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REPORT

ENERGY SAVINGS IN AGRICULTURE:
EU EXPERIENCES TO SUPPORT SOUTH AFRICA'S AMBITIONS

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Table of Contents

List of Figures

List of Tables

Executive Summary

The agricultural sector's importance to the South African economy has been highlighted in recent years; it was the -. And while the sector's contribution to annual GDP is relatively modest, it rises to 12%, when combined with agro-processing, agriculture importantly provides much needed labour-intensive low skill opportunities – acknowledged in the National Development Plan 2030, which set targets of approximately one million additional direct and indirect jobs in agriculture and agro-processing.

The agricultural sector is also a consistent generator of foreign exchange earnings; with annual agriculture exports having reached peaks of $10 billion. The European Union (EU) now accounts for over 25% of South Africa's agricultural exports; making it South Africa's second largest destination, and one of South Africa's fastest growing agricultural export markets.

Both South Africa and EU Member States are signatories of the Paris Climate Agreement and accept that energy transition is inevitable – including the imminent formal global adoption of a net zero emission target date of no later than 2050. Indeed, the EU is already transitioning to a low-carbon economy; with the EU Commission planning to reduce GHG emissions by at least 55% by 2030. This points to the probable introduction of border carbon adjustment mechanisms, such as surcharges for non-carbon neutral imports; or even exclusions of imports from countries uninvested in green energy and green production. It makes South African agriculture production, which currently posts higher than global average energy intensity levels, particularly vulnerable.

In recognition of this, and as part of its commitment to meeting government's global climate obligations and national energy policy objectives, the Department of Mineral Resources and Energy (DMRE) intends to contribute to the modernisation of the entire agricultural value chain. To this end, agriculture is now recognised as a fully independent sector in the National Energy Efficiency Strategy (NEES 2015); and a specific focus falls on rebuilding an inclusive rural economy, by addressing the inefficient use of energy in agriculture.

Supporting South Africa in improving (lowering) the energy intensity of the agricultural sector, is clearly in the long-term commercial and environmental interests of both territories. South Africa can also learn from the available evidence from the EU. Specifically, a detailed EU agriculture study on energy conservation in six[1] member states and 13 sub-sectors (wheat, tomatoes, poultry etc) identified 481 measures to improve energy savings in the sector. These have been screened as part of this paper to identify those most suited to South Africa.

These findings, as well as the wider EU policy experience, can serve to support the current work being undertaken by the DMRE to develop programmes and action plans to achieve the NEES target. Specific recommendations emanating from this review include:

- For direct energy usage: 1) Notwithstanding that the post-2015 NEES is an official government policy framework and plan it is yet to be ratified by Cabinet. This should be prioritised to demonstrate that its contribution to energy mix is accepted and supported at the highest level of government; The DMRE could consider developing a National Energy Efficiency Action Plan (NEEAP); 2) Prioritise the ongoing development of ambitious minimum energy performance standards for electric motors, lighting and identify

[1] Finland, Germany, Greece, the Netherlands, Poland, and Portugal

new electrical equipment to incorporate into its existing Standards and Labelling programme; 3) Promote energy audits to provide technical assistance to farmers; 4) Leverage industry associations for awareness raising; and 5) With the overwhelming majority of energy consumption being in the form of petroleum products, actioning points 3 and 4 must be inclusive of liquid fuel usage.

- With regards indirect energy use and recognizing that it is not an energy efficiency measure per se but crucial in decarbonizing the sector, the production of green ammonia, the primary ingredient in fertilizers, will decrease the carbon intensity of agricultural produce, create a new industry in itself, and with it a new export market.

Abbreviations

AGREE	Agriculture and Energy Efficiency
CAP	Common Agricultural Policy
DMRE	Department of Mineral Resources and Energy (previously DoE)
EE	Energy Efficiency
EU	European Union
ES	Energy Saving
GDP	Gross Domestic Product
GHG	Greenhouse Gas (emissions)
MEPS	Minimum Energy Performance Standards
NEES	National Energy Efficiency Strategy
NEEAP	National Energy Efficiency Action Plan
OECD	Organisation for Economic Co-operation and Development
PSEE	Private Sector Energy Efficiency
SANEDI	South African National Energy Development Institute
RE	Renewable Energy
REEEP	Renewable Energy and Energy Efficiency Programme
UN COP	United Nations Climate Change Congress of Parties

1 Report Objectives and Structure

Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors (World Bank, 2020). However, the sector in South Africa faces multiple challenges. Two more recent and interlinked issues have local and international significance. The first, is the consecutive annual above inflation electricity tariff increases since 2007 (356% in nominal terms 2007 to 2017) and ongoing electricity supply issues faced by all South African sectors which has an adverse effect on productivity and costs. The second, is climate change, which has multiple further impacts.

On one hand is adaptation, the protection of crops or livestock from extreme weather conditions (drought, heat waves, floods etc) as well as mitigation actions such as crop switching, conservation agriculture, alternate farming approaches and new technologies such as greenhouses, shade netting, and drip irrigation. On the other, is the imperative to reduce, and by 2050, eliminate the carbon footprint of agricultural products to meet the 2050 net zero emission target of an ever-increasing number of countries, which has now been legislated by the EU. Non-compliant products may in future face tariffs, or other restrictions, from importing countries (EU and others) as 2050 nears. South African agricultural products have a distinct disadvantage in this regard, because not only is most of the sector's energy sourced from liquid fuels, which admittedly is the global norm, but this is compounded by the country's electricity having one of the world's highest carbon contents due to coal being the primary energy source (>80%). This makes the agricultural sector particularly vulnerable.

The NEES provides the opportunity to provide much-needed interventions to protect the sector's recent productivity gains - as detailed in Section 3.1. This contrasts with other economic sectors which are stagnant after a decade of low or no GDP growth, and more recently ravaged by the Covid-19 pandemic. Moreover, a competitive agricultural sector will increase much needed foreign exchange earnings; create jobs; and strengthen food security.

Thus, energy savings can help mitigate the risks of rising electricity tariffs, power outages, depreciating currency (liquid fuel costs), carbon intensity and national climate change commitments. To an extent, this transformation has commenced, with GreenAgri reporting that their case studies have found that energy efficiency measures undertaken by farmers have yielded savings of up to 20%. However, this has only been accessed by a small percentage of farmers and for meaningful progress, implementation is required from a significantly higher percentage, and more especially by marginal and emergent farmers. The Department of Mineral Resources and Energy (DMRE) believes that agriculture has a high energy efficiency potential and has thus set a 2030 target of 30% for the sector in the post-2015 NEES. Achieving this target will largely depend on the mechanisms chosen and how they are implemented.

The EU agricultural sector faces similar operational cost containment and climate change challenges. In response, the EU Commission has developed polices, strategies and programmes to support the sector, many of which could be appropriate for South Africa. As the DMRE is in the process of developing dedicated sector specific energy saving programmes to achieve its 2030 NEES target, this report is framed from a climate change and energy saving[2] perspective and seeks to support the DMRE planning process in two ways. The first (Chapter 2) is to

[2] This is made up of energy efficiency (technology that requires less energy to perform the same function) and energy conservation (behaviour that results in the use of less energy)

provide an overview of the South African agricultural sector from an energy usage and decarbonization perspective. The second (Chapter 3), details the policy implementation approach and experience of the EU and identifies and presents a range of country appropriate energy saving interventions for the DMRE to consider. The report then concludes with report findings and recommendations.

