<thead>
<tr>
<th>Program</th>
<th>Farming Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>Inspired Evolution Investment Management (Pty) Ltd</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Investment fund available for assets</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Sub-Saharan Africa and South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>Clean Energy industry, Agribusiness &amp; Forestry, New Energy and Waste Management</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>The Inspired Evolution Fund is focused on resource efficiency and clean energy investments through the deployment of capital for clean energy solutions.</td>
</tr>
<tr>
<td><strong>Features of note</strong></td>
<td>+ Specialised knowledge and global knowledge of clean energy projects</td>
</tr>
<tr>
<td></td>
<td>+ Customised financial solutions</td>
</tr>
<tr>
<td></td>
<td>+ Targets small, medium and large companies</td>
</tr>
<tr>
<td></td>
<td>- Approval process is timeous</td>
</tr>
</tbody>
</table>

**Eligibility Criteria**

Key criteria for technology investments includes companies (Industrial Development Corporation, n.d.):
- with proven technology/minimised risk
- where product (market) adoption can be demonstrated with platform application that are immediately scalable with appropriately skilled management teams with proven track records

Key criteria for project-based investments includes project (Inspired Evolution Investment Management, 2011):
- where there is an option to take equity in the developer and/or project(s)
- where cost control influence (overheads) can be effected
- where the developer can demonstrate track record
- where the pipeline and probability of success can be validated
- project inputs (feedstock) and offtake agreements are in place
- where technology is proven and there is limited execution risk
- where the technology provider guarantees are available
- where technology supply contracts are in place
- where senior long-term debt is available at the appropriate terms and cost where operator and maintenance agreements are in place

**How to Apply**

Apply for assistance via the below:
- Contact a fund advisor
- Checklist will be provided
- Completed information and checklist will be sent to the fund advisor

Contact: Christopher Clarke
Mobile +27 (0) 82 496 0522
E-mail chris@inspiredevolution.co.za
### 6.1.11 INSPIRED EVOLUTION FUND

![Eskom Logo](image)

**Program**

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Eskom</th>
</tr>
</thead>
</table>

**Nature of Assistance**

Up to a 100% funding available of the financial benchmark value by Eskom for ESCo projects

**Spatial Coverage**

Energy Service Companies (ESCos) accredited by Eskom

**Targeted Industries and Sub Sectors**

Various

**Overview**

The ESco funding model is a support model with supports Eskom accredited ESCos in reducing their energy use, improving their energy efficiency and shifting their energy load through the funding of energy projects and programs (Eskom's Integrated Demand Management (IDM) Business Unit, 2011).

**Features of note**

+ Customers going through ESCos can benefit from the knowledge of DSM technologies and programmes to assist customers wanting to implement renewable energy and energy efficient practices
+ The customer, the end user in this case, will be able to save costs without investing large amounts of money into renewable energy technologies/energy efficiency technologies
+ The review period for project sustainability is reviewed over a period of 5 years

- Customers have to go through ESCos and M&Vs, which can result in long lead times due to legal contracts being in place
- 7.5% performance retainer only paid on the completion of the project, this is only paid if the agreed savings are accomplished
- There’s a penalty clause implication to ensure project savings are achieved
- Funding is limited

**Eligibility Criteria**

According to Eskom’s Integrated Demand Management (IDM) Business Unit, (2011):

- the ESCo needs to be Eskom accredited
- Energy efficient projects need to be from the programmes below and with the following benchmark values:
  - Lighting & HVAC- Up to 5.2m/MW
  - Hot Water- Up to 6.3m/MW
  - Demand Response- Up to 3.9m/MW
  - Compressed Air- Up to 4.4m/MW
  - Process Optimisation- Up to 5.2m/MW
  - Other- Up to 5.2m/MW

**How to Apply**

Apply via the following methods:

Customers wanting to implement energy efficiency and renewable energy project or programs will have to contact one of the accredited ESCo companies, visit the website.

http://www.eskom.co.za/sites/idm/Pages/Home.aspx

Application forms are available on the website below:

http://www.eskom.co.za/sites/idm/Business/Pages/Escomodel.aspx
### 6.1.13 SUSTAINABLE ENERGY FUND FOR AFRICA

<table>
<thead>
<tr>
<th>Program</th>
<th>Clean Energy Project Funding/Renewable Energy Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>African Development Bank Group</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Financial investment for renewable energy and energy efficiency projects</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>African countries and South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Private sector</td>
</tr>
</tbody>
</table>

#### Overview
The Sustainable Energy Fund for Africa (SEFA) is a multi-donor trust fund administered by the African Development Bank anchored in a commitment of USD 60 million by the Governments of Denmark and the United States to support small- and medium-scale Renewable Energy (RE) and Energy Efficiency (EE) projects in Africa (African Development Bank Group, 2016). The three functional areas are: project preparation, equity investments and enabling environments.

#### Features of note
- Assists with capital investments for projects between USD 30 million – 200 million for large projects
- Promotes clean energy initiatives
- Turnover period is currently 5-9 months

#### Eligibility Criteria
Eligibility will be identified based on the below:
- Preliminary Evaluation Criteria
- Internal Review and Approval Process
- Utilisation of Resource
- Implementation Responsibility
- Procurement Arrangements
- Disbursement
- Application

For additional details on the criteria, see below link

#### How to Apply
Applications should be sent to: sefa@afdb.org
For further information, contact:
Technical Contact (Secretariat): João Duarte Cunha - SEFA Coordinator, Energy, Environment and Climate Change Dept. - j.cunha@afdb.org
Resource Mobilization Focal Point: Serign Cham - Principal Resource Mobilization Officer - s.cham@afdb.org
6.1.14 THE AFRICA ENTERPRISE CHALLENGE FUND- AECF

<table>
<thead>
<tr>
<th>Program</th>
<th>The African Enterprise Challenge Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Supported by Australia, Denmark, the Netherlands, Sweden and the United Kingdom, as well as the International Fund for Agricultural Development (IFAD).</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Funding through competitions</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>23 sub-Saharan Africa countries including South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agriculture, agribusiness and renewable energy in private sector rural areas (small holder farmers)</td>
</tr>
<tr>
<td>Overview</td>
<td>The fund has been created for the promotion of climate change through projects and business ideas that have a positive impact on the environment. It will support renewable energy initiatives in agriculture through funding competitions (African Enterprise Challenge Fund, 2016).</td>
</tr>
</tbody>
</table>
| Features of note         | + US$1.5m in grants and interest free loans are awarded to the best ideas  
+ Exclusively focused on the private sector  
+ Competition criteria and rules are publicised  
- Highly competitive  
- Must focus on the poorer rural areas |
| Eligibility Criteria     | The proposals will be judged on the below (African Enterprise Challenge Fund, 2016):  
• Commercial viability  
• Innovation  
• Potential development impact  
• Business performance  
• Market assessment performance |
| How to Apply             | To enter the competition, the below must be followed:  
• Submit an application- information on the business and the ideas they would like to implement as well as the impact on the environment  
• If successful, the next stage will require the business to submit a comprehensive business plan for the project  
More information is available on website below:  
http://www.aecfafrica.org/fund-process/applying |
### 6.1.15 COMPREHENSIVE AGRICULTURAL SUPPORT PROGRAMME (CASP)