The overriding objective of this study is to provide a starting point for increased interaction between the DMRE and the EU, which could take the form of research reports, knowledge exchanges or technical workshops.

2 The South African Agricultural Sector

2.1 Sector Overview

In 2020 Statistics South Africa released the findings of a census undertaken on the commercial agricultural sector, which covered a 10-year period (2007 to 2017). The report states that the number of commercial farms has remained stable and in 2017 there were 40 122 commercial farms across five sectors (

Table 1). These farms are segmented into four categories (large, medium, small and micro); with micro split between those farms whose annual income is greater than R1 million and those below this threshold (

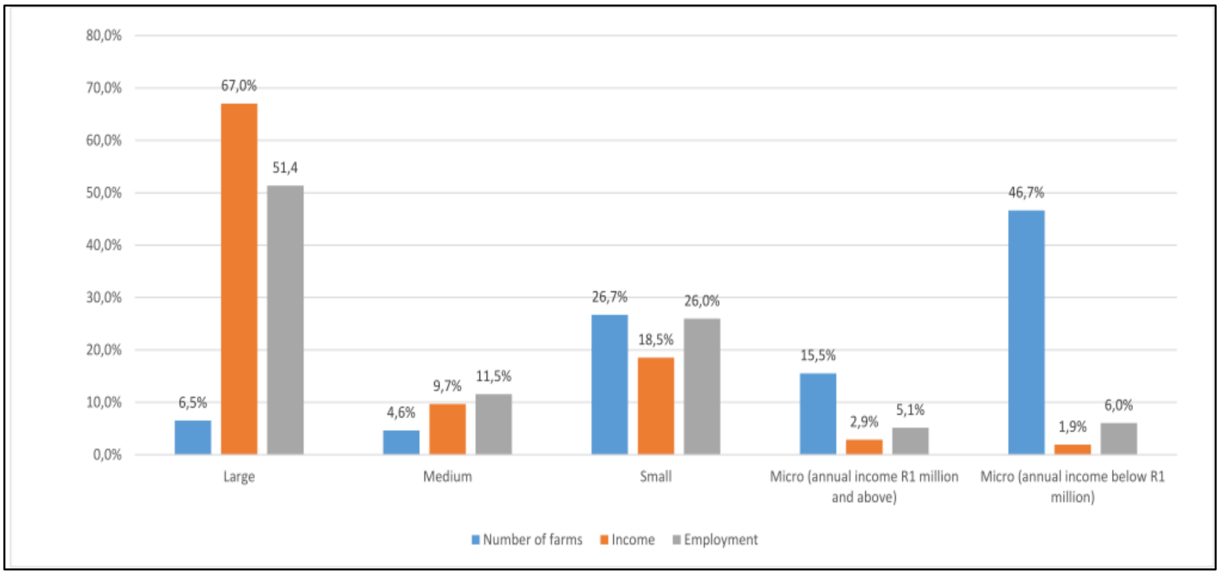
Figure 1). Large commercial farms make up less than 7% of the total but account for 67% of total income. Micro farms, with annual income of less than R2.25 million, are the majority group at 62% followed by small farms at 27%.

Table 1: Number of farms units in the commercial agriculture industry (2007 and 2017)

Type of activity	Farms			
	Number		% contribution	
	2007	2017	2007	2017
Growing of cereals and other crops	13 760	8 559	34,3	21,3
Horticulture	3 801	4 643	9,5	11,6
Farming of animals	13 414	13 639	33,5	33,9
Mixed farming (growing of crops combined with farming of animals)	9 104	12 458	22,7	31,1
Agricultural services and fertiliser production	..	823	..	2,1
South Africa	**40 079**	**40 122**	**100,0**	**100,0**

Source: StatsSA (2020)

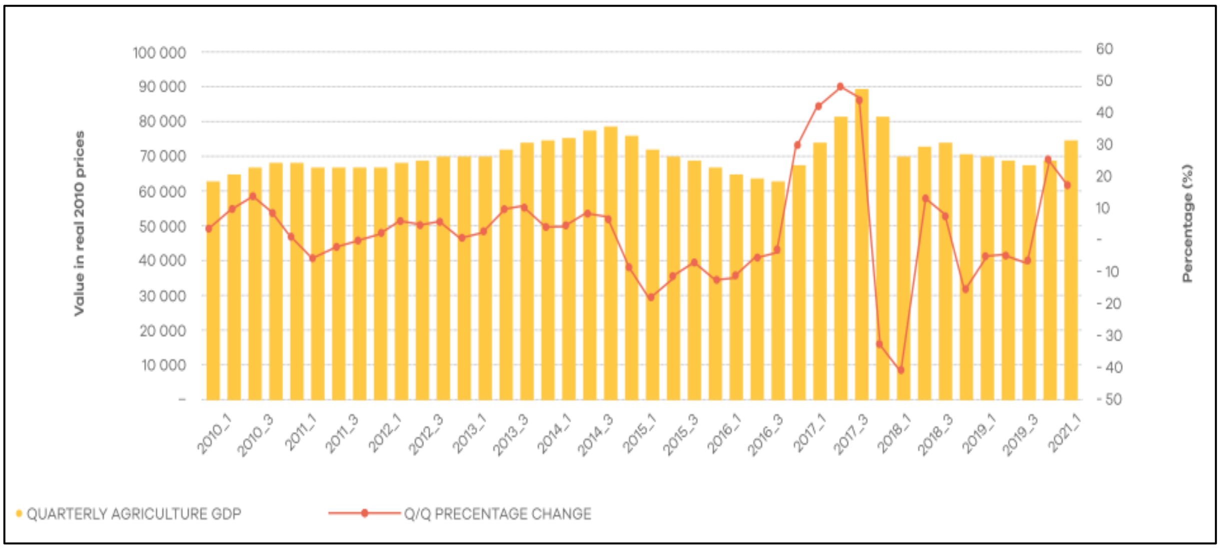
Figure 1: Number of farms, income and employment in the commercial agricultural industry (% of total, 2017)



Source: StatsSA (2020)

South African annual agricultural exports broke through the $10 billion barrier in 2017. This represented a substantial 15% increase from 2016 – boosted by growth in exports of edible fruits, beverages, spirits, vegetables, grains and other agricultural products. Most importantly, South Africa's agricultural sector recorded a positive trade balance of $3.3 billion in 2017, which was also a record high in a dataset dating back to 2001 (GreenCape 2020). Of particular significance, these trends appear to be consistent. The agricultural sector performed well in 2020, despite the national GDP declining for a fourth consecutive quarter in the second quarter of the year, largely driven by the impact of Covid-19. First quarter GDP increased by 27.8% quarter-on-quarter with a 0.5%-point positive contribution to the country's GDP (Makube, 2020).

Figure 2: GDP Contribution from Agriculture in South Africa (ZAR billion)



Source: Green Cape (2020)

Even though the agriculture sector's contribution to annual GDP is relatively modest (2.6% in 2018), its untapped potential remains vast. Including agro-processing, the contribution of the sector grows to 12% of GDP, which comprises a highly diverse group of sub-sectors and industries, which include food processing, storage facilities, beverages, aquaculture, horticulture, medicinal, aromatics and flavourant. These two sub-sectors (farming and agro-processing) provide employment and much needed labour-intensive low skill opportunities, as well as consistently generating foreign exchange earnings (Green Cape, 2020). For this reason, the National Development Plan 2030 places a strong emphasis on agricultural development – targeting an additional 643 000 direct and 326 000 indirect jobs in agriculture and agro-processing by 2030.