<table>
<thead>
<tr>
<th>Program</th>
<th>Comprehensive Agricultural Support Programme (CASP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Department Agriculture, Forestry and Fisheries/Micro-agricultural Financial Institutions of South Africa (Mafisa)</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Grants and support services for farmers</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>Implementation in 8 provinces below:</td>
</tr>
<tr>
<td></td>
<td>• Eastern Cape</td>
</tr>
<tr>
<td></td>
<td>• Free State</td>
</tr>
<tr>
<td></td>
<td>• Gauteng</td>
</tr>
<tr>
<td></td>
<td>• KwaZulu-Natal</td>
</tr>
<tr>
<td></td>
<td>• Limpopo</td>
</tr>
<tr>
<td></td>
<td>• Mpumalanga</td>
</tr>
<tr>
<td></td>
<td>• Northern Cape</td>
</tr>
<tr>
<td></td>
<td>• North West</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agricultural sector</td>
</tr>
<tr>
<td>Overview</td>
<td>The programme is designed to support small holder farmers in improving efficiency and obtaining access for funding in creation of a sustainable environment (DAFF, 2015).</td>
</tr>
<tr>
<td>Features of note</td>
<td>+ Focuses on sustainability in agriculture</td>
</tr>
<tr>
<td></td>
<td>+ Vast range of support offered</td>
</tr>
<tr>
<td></td>
<td>- Funding for infrastructure is only for damaged infrastructure as a result of flooding</td>
</tr>
<tr>
<td>Eligibility Criteria</td>
<td>Objectives and Allocation criteria:</td>
</tr>
<tr>
<td></td>
<td>• priority is given to value chains as identified in the Agriculture Policy Action Plan (APAP),</td>
</tr>
<tr>
<td></td>
<td>• the full utilisation of partnerships in order to exploit the strengths of key private sector partners,</td>
</tr>
<tr>
<td></td>
<td>• support for land reform projects,</td>
</tr>
<tr>
<td></td>
<td>• access to markets and potential for job creation,</td>
</tr>
<tr>
<td></td>
<td>• provide a comprehensive support package to farmers, and mentorship support to small holder farmers.SMALLHOLDER AND COMMERCIAL FARMERS CRITERIA:</td>
</tr>
<tr>
<td></td>
<td>• must have access to land (owned or leased),</td>
</tr>
<tr>
<td></td>
<td>• in the case of leased land, the applicant must have a lease arrangement for not less than 9 years and 11 months and a longer lease period is required for long term crops,</td>
</tr>
<tr>
<td></td>
<td>• must be a land reform project,</td>
</tr>
<tr>
<td></td>
<td>• must have the potential to create jobs,</td>
</tr>
<tr>
<td></td>
<td>• must contribute to transformation of the agricultural sector, and</td>
</tr>
<tr>
<td></td>
<td>• agri processing project initiatives will be considered.</td>
</tr>
</tbody>
</table>
6.1.15 COMPREHENSIVE AGRICULTURAL SUPPORT PROGRAMME (CASP)

How to Apply

How to apply:

- Obtain a request form from a local office of the Department, or download it here: http://www.elsenburg.com/funding.
- Submit completed form within the required time frame accompanied by a tax clearance certificate, security of tenure documentation (copy of title deed or lease contract) to the local office of the Department for further processing by the relevant Commodity Project Allocation Committee (CPAC).
- Once the application is received the Department will confirm receipt in writing and advise further on the process.

Conditions:

Once the project is approved the applicant will be expected to enter into a contract with the Department of Agriculture or its implementing agency committing to the following conditions of implementation:

- commitment to ensure effective and productive usage of all equipment and inputs (equipment may be removed if not used productively/misused),
- commitment to give access to the financial records of the business – through participation in the Department's Financial Record Keeping Programme (FRK),
- commitment to give access to the Department to the premises for site visits for extension and monitoring purposes,
- commitment to the conditions of the Department to exit the project in line with its exit strategy,
- commitment to compulsory attendance of project meetings,
- commitment to the project training plan, and
- commitment to successful applicants' voluntary support with struggling projects.
### 6.1.16 Carbon Tax Bill

<table>
<thead>
<tr>
<th>Program</th>
<th>Clean Energy Project Funding/Renewable Energy Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>The National Treasury</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Pricing Policy for carbon produced</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>All producers of carbon emissions- businesses and individuals within any sector</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>The carbon tax bill is tax on carbon emissions produced for producers. In the initial phase, the bill will exclude emissions below 60% The proposed cost is a marginal cost of R120 per tonne. The tax implications are on emissions from fossil fuel combustion, emissions from industrial process and product use and fugitive emissions (The Carbon Report, 2015).</td>
</tr>
</tbody>
</table>
| **Features of note**            | + Targets climate change and will encourage a reduction in the use of fossil fuel  
  + Promotes investment in renewable energy technologies and a shift towards energy efficiency practices  
  + Tax will be recycled and used for energy efficiency tax incentives  
- May increase unemployment and reduce investment |
| **Eligibility Criteria**        | The first phase only applies to producers who produce 60% or more of carbon tax (The Carbon Report, 2015). |
| **How to Apply**                | To find out more information on the Carbon Tax Bill and the implications on the business, contact the below number or visit the website for additional consulting services.  
  Phone Number: +27 21 403 6411  
  Website: http://www.thecarbonreport.co.za/services/carbon-tax-consulting/ |
6.1.17 SMALL PROJECTS IPP PROGRAMME

<table>
<thead>
<tr>
<th>Program</th>
<th>Small Projects IPP Programme Grant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>Department of Energy</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Financial incentive for the generation of renewable energy</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>SME's</td>
</tr>
</tbody>
</table>

**Overview**

The Small Projects IPP Programme was designed to procure 400MW of electricity from small renewable energy producers (Eskom, 2016). Renewable energy is produced by an individual power producer that bids on a tariff, the tariff is then payable by the buyer.

**Features of note**

+ A bidder may elect whether or not to use internationally certified equipment in its Project under the Programme (Eskom, 2016).

**Eligibility Criteria**

- Small producers need to generate less than 5MW
- Priority is given to SME’s

**How to Apply**

To apply the following has to be followed:

- a non-refundable fee of R15 000 (fifteen thousand Rand) per Bidder
- proof of payment should be sent to query@ipp-renewables.co.za
- a registration form then needs to be completed
6.1.18 FUNDING FOR ALTERNATIVE ENERGY PROJECTS AND PRODUCTS

Program Funding for alternative energy projects and products

<table>
<thead>
<tr>
<th>Organisation</th>
<th>The National Treasury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Assistance</td>
<td>Pricing Policy for carbon produced</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>All producers of carbon emissions- businesses and individuals within any sector</td>
</tr>
<tr>
<td>Overview</td>
<td>The SAAEA assists with implementation, funding and negotiating of infrastructure projects and green sustainable technologies through their applicable accredited and institutional investors, who may have interest in investing in the following alternative energy channels (SAAEA, 2016).</td>
</tr>
<tr>
<td></td>
<td>• Wind</td>
</tr>
<tr>
<td></td>
<td>• Solar PV</td>
</tr>
<tr>
<td></td>
<td>• Solar CSP</td>
</tr>
<tr>
<td></td>
<td>• Solar Water Heating Hydro</td>
</tr>
<tr>
<td></td>
<td>• Biogas</td>
</tr>
<tr>
<td></td>
<td>• Biomass</td>
</tr>
<tr>
<td></td>
<td>• Waste to Energy</td>
</tr>
<tr>
<td></td>
<td>• Fuel Cells</td>
</tr>
<tr>
<td></td>
<td>• Batteries</td>
</tr>
<tr>
<td>Features of note</td>
<td>+ Offers a large networking platform</td>
</tr>
<tr>
<td></td>
<td>- Registration is required as well as a membership fee of R2900.00 per annum</td>
</tr>
<tr>
<td>Eligibility Criteria</td>
<td>In order to be eligible to apply for the fund registration as a member of SAAEA is required.</td>
</tr>
<tr>
<td>How to Apply</td>
<td>Contact the office at the below for more information:</td>
</tr>
<tr>
<td></td>
<td>Phone number: 071 637 8466</td>
</tr>
<tr>
<td></td>
<td>Email: <a href="mailto:alwyn@saaea.org">alwyn@saaea.org</a></td>
</tr>
</tbody>
</table>
6.1.18 FUNDING FOR ALTERNATIVE ENERGY PROJECTS AND PRODUCTS

### Program: Rural and Community Development Fund

<table>
<thead>
<tr>
<th>Organisation</th>
<th>National Empowerment Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Assistance</td>
<td>Funding for rural farmers</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agro Processing and Manufacturing</td>
</tr>
</tbody>
</table>

#### Overview
The fund offers assistance for the following (National Empowerment Fund, 2016):
- Acquisition New
- Venture Capital
- Expansion Capital

#### Features of note
- Funds ranging from a minimum of R1 million to R50 million
- Focuses on sustainable new ventures in the agri-sector with the new venture capital fund
- Investment period between 5-10 years
- Application process is 3-4 months

- NEF can enforce the applicants to participate in the NEF programme
- Documentation required is extensive, which small holder farmers may not be able to produce

#### Eligibility Criteria
- A minimum of 25.1% black ownership is required and BEE applicants need to be directly involved in the daily operations of the business
- The business needs to be able to prove the financial stability of the project in order to make repayment obligations of the fund
- The technical partners also need to be involved in the daily operations

#### How to Apply
Applications are submitted via the website and the below process is followed (National Empowerment Fund, 2016):
- Application form filled in and submitted via the website
- The form then goes through the screening process
- Submission is then followed to the investment committee
- Due diligence process
- Resubmission of the final report
- Legal process and procedures
- Disbursement of funds
6.2 NON-FINANCIAL MECHANISMS

Programmes and advisory service offerings for farmers, provided by various institutions and companies include:
- Technical knowledge
- Energy audits
- Energy advisory services
- Incentivised solutions
- Training
- Recommendations
- Cost-benefit analysis

Many of the programmes and advisory services are government run programmes focus on sustainable agriculture.