Within this context, the EU is an important stakeholder as it now accounts for over 27% of South Africa's agricultural exports – up by 13% from the pre 2017 five-year average share. This makes the EU second only to continental Africa (38%) as South Africa's largest market for agricultural exports (agbiz, 2021). South African exports of fruit, wine and other agricultural commodities to the EU are thus a significant contributor to the economy; while the trade relationships between South Africa and the EU as a regional bloc, are both longstanding and extensive. Indeed, the dtic (in a presentation to the Parliamentary portfolio committee on trade and industry) noted that the benefits under the Economic Partnership Agreement (EPA) to the local agricultural sector included: improved market access for 32 agricultural products, with a significant improvement for wine (110 million litres duty free), sugar (150 000 tons duty free) and ethanol (80 000 tons duty free); as well as improved access for exports of flowers; some dairy; fruit and fruit products; as well as new market access for fishery products (dtic, 2020).

In summary, the South African agricultural sector has the following attributes: it is well established; enjoying economic growth; appropriately segmented; and the sectors and sub-sectors are supported by functional industry associations, at both the national and provincial level. Examples include Green Cape; AgriSA; SABI (South African Irrigation Institute); Farmwise Grains, Poultry Association etc - In total 55 were identified (Farmers Weekly).

2.2 Agriculture and Climate Change

South Africa, as a signatory to the Paris Climate Agreement, is already strongly aligned with the globally accepted premise that an energy transition is inevitable. 2021 is the year of the 26th United Nations Climate Change Conference, (also known as COP26), which strongly implies the formal global adoption of a net zero emission target date of not later than 2050. This means that the EU, together with many other countries, is transitioning to a low-carbon economy; with the EU Commission's targets (detailed Section 2.1) specifically planning to reduce its GHG emissions by at least 55% by 2030 and carbon neutrality by 2050.

Of particular relevance to South Africa is the potential introduction of a border carbon adjustment mechanism, to address carbon leakage. Such a surcharge would increase the price of imports of emission-intensive goods and will include policy instruments such as the lifecycle assessment (LCA) of goods to determine their green credentials. What this means to South Africa, is that the EU could demand that all imported goods be carbon neutral; effectively prohibiting imports from countries that have not invested in green energy and green production. A study undertaken by TIPS (Trade and Industrial Policy Strategies, 2020) found that South African agricultural exports have a carbon intensity of more than 1 100 tCO2e per US$ million, while most countries have an intensity of between 100 and 500 tCO2e per US$ million. The large proportion of South Africa's agricultural exports to the EU, therefore, makes the sector acutely vulnerable to trade-related climate risks (Green Cape, 2021).

Today, within contemporary South African agriculture, certain individual and collective responses to the growing demand for carbon neutrality already point to huge potential, which is still largely unexplored. Indeed, be they public, private, or non-governmental initiatives – or oftentimes combinations thereof – current projects focus on issues that range from irrigation pump efficiency (as the biggest user of electricity) and drip irrigation; to the proliferation of Energy Management Systems and renewable energy supply; to carbon footprinting projects that assist certain agricultural sectors to identify and respond to the risks and opportunities associated with carbon emissions; to the facilitation of improved land use planning; shade netting; and responsible farming practices (BlueNorth 2021; WWF Sustainable Agriculture Report 2021). The incorporation of digital technology has also greatly increased – including the development of mobile applications as tools to engage farmers in sustainable farming practices, in return for securing market access of high-value horticulture chains. The individual successes of such initiatives clearly imply that there is still much to gain in this domain, particularly through a strategic agricultural industry-wide approach.

2.3 Energy Consumption in the Agricultural Sector

Between 2000 and 2015, the fraction of South Africa's total energy consumption accounted for by agriculture, remained constant, at between 3 - 3.5%. The total amount of energy consumed by the sector (which also includes forestry and fishing) was 21% higher in 2015 compared with 2000. The volume of agricultural production did however increase by 38% over the same period. The sector was therefore using about 12% less energy in 2015 relative to 2000, to produce each unit output (Urban Econ, 2016). There is insufficient evidence to determine whether this represented an improvement in efficiency or was the result of a shift away from more energy intensive modes of agriculture. However, this reduction is significantly higher than the 2% (2015) OECD average. On the one hand, this suggests that major first-round (low hanging fruit) energy saving opportunities could potentially be achieved through a coordinated and well-informed programme. On the other hand, a failure to reduce and eliminate these inefficiencies will certainly place additional pressure on this vital but vulnerable economic sector. Indeed, rising energy costs in 2021, and their direct (fuel and electricity) and indirect (fertilizers and herbicides) impact are already being noted (Business Day, July 2021). In the medium to long term, new trade barriers are likely to emerge linked to the global energy transition.

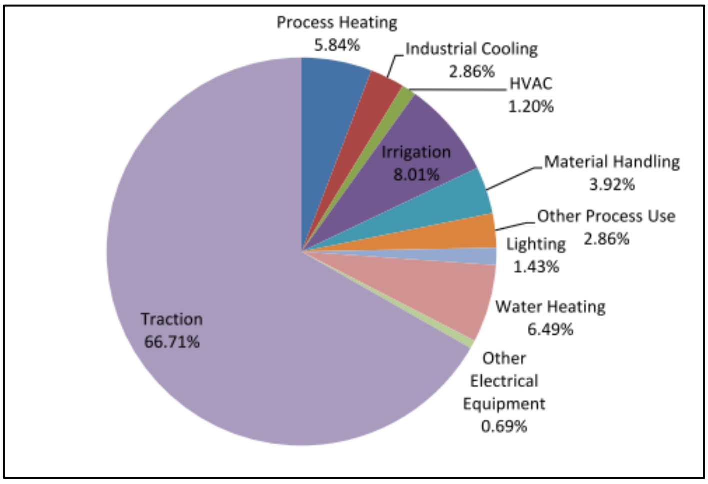
The need to improve the competitiveness of the agricultural sector from an energy input cost perspective, is not new. Several studies have been undertaken in the past. Key amongst these is the previously cited Switch Africa Green Research and Training report, undertaken by REEP in 2016. The report confirmed that the agricultural sector in South Africa is heavily reliant on energy as a production factor. This makes it highly susceptible to energy prices and availability, noting that the entire sector needs to find a way to increase energy independence. The South African Government, through the DMRE, recognises the long-term economic benefits of energy savings and the pressing need for South Africa to decouple economic growth from energy consumption. In this regard, the DMRE has sought to improve the energy saving policy and regulatory environment, through a number of policy instruments, including the NEES (2005 and post-2015). As stated earlier, the inclusion of agriculture as a sector in NEES (post-2015) bears testament to the recognition of the agricultural value chain's importance to the nation's energy efficiency strategy. The DMRE in its own words stated the following:

> *The agricultural sector is not a major consumer of energy, accounting for only 3.5% of South Africa's total energy consumption in 2015. However, it has been estimated that the sector provides livelihoods (either directly or indirectly) for about one in five South Africans. Improving energy efficiency in agriculture is a thus key part of the more general modernisation of the sector, which is essential for rebuilding an inclusive and sustainable rural economy*.