6.2.1 AFRISAM RENEWABLE ENERGYS

<table>
<thead>
<tr>
<th>Program</th>
<th>Funding for alternative energy projects and products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA) in partnership with AFRISAM</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Non-financial assistance in the form of a project to promote renewable energy</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Only available in the Northern Cape of South Africa</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>Agricultural sector in the Northern Cape</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>The AFRISAM renewable energy project is focused on reducing the burning of fossil fuel through the Utilisation of current invasive species within the agricultural land (Northern Cape Economic Development Trade and Investment Promotion Agency, 2016).</td>
</tr>
</tbody>
</table>
| **Features of note**                         | + Farmers can supply invader species to the AFRISAM plant in the Northern Cape in order to promote renewable energy generation  
+ Reduces the negative impact of invader species on productivity on the farm |
| **Eligibility Criteria**                     | Requirements as below (Northern Cape Economic Development Trade and Investment Promotion Agency, 2016):  
• Farmers need to be within a 15-kilometre radius from the AFRISAM plant  
• BEE project/initiative |
| **How to Apply**                             | Contact the project manager on the below to apply:  
Project Manager for Agriculture and Agro-Processing- Bernard Mabele  
Email: bernard2011@webmail.co.za  
Telephone Number: +27 53 833 1503 |
6.2.2 THE COMPREHENSIVE RURAL DEVELOPMENT PROGRAMME

<table>
<thead>
<tr>
<th>Program</th>
<th>Rural and Community Development Fund</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>Department of Agriculture, Rural Development and Land Administration</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Non-financial services for farmers</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Rural areas in Mpumalanga</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>Agrarian transformation and economic infrastructure</td>
</tr>
</tbody>
</table>

**Overview**

The Department of Agriculture, Rural Development, Land and Environmental Affairs focuses on sustainable agriculture and improving the sector. They aim to promote conservation through the use of natural resources and biodiversity (Mpumalanga Provincial Government, 2013).

**Features of note**

+ Focuses on sustainable resource management  
+ Looks at agricultural production and provides support  

- Main focus on rural development and social impacts  
- May lack experience and technical knowledge of renewable energy to provide adequate support

**Eligibility Criteria**

Farmers need to reside in Mpumalanga

**How to Apply**

To find out more about the fund see below for contact details:

Carina Koelman  
Department of Agriculture, Rural Development, Land and Environmental Affairs  
AD: Rural Development and Land Reform  
Middelburg  
072 158 8180  
013 243 0583
6.2.3 ENERGY AUDITS

<table>
<thead>
<tr>
<th>Program</th>
<th>Energy Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>National Cleaner Production Centre of South Africa (NCPC)</td>
</tr>
<tr>
<td>Nature of Assistance</td>
<td>Non-financial assistance, however they help source funding and the audit is fully subsidised</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>South Africa</td>
</tr>
<tr>
<td>Targeted Industries and Sub Sectors</td>
<td>Agricultural sector is one of the industries they support</td>
</tr>
<tr>
<td>Overview</td>
<td>Identifies areas where energy, water, raw-material efficiency and waste management practices can be improved through the implementation of resource efficiency and cleaner production (RECP) methodologies, this is done via energy assessment (National Cleaner Production Centre , 2014).</td>
</tr>
<tr>
<td>Eligibility Criteria</td>
<td>To qualify for an assessment, the thematic focus areas of the business need to be one or more of the below:</td>
</tr>
<tr>
<td>How to Apply</td>
<td>Visit the NCPC website to apply for a Resource Efficiency and Cleaner Production (RECP) assessment. The NCPC will then contact applicants to meet for an introductory meeting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eligibility Criteria</th>
<th>How to Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contact Details for further information: Sashay Ramdharee- Project Manager for Energy Systems Optimization</td>
</tr>
<tr>
<td></td>
<td>E-mail: <a href="mailto:SRamdharee@csir.co.za">SRamdharee@csir.co.za</a></td>
</tr>
<tr>
<td></td>
<td>Direct: +27 74 254 3488</td>
</tr>
<tr>
<td></td>
<td>Office: +27 12 841 3915</td>
</tr>
</tbody>
</table>
### 6.2.4 SOUTH AFRICAN-GERMAN ENERGY PROGRAMME (SAGEN)