Note: The post-2015 NEES is yet to be formally accepted by Government and this invariably raises concerns about commitment, inhibits internal budget allocations and creates uncertainty.

In 2012, the DMRE reported that the bulk of energy consumption within the South African agricultural sector was used in traction (~67%) i.e. tractors, harvesters, transport. With regard to electricity usage, the largest share was for irrigation (~28%) followed by water heating activities (~22%), as shown below.

Figure 3: Agricultural sector energy end use

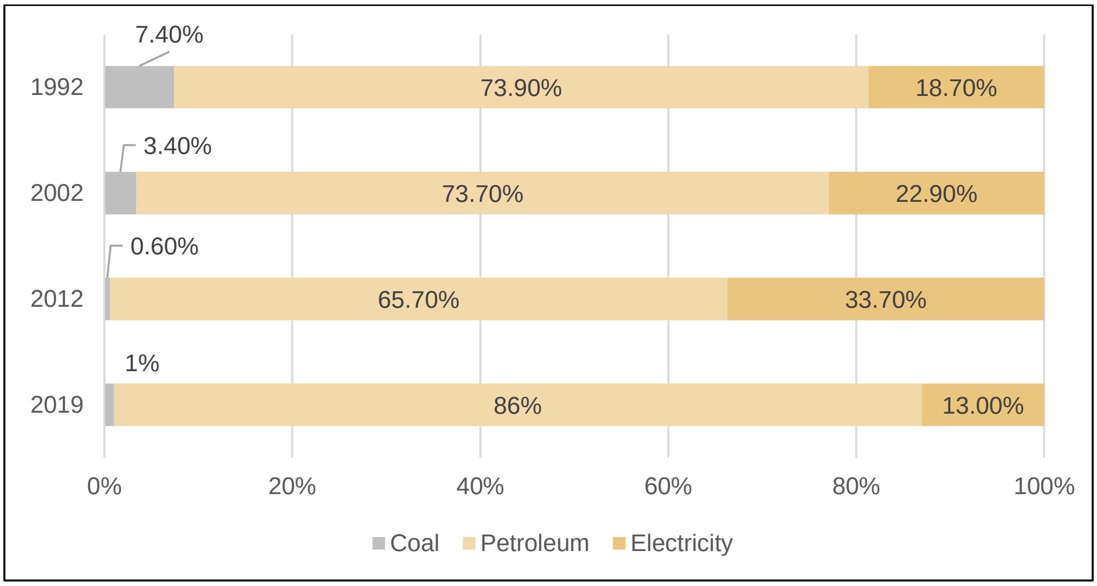


Source: DMRE (2012)

A seemingly positive development in 2012 (

Figure 4) was the almost complete elimination of direct coal usage and the strong shift to electricity as the main source of energy supply in the sector, which itself is almost entirely coal based (87%). However, the switch to electricity does provide the opportunity for the sector to more readily access energy efficiency and renewable energy opportunities. However, the DMRE's 2019 figures showed a sharp reversal - in just seven years, coal usage increased to 1% (0.6%) and petroleum to 86% (67%), at the expense of electricity, which more than halved to 13% (33.7%). The DMRE report does not provide an analysis or explanation, so it may be that this reversal was driven in part by the ongoing electricity supply crisis that started in 2006 and steep tariff increases. However, it is unclear if this figure includes some (or all) of agro-processing, which would provide a more plausible explanation – as per the report (pg. 33) "*This is as a result of transportation of agricultural raw materials, feeds****, intermediary and finished products from farms to various market areas***."

Figure 4: Agricultural sector energy use by source (% of total, 1992 to 2019)



Source: Department of Energy (2012; 2019)

As a result, any electricity savings target for the agriculture sector represents only one part of a much broader energy saving outcome, to be achieved through of a package of policy measures. The EU policy experience, and research undertaken, provides some general lessons and highlights a large number of specific measures that can be considered to increase energy savings throughout the entire agricultural value chain

3 The EU Policy and Research Experience

In 2020 the EU agricultural sector contributed 1.3% to the EU's GDP and created a gross value add of EUR 177 billion. But, as in most countries, agriculture enjoys privileges that perhaps other sectors do not for reasons such as food security; land use; employment etc. Within this sector, energy is an indispensable production resource, and remains relatively high in the EU. Indeed, agriculture's share of total energy use as a percentage grew from 2% (2000) to 3.2% in 2018, with the OECD average being 1.7% and 2% respectively. Increasingly however, farmers of member states are shifting to renewable energy, while the sector produced more than it consumed from this source, and in the top five countries accounted for more than 20% of total energy use. The process of energy diversification (and ultimately transition) is thus already underway but will have to improve significantly if the ambitious mandatory 2030 and 2050 targets set by the EU Commission are to be achieved. As the agricultural sector continues to increase mechanization to replace human work, so too will its energy consumption; and this can be offset by increased installation of energy efficiency and renewable energy technologies (Rokicki et al, 2021).

3.1 EU Climate Action

The EUs plans and progress in agriculture are informed by the region's overarching climate change commitments. Under the EU 2030 climate and energy framework, member states have committed to the following targets (European Commission):

- Reducing carbon dioxide emission by 40% compared to 1990 levels.
- A minimum of 32% of energy consumption to be sourced from renewable energy.
- A minimum of 32.5% of energy savings as compared with the business-as-usual scenario.

In May 2021 a landmark was achieved when all relevant EU institutions agreed to legislate the EU target of net-zero emissions by 2050, including the revision of the existing goal of reducing carbon dioxide emissions from 40% to 55% (of 1990 levels) by 2030. The EU's Energy Roadmap 2050 explores the transition of the energy system in ways that would be compatible with this GHG reductions target, while also increasing competitiveness and security of supply.

The 2012/27 EU Directive obligates member states to develop and publish National Energy Efficiency Action Plans (NEEAP) every three years as well as to report on progress achieved towards meeting their national energy efficiency targets on an annual basis. The NEEAP details a member state's estimated energy consumption, planned energy efficiency measures, long-term renovation strategies, and the energy saving measures it expects to achieve to originally achieve the 2020 and now 2030 targets.

A review of several member states NEEAP's found that each country adopted different approaches. For example, France's 2014 plan was very detailed at 118 pages, with agriculture having its own section (3 pages), detailing specific programmes and actions to reduce energy consumption and specifically target "*energy hungry processes in particular greenhouses production, intensive production and the use of tractors and renewable energy" (*pg. 63). This supports Rokicki's research findings on the sector's preference to increase supply rather than reduce demand. The design of France's energy saving measures specifically consider economic development and employment.

Other plans offer less detail. Germany's 2014 NEEAP is half the length and approaches energy savings by services / technology rather than sectors, with agriculture included in Commerce, Trade and Services. Its 2017 NEEAP, again follows a similar approach and does not list discrete actions but adopts a programmatic sectoral approach. Agriculture is a sub-sector of industry, with the primary interventions of: 1) tightening existing and expanding the minimum energy performance standards (MEPS) for equipment, such as motors, AC etc.; 2) vehicle efficiency standards; and 3) energy audits by qualified energy service companies (ESCOs). Finally, Sweden's NEEAP (2017) takes a similar approach (pg. 24): "*Jordbruksverket [the Swedish Board of Agriculture] also offers advice on energy efficiency free of charge to agricultural units in its support programme*".

The crosscutting nature of energy conservation measures may partly explain why actions are presented at a high level. For example, energy audits, performance standards for electrical equipment, vehicle efficiency, insulation, cooling to name but a few, are needed in all economic sectors. And indeed, the detailed interventions probably reside with the various implementing agencies. Moreover, at the policy level a holistic approach to climate change can offer multiple benefits.

The EU's Green Deal, which was released in December 2019, lays out a multi-dimensional action plan designed to cover several policy areas: climate, clean energy, circular economy, building standards, transportation and mobility. Included in the strategy:

- Stipulating that at least 40% of Common Agricultural Policy's spending contribute to climate action
- Shifting the focus of payments from compliance to performance, rewarding producers for improved environmental and climate outcomes
- Seeking to significantly reduce the use of chemical products in agriculture
- Ensuring that actions are taken to improve the circular economy in the food value chain
- Stimulating sustainable food consumption and promoting healthy food
- Enhanced focus on research, innovation, education and training to achieve the strategic green deal objectives

These high-level targets undoubtedly seek to reduce both direct and indirect energy inputs, and this in turn is reflected in member states programmes (OECD, 2020): Select examples:

Belgium: *(*35% reduction in emissions by 2030 compared with 2005 levels)

- Increased support for energy efficiency and renewables (direct)
- Implementation of an agreement on enteric emissions for cattle (direct)
- Promotion of precision fertilisation and guidelines for farmers (indirect)
- Adaptation of fertilization practices and animal feed (indirect)

Germany: (55% reduction in emissions by 2030 compared with 1990, GHG neutrality by 2050)

- Reduce the nitrogen surplus (direct)
- Derive energy production from organic residuals in biogas production (direct)
- Reduce emissions in livestock production (direct)
- Increase the energy efficiency of agro-technology (direct)
- Extend organic agriculture (indirect)
- Maintain or build up humus/soil organic matter levels in arable land (indirect)
- Reduce food waste (indirect)

Greece: *(*16% reduction in emissions by 2030 compared with 2005 levels)

- Development of advanced biofuels (direct)
- Promotion and use of renewable energy sources (direct)
- Actions targeting energy efficiency improvement, including restrictions on importing used cotton harvesting machines manufactured before 2002 (direct)
- Agricultural and livestock waste management (indirect)

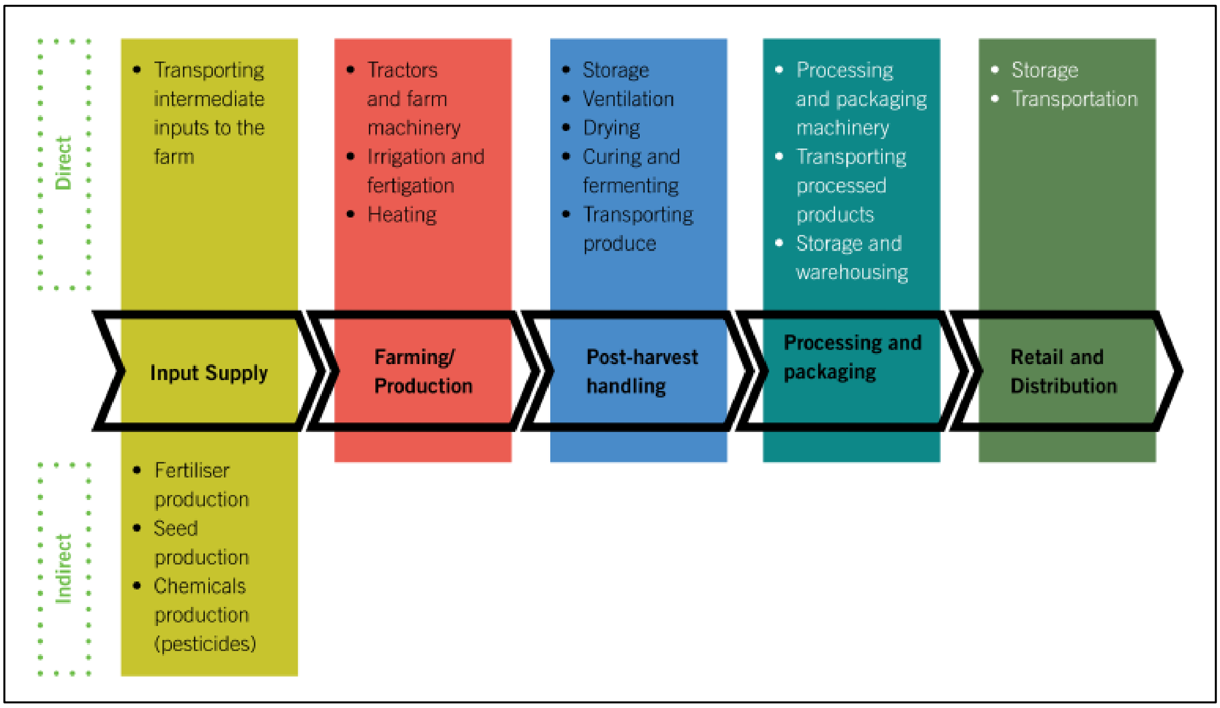
3.2 Energy Consumption in the Agricultural Sector

While relying on a mix of renewable energy, such as solar technology, EU agricultural production largely remains reliant on the use of energy from fossil resources. This relates either directly to the use of fuel or electricity, or indirectly to the use of agricultural machinery, fertilizers or pesticides (Table 2). And while the discussion on energy use in agriculture is often focused on direct energy use, it needs to be acknowledged that more than 50% of the total energy use is related to the production of nitrogen fertilizer and other indirect energy uses (Woods et al. 2010, Pelletier et al. 2011) -

Table 2: Classification of energy consumption

Item	Crop Production	Animal Production
Direct energy input	Fuel, lubricant, oil, heating	Fuel, lubricant, electricity, gas heating
Indirect energy input	Machines, fertilizers, pesticides, seeds, machine sheds	Machines, sheds, fodder import, fodder processing

Figure 5: Energy consumption in crop production



Source: SWITCH Africa Green (2016)

Statistically, the agricultural sector accounts for almost 10% of GHG emissions in the EU, mainly for food production and transport. Overall, energy consumption by agriculture made up only 3.2 % of final energy consumption in 2018 and decreased by 10.8 % between 1998 and 2018. Oil and petroleum products were the main fuel types and contributed to 56% of total energy consumption by agriculture in the EU-27 in 2018, but the share of electricity and renewables and biofuels increased since 1998 (Eurostat Agri-environmental indicator 2018).

Given that in many regions agriculture is the biggest land user, the sector has a large technical and economic potential for contributing meaningfully to the EU's legislated renewable energy generation and energy savings targets. The sheer land surface involved allows for the deployment of sizable renewable energy installations, both for own use and sale. Accordingly, capital costs and/or energy sales can be maximised if own use consumption is optimised through energy efficiency. The sector also has the potential to produce bioenergy (biogas and biofuels) to replace liquid fuels. Moreover, although European farmers have in recent years made efforts to reduce their direct and indirect energy consumption (AgroRes), it is not at the required scale and actions will need to be significantly intensified in the coming years.