<table>
<thead>
<tr>
<th>Program</th>
<th>Energy Audits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>German Federal Ministry for Economic Cooperation and Development (BMZ)</td>
</tr>
<tr>
<td><strong>Nature of Assistance</strong></td>
<td>Support for the implementation of renewable energy and energy efficiency initiatives</td>
</tr>
<tr>
<td><strong>Spatial Coverage</strong></td>
<td>Private sector within all areas of South Africa; however, specific focus is on the Eastern Cape</td>
</tr>
<tr>
<td><strong>Targeted Industries and Sub Sectors</strong></td>
<td>Renewable Energy and Energy Efficiency</td>
</tr>
<tr>
<td><strong>Overview</strong></td>
<td>The purpose of the program is to improve conditions for increased investments in renewable energy and energy efficiency (SANEDI, 2013). Technical solutions and advice is provided based on existing mechanisms. It focuses on Waste-to-energy, Solar PV, RE technology, biogas projects and on grid-connected projects.</td>
</tr>
</tbody>
</table>
| **Features of note** | - Supports SANEDI in their initiatives and programmes  
- Budget of EUR 17.5 million, incl. 5 million SECO co-funding  
- In addition, the programme provides support for the establishment of research and training facilities  
- Feasibility studies conducted for renewable energy projects  
- Focused on assisting farmers  
- Trainings and workshops |
| **Eligibility Criteria** | Based on a project to project basis |
| **How to Apply** | Contact the below for further information on how to apply: Sofja Giljova  
South African - German Energy Programme (SAGEN)  
T: +27 (0)12 423 6330  
C: +27 (0)79 591 2478  
F: +27 (0)12 423 6347  
E: sofja.giljova@giz.de  
S: sofja.giljova@giz.com |
6.3 TOOLS

Tools for renewable energy and energy efficiency projects are used to assess the economic and financial implications of projects within sustainable agriculture. In addition, they provide an informative database, assisting with project implementation and providing tools to conduct assessments prior to implementation. A farmer could access tools via internet portals in order to assess the viability of renewable energy and energy efficiency projects. It addresses the gap in financial and economic assessment skills farmers may lack in determining risk and viability of projects.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCA-Tool 3.2. software for Cost-Benefit Analysis <a href="http://www.fao.org">http://www.fao.org</a></td>
<td>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.</td>
</tr>
<tr>
<td>Power Irrigation Tool <a href="http://www.fao.org">http://www.fao.org</a></td>
<td>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).</td>
</tr>
<tr>
<td>Decision support tool for sustainable bioenergy <a href="https://cleanenergysolutions.org">https://cleanenergysolutions.org</a></td>
<td>The tool can be used to assess investment opportunities. It provides supporting resources and assistance in the decision-making process when opting for bioenergy.</td>
</tr>
<tr>
<td>Biofuels project screening tool kit <a href="http://www.fao.org">http://www.fao.org</a></td>
<td>Assistance in the implementation, approval and design phase of liquid biofuel projects through screening and evaluation, which will identify sustainability issues within the project.</td>
</tr>
<tr>
<td>CTI Private Financing Advisory Network (PFAN) <a href="http://cti-pfan.net">http://cti-pfan.net</a></td>
<td>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.</td>
</tr>
<tr>
<td>GreenAgri <a href="http://www.greenagri.org.za">http://www.greenagri.org.za</a></td>
<td>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.</td>
</tr>
</tbody>
</table>
CHAPTER 7
CONCLUSION AND RECOMMENDATIONS

Agriculture and specific agricultural industries are highly reliant on energy inputs and therefore, are susceptible to fluctuations in energy prices. Globally, the international agencies are advocating for the transition from conventional agricultural practices to sustainable agriculture that is associated with lower energy input requirements and more efficient use of energy. However, such a transition will take decades to achieve fully; thus requiring intermediate solutions aimed at sustainable energy consumption and production.

The study has analysed the energy usage as well as energy intensity of various agricultural sub-sectors, examined renewable energy and energy efficiency technologies that can be adopted in agriculture, studied the current adoption of these in South Africa, and investigated the state of enabling environment that exists in the country to support the deployment and a wide uptake of these technologies.