3.3 EU Agriculture Research on Energy Saving Measures (AGREE)

In order to support the efforts of farmers in the EU to maximise their energy usage at the lowest cost, a detailed study on Agricultural Energy Efficiency (AGREE) was conducted in 2012, covering six countries (Finland, Germany, Greece, the Netherlands, Poland, and Portugal). The research methodology and results provides useful and applicable insights not only for the EU, but also for other agriculture producing countries. The study identified energy saving measures in 13 subsectors of agricultural production, their importance, achievability, cost of implementation and the estimated payback period.

3.3.1 Research Methodology

The data was collected from in-depth interviews, national statistics, and primary academic research. The variables considered include:

1. INPUT ENERGY: Direct or Indirect
2. ENERGY SAVING (ES) MEASURE:
    a. Operational level (single production activity)
    b. Systems level (intervention in a production system, affecting multiple activities)
    c. Process monitoring (total process optimization i.e: IT and management
    d. Farm management (organization of farm and its activities)
    e. Market orientation (production planning, matching supply and demand)
    f. Capital goods (energy efficiency investments – buildings, machinery)
3. IMPORTANCE OF ENERGY SAVINGS IN A GIVEN PRODUCTION (Energy efficiency potential): Scale 1 to 5, where 1= low and 5= high
4. NEED FOR RESEARCH AND DEVELOPMENT: Yes / No
5. INDICATION AS TO WHETHER MEASURE IS IMMEDIATELY ACHIEVABLE OR NOT: A= Achievable / P = Potential but in the future
6. INDICATIVE INVESTEMENT COST: 5 Categories - <EUR1 000; 1 000 to 25 000; 25 000 to 1 000 000; > 1 000 000; Not applicable
7. ESTIMATED PAYBACK TIME: 1 year; 1-5 years; >5 years; not estimated.

3.3.2 Summary of AGREE Research Findings

The study considered 13 agricultural sub-sectors across six EU member states, and in so doing, identified 481 energy saving measures. The high number of opportunities available provides significant scope for immediate benefits; and many can be achieved through a process of practical implementation (managerial and organizational changes) which come at a low cost. The research also noted several energy saving measures that required further research and development to make them economically viable and require a sizable capital investment of greater than EUR100 000. Moreover, there is considerable overlap with many of the identified measures. This allows a national coordinating body (the DMRE or one of its agencies) to develop a broad programme, which could target direct and indirect energy usage, such as efficient motors; lighting; tractor sizing; insulation and ventilation; organic fertilizers (green ammonia). Finally, two thirds of the identified energy saving measures were valued at less than EUR 25 000.

3.4 Learnings for South Africa

The AGREE study identified 481 ES measures for 13 subsectors, but not all agricultural products cultivated/farmed in the EU are relevant to the South African context, and vice versa. A 2016 study undertaken by the Renewable Energy and Energy Efficiency Partnership (REEEP) on sustainable energy and waste consumption in the South African agricultural sector identified the most prevalent sub-sectors, by gross value contribution. These have been compared to the products covered by the AGREE study (Table 3) and the common ones are highlighted in blue.

Table 3: Energy saving (ES) measures by subsector of agricultural production (by country).

Product	No. of ES measures	Finland	Germany	Greece	Netherlands	Poland	Portugal	Total

Wheat	58	9	14	20	16	21	13	93
Sugar beat	30		2		16	17		35
Potatoes	31		2		17	19		38
Sunflower	10		6				6	12
Cotton	19			19				19
Tomatoes	43		4	28	7		12	51
Cucumber	37		4	28	7			39
Peppers	10		4		7			11
Vineyards	24		3	18			16	37
Olive	19			18			8	26
Dairy	37	7	4		16	7	7	41
Pigs	30	5	7		13	7	3	35
Broilers (Poultry)	40	4	7		21	7	5	44
Total	**388**	**25**	**57**	**131**	**120**	**78**	**70**	**481**

Source: AGREE (2012)

This short-list of products categorised by energy intensity and share in agricultural GDP (REEEP, 2016), is shown in Table 4. Most are relatively intensive, and account for a high share of South Africa's agriculture production. Implementing energy saving measures for these products would have a significant impact on the long-term efficiency and competitiveness of the sector.

Table 4: Categorization of agricultural products in SA (Energy intensity and GDP contribution)

Product	Energy Intensity	Share in agricultural GDP (SA)
Wheat	Med	Med
Potatoes	Low	Med
Sunflower	Med	Med
Tomatoes	Med	High
Vineyards	Med	Low
Olive	Med	Low
Dairy	Med	High
Broilers (Poultry)	High	High

Low	Med	High

Source: REEEP (2016)

3.4.1 Identified AGREE Measures for Selected Agricultural Products

The AGREE study identifies the energy saving measures mentioned most consistently in the EU, for both direct and indirect energy use, for all of the short-listed products. These findings are consolidated in Table 5.

Table 5: Identified direct and indirect energy saving measures by agricultural product

Product	Energy inputs and associated ES measures	ES measures	
		Direct	Indirect
Wheat	Sowing (5); Fertilization (30); Plant protection (9); Irrigation (9); Field operation (26); Harvest (3); Post-harvest (12); Other (5)	39	54
Potatoes	Sowing (2); Fertilization (15); Plant protection (2); Field operation (12); Harvest (1); Post-harvest (2); Other (3)	15	23
Sunflower	Sowing (2); Fertilization (1); Plant protection (3); Field operation (6)	9	3

Tomatoes	Sowing (1); Fertilization (9); Plant protection (9); Irrigation (4); Field operation (1); Production operations (17); Greenhouse infrastructure (10)	25	26
Vineyards	Sowing (1); Fertilization (15); Plant protection (9); Irrigation (3); Field operation (7); Harvest (1); Other (1)	10	27
Olive	Sowing (1); Fertilization (9); Plant protection (7); Irrigation (2); Field operation (5); Harvest (1); Other (1)	27	14
Dairy	Feed (19); Energy use (12); Diesel use (5); Ventilation (2); Veterinary Drugs & Service (2); Water use (1); Building / Construction (1); Diesel and labour use (1); Feed additives (1); Lighting (1)	24	11
Broilers (Poultry)	Building/Construction (23); Feed (5); Energy use (6); Diesel use (3); Spatial planning (2); Water use (1); Feed additives (1); Lighting (1); Ventilation (1); Veterinary Drugs & Service (1)	30	14

Source: AGREE (2012)

The most common measures identified in the AGREE study are as follows:

1. Application in accordance with soil fertility and availability of the compounds (24)
2. Reduced use of herbicides (18), fungicides (12) and pesticides (11)
3. Rational use of transportation (15)
4. Appropriate power of the tractor and other machinery (13)
5. Increased use of organic (11) & multi-compound fertilizers (9) / reduced use of synthetic fertilizers (9)
6. Application of bioactive microorganisms / insects (10)
7. Better heat insulation (10)
8. High quality seeds (9).