The findings of the study have concluded that the South African agricultural sector is yet to achieve the high level of penetration of renewable energy and energy efficient technologies. The study established many gaps that will need to be addressed in order to develop the enabling environment and stimulate the adoption of SECP practices in the agricultural sector. These, together with the proposed recommendations, are illustrated in the table below.

<table>
<thead>
<tr>
<th>Energy demand source</th>
<th>Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td></td>
</tr>
<tr>
<td>• Information and statistics on the energy intensity and waste intensity within the South African agricultural sector are not available or significantly outdated.</td>
<td>• A bottom-up approach to data collection on energy use in agriculture should be considered; which should be done through annual submission of energy usage by individual farmers to the DOE</td>
</tr>
<tr>
<td>• Sub-sector data for crop production, horticulture and animal and animal products within the South African agricultural sector is absent.</td>
<td>• Statistic on waste generation in the agricultural sector need to be updated.</td>
</tr>
<tr>
<td>• Primary research needs to be undertaken to determine the energy inputs and energy intensity of key agricultural sectors in the country.</td>
<td></td>
</tr>
</tbody>
</table>
SUSTAINABLE ENERGY CONSUMPTION AND PRODUCTION (SECP) IN AGRICULTURE

Energy demand source | Energy Source
--- | ---
**Policy and regulatory environment**
- Food waste in South Africa is high; policy interventions need to address this as food security is at risk.
- Policies are generally aligned to what SECP promotes within agriculture and integrated waste management; however, evidence of compliance is not seen within the sector.
- Short-term targets are lacking in the policies; they mostly fall short in the implementation of interim solutions for the long-term objectives that encourage SECP.
- Promote and advocate for monitoring and evaluation of the legislations to ensure compliance.
- Emphasis on policies offering incentives for SECP implementation should be promoted along with regulatory legislations that promote zero-waste.
- Short-term solutions need to be provided as incentives to shift to sustainable agricultural practices.

**Knowledge and awareness**
- Changing a farmer’s mindset from a conventional agriculture approach to a sustainable agricultural approach to farming is a challenge due to behavioural tendencies and lack of knowledge among the farming community on the benefits of renewable energy and energy efficient technologies.
- The study established that there is a major lack of awareness in terms of funding, incentives and programmes available for farmers associated with the deployment of renewable energy and energy efficient technologies.
- Promote and support training and awareness campaigns on sustainable agriculture.
- Undertake road shows to raise awareness among farming associations and groups of farmers on the benefits of renewable energy and energy efficient technologies. This should include information on the financial mechanisms that could be accessed and training on how to apply/access these.
- Develop brochures that can be distributed to the stakeholders of the agricultural sector to raise awareness of the benefits of renewable energy and energy efficient technologies.
- Promote the increased utilisation of well-structured hybrid renewable energy systems that could ameliorate the reliability concerns that characterise most standalone renewable energy technologies such as wind and solar.
<table>
<thead>
<tr>
<th>Energy demand source</th>
<th>Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs and financial support</td>
<td>- Implementation of renewable energy and energy efficient technologies are still associated with high investment costs, which deters their adoption among the agricultural MSMEs.</td>
</tr>
<tr>
<td></td>
<td>- There are limited accessible financial mechanisms available for deployment of renewable energy and energy efficient technologies in South Africa.</td>
</tr>
<tr>
<td></td>
<td>- The eligibility criteria to access funding for renewable energy and energy efficient technologies can be difficult to meet and impractical for small-scale farmers; thus, further exacerbating their lack of access to funding.</td>
</tr>
<tr>
<td></td>
<td>- Innovative and flexible end-user financial assistance mechanisms should be devised in order to increase uptake within the small-to-medium rural and peri-urban agricultural markets. Other post-sales support mechanisms, e.g. maintenance, should also be considered by SECP technology providers and promoters.</td>
</tr>
<tr>
<td></td>
<td>- To address difficulties in gaining access to funding, promoting associations to assist in obtaining funding is imperative.</td>
</tr>
</tbody>
</table>
REFERENCES


DAFF. (2015, December 13). General Submission for CASP.


Eskom (n.d.). Globalisation and commercialisation are pushing grain farmers to optimise energy efficiency. Johannesburg: Eskom.


Eskom and the Agricultural Sector.