A short explanation of these measures is provided in **Appendix A.**

3.5 Recent Developments

The AGREE study was completed in 2012 and its value lies in the large sample size which identified the most common energy saving measures across member states. A follow-up study to track progress and any new developments has not been commissioned[3]. However, a 2021 study (Rokicki et al) tracked the changes in agricultural energy consumption across all 28 EU member states between 2005 and 2018[4]. The study:

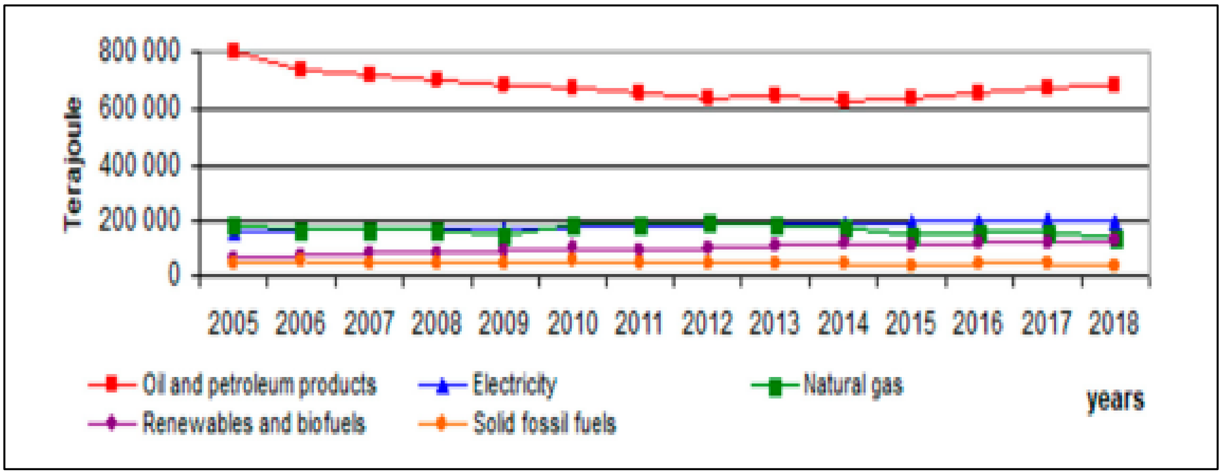
1. Confirmed that the largest agricultural nations (Poland and France) have the highest energy intensity.
2. Found a very strong link between the adoption of renewable energy technologies and economically developed countries (Sweden 35%; Austria 33%; Finland 25%; Germany and Slovakia (23% each). In total 12 member states exceeded the EU average of 10%, but surprisingly France (5%) Italy (3%) and Spain (2%) were very low.
3. Noted that even though the EU's agricultural sector's overall energy consumption remained stable, this figure masks the reality that certain countries increased their energy consumption (Romania, Latvia and Germany) while others declined (Greece, Portugal Ireland and Sweden) – however this may be due to decreased production or more efficient technologies, but the cause can only be revealed from a detailed country study.

[3] The researcher found large quantities of detailed technology specific research on energy efficiency and energy conservation products. The AGREE study focused on energy saving measures.

[4] The number of member states in 2021 is 27 after the UK's exit.

4. Identified liquid fuels as the biggest energy source (60%); electricity and natural gas (12%); and renewable energy (10%) – as shown in Figure 6.
5. Concluded, that the adoption of RE in the agricultural sector has increased over the period under review and expects this trend to continue; however, the energy intensity of the agricultural sector has decreased slightly; and there is a strong possibility that further gains may be offset as farmers continually seek to increase the percentage of mechanization of their production, and it is in this sphere that energy efficiency has an important role to play.

Figure 6: Sources of energy used in agriculture (2005 to 2018)



Source: Rokicki et al (2021)

4 Findings, Recommendations and Concluding Comment

The REEEP study identified energy saving opportunities throughout the entire agricultural value chain, which align strongly with those from the EU experience, as per the AGREE study. Noteworthy amongst these: fertilizer; irrigation; refrigeration; transport; lighting; crop drying; optimum machinery and motors; greenhouses; hot water. To these, tillage and pesticides could be added. The REEEP study then lists financial mechanisms (loans; tax incentives; funds; rebates; competitions; investments; and grants) and non-financial (awareness; case studies; energy audits; data collection) for these energy savings opportunities to be realised. A detailed list of available private and public sector energy saving financing and support programmes are provided in the report; noting that some may no longer be available in 2021 but are nonetheless a useful resource.

In 2021, under an initiative funded by the World Bank, the DMRE is being supported by expert consultants, to conduct a detailed analysis of each sector. This will be used to develop financial instruments to achieve the post-2015 NEES energy reduction targets. The research team has the benefit of access to a high number of energy audits undertaken in the agricultural value chain under the Private Sector Energy Efficiency (PSEE) initiative, which was funded by the UK government, and will provide significant insight into identifying and prioritising actions. Preliminary findings from the study, which is due for completion Q4 2021 / Q1 2022, are that efforts in the agricultural sector should prioritise medium, small, and micro farmers (89% of commercial farms or approximately 35 700 farms). The 'majors' have adequate resources (funding, technical expertise, infrastructure, equipment etc.) and run efficient operations that meet best international practice. This has been confirmed by the research in an interview with Blue North and Stellenbosch University. Here, in the words of Professor Stephanie Midgley (Horticulturalist at Stellenbosch University) "*government programmes should target farmers who cannot survive more than two loss making seasons (drought, floods, low market prices etc). They are the bedrock of the sector and are in desperate need of support.*" Crucially, it is indeed these farmers who are least likely to be able to exploit energy saving opportunities, either due to a lack of information, access to finance (creditworthiness), or both. But, as the research has found, the first round of interventions can be no or low cost – strengthened by favourable (short) payback periods. Herein thus lies the opportunity for the DMRE to develop and implement a targeted action plan, aimed at achieving its 2030 high-level energy efficiency savings target for the agricultural sector of 30%. Knowing that the agricultural sector is well represented by industry associations, there are direct entry points into the farming community, at the sector; sub-sector and product/technology level.

Ultimately, the objective of this report is to support the DMRE, by providing an additional perspective through the EU experience. It is not intended to pre-empt the above-mentioned ongoing study, which will provide a detailed list of actions, as the outcome of a significantly more focused and detailed research. Suffice to say though, that the researcher has found adequate evidence to suggest that although helpful, energy savings case studies are plentiful, but have had a limited impact. The DMRE should focus on disseminating rather than developing new studies. This study has listed proven energy saving opportunities and trends which could assist, inform and confirm findings of the ongoing DMRE work.

Within this context however, the research findings are sufficiently conclusive to provide an informed opinion on a number of straightforward actions – which have a high likelihood to create long-term energy and GHG emission savings, for both direct and indirect consumption.

Direct Energy:

1. **Formalise the NEES and develop a NEEAP**: The post-2015 NEES, although developed has yet to be ratified by Cabinet, more than six years into its 15-year life. This must be prioritised to give the Strategy official status and in so doing the mandate DMRE officials require to work towards achieving its targets. Moreover, a NEEAP is a powerful supporting tool to achieve the long term NEES targets, and its regular revision provides the opportunity for refinement, reprioritisation and additions based on performance and experience. The EU has more than a decade of experience in NEEAP's and could provide valuable support. As with the NEES, if a NEEAP is developed it requires formal Government endorsement.
2. **MEPS**: The DMRE should prioritise and fast-track its current efforts to introduce MEPS for electric motors and efficient lighting – including regular (3 years) performance standard reviews to strengthen the standards.
    - Electric motors are ubiquitous in all sub-sectors of agriculture and the overwhelming majority of motors sold in South Africa are IE0 i.e. no energy efficiency classification. A retrofit / swop out programme would deliver immediate direct energy usage reductions and provide an opportunity for other awareness raising efforts. This offer could be expanded with concessional financing if the entire system is retrofitted; i.e. in addition to an efficient motor, pipework and flow control are upgraded. This could be extended for transitioning to drip irrigation, or the installation of a standalone direct pumping photovoltaic system

- LED lighting offers significant savings, especially in the poultry industry, but should be a standard fixture in all usage applications
- The DMRE should identify additional electrical apparatus with a high penetration rate in the agriculture and agro-processing, such as commercial refrigeration, and prioritise them

MEPS offer an effective and proven policy tool that is mature and well understood. Its structure ensures that all stakeholders benefit and alignment with primary trading partners ensures a level playing field and discourages the dumping of old and inefficient technology. The DMRE has an established S&L programme making it a seamless and straightforward intervention.

3. **Energy Audits**: Most farmers, especially financially constrained ones, may very well be sceptical about investing in an energy audit. The PSEE experience, which provided free energy audits, was that the conversion rate was low. Indeed, not a single commercial farm has registered a programme under the national 12L EE tax incentive which is administered by the South African National Energy Development Institute (SANEDI). Energy audits are a priority action in the EU, featuring regularly in the three yearly NEEAP updates of most member states. It could be useful for the DMRE to gain insight of the EU experience to gain a better understanding of the key success factors needed to increase uptake and implementation of the recommendations.
4. **Awareness**: The South African agricultural sector is well organized and has strong and capable industry associations who are active and capable in advocacy, lobbying and technical skills. The DMRE could consider formulating a strategy to leverage this extensive network to reach farmers directly through a trusted partner. This is likely to be a cost-effective approach and will additionally provide specialised technical input.

Indirect Energy:

In little more than a year, green hydrogen has grown from poorly understood and something for the future, to a priority intervention. It now enjoys ministerial support from the Presidency, DMRE, dtic and Department of Science and Innovation; and the NEES should leverage this opportunity to promote the production of green ammonia[5] which is the primary ingredient in fertilizers. Over time, green hydrogen can play a meaningful role in the so-called ‘difficult to abate’ transport sector, and traction requirements in the agricultural sector are a textbook application. Although not an energy saving opportunity, this action is a crucial decarbonization effort.

In conclusion, the relationship between energy consumption in agriculture and economic growth has been established by several studies; and it is a global challenge requiring urgent prioritisation. Moreover, as Rokicki (2021) states, it is precisely the increase in energy efficiency in agriculture that should reduce the differences between developed and developing countries. To this end, the EU is actively working to support developing countries and regions, both in multilateral fora and through bilateral cooperation, in their efforts to tackle climate change (European Commission 2021), while being a top provider of international climate finance.

[5] The ammonia produced from green hydrogen can be considered green ammonia and its combustion does not generate CO_2. Compounds such as the ammonia itself are widely used in the chemical and fertiliser industry

Ultimately, it is in this spirit of constructive collaboration that this report is written. It represents the EU’s firm commitment to supporting South Africa in actualising the rapid evolution of its agricultural sector in terms of NEES 2015, and continuing to thrive as a valued and ever-growing agricultural trading partner to the EU.

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6 Appendix A – The Most Frequently Cited Energy Efficiency Measures

Annual (wheat, potatoes, sunflower) and Perennial (olives and vineyards) Crop Production

Unsurprisingly, the most common measures are associated with fertilization and field operations; followed by post-harvest activities, namely drying and storage. Immediately evident is that many of these measures have a low cost, but carry a 'nuisance' factor (correct tyre pressure, unnecessary usage) and / or require informed planning (appropriate tractor size selection)

Direct Energy Inputs

1. **Tillage:** To the greatest extent possible, minimise tillage; together with controlled traffic farming[6]; precision arable farming[7], yield mapping and plant rotation
2. **Tractors and machinery:** Appropriately sized tractors (i.e. not over or under powered); correct tire size, tire pressure and weight of front axle, machinery aggregation, combined application of production means. The same principles apply to electric motors (pumps etc).
3. **Infrastructure:** Prevention of heat loss from dryers and crop stores; heat recovery using heat pumps, use of energy from farm residuals; optimization of dryer and crop store designs; energy efficient drip irrigation systems; maintenance and electronic control systems.

Indirect Energy Inputs

1. **Seeds:** Cultivars with high yield potential and lower energy inputs per unit of production.
2. **Fertilizers:** Application of fertilizers in accordance with soil fertility and nutrient availability; as well as appropriate dosing; application of bioactive microorganisms, green fertilizers, multi-compound and organic fertilization on the basis of N fertilizer working coefficient; together with replacement of synthetic Nitrogen fertilizer with biological nitrogen fixing and cultivation of green manure crops.
3. **Pesticides:** Use of bioactive microorganisms; site specific application of pesticides; disease resistant cultivars

Greenhouse Crop Production (tomatoes)

Greenhouse energy saving measures stem primarily from design (infrastructure), processes and production operations. This largely relates to attaining the optimal temperatures at the various stages of the growth cycle, with the minimum use of energy. More recently, with technological advances, this extends to energy recovery and alternative energy sources, such as photovoltaics, bioenergy and waste heat. Thereafter, the measures listed above, which dominate crop production – fertilization, irrigation etc. – also provide meaningful energy saving opportunities.

Direct Energy Inputs

[6] Controlled traffic farming is a management tool which is used to reduce the damage to soils caused by heavy or repeated agricultural machinery passes on the land

[7] Precision farming is a management concept based on observing, measuring and responding to inter and intra-field variability in crops. This technique has been enabled by the advent GPS

1. **Energy use:** Optimization of energy parameters of the production process (heating/cooling/ventilation); heat recovery from exhaust air of ventilation; geothermal energy use; reduced use of fuel for heating; lowered temperature set point.
2. **Greenhouse infrastructure:** Double thermal screen; adaptive set-points; increased set point for air relative humidity; shading system during summer period; crop-based humidity control, crop-based use of energy screen. anti-reflection glass; greenhouse cover film with anti-drip coating that removes condensed water; and a wind break.
3. **Production process:** Irrigation - optimal water input; energy efficient application of fertilizers and pesticides; reduction of crop transpiration

Indirect Energy Inputs

1. **Seeds**: plant breeding, as well as high quality seeds and seedlings
2. **Production means**: optimal fertilizer doses and division of doses; application of bioactive microorganisms; application of organic fertilizers; reduction of fertilizers and pesticides use.

Livestock Production

There is a greater variance between the different energy savings opportunities in livestock subsector, depending on the country's production structure. Distribution of food and welfare of animals are the major energy drivers in some countries. In others, costs are directly linked to the electricity needed in the buildings which house the animals and the associated infrastructure – as detailed below. However, for both, diesel usage can be reduced by adopting similar practices to the ones put forward in the crop production section above. Finally, feeding practices and techniques can also offer significant energy saving opportunities.

Direct Energy Inputs

1. **Energy use**: Efficient water cleaning; pumping system; heating system and insulation; lighting with low energy consumption; optimization of production process; heat recovery, energy production from farm residuals; ventilation
2. **Diesel use:** Appropriate power of the tractor and other machines of production operations and rational use of transportation
3. **Buildings:** Reduction of ammonia; use of recovery energy for the drying of manure; use of heat exchangers, controls of inside climate

Indirect Energy Inputs

1. **Feed and feeding**: Higher quality of fodder; feeding in accordance with specific animal needs; better fodder utilization improved feeding value; reduced use of concentrates; replacement of compound feed by home grown production; water management; cultivation of silage lays, consisting of mixture of legumes and grasses