The energy productivity Roadmap: Re-energising the Australian economy

Doubling energy productivity by 2030 to improve the competitiveness of the AGRICULTURE sector

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Thanks

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The views expressed in this text are those of A2SE and not necessarily those of our supporters and partners. We have taken all care to ensure that data is correct. All responsibility for the text rests with A2SE.

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Executive summary

Modern agricultural operations have become progressively more intensive users of energy (electricity and fuel) in order to secure efficiencies of labour and capital inputs. Electricity prices in Australia are the highest in the world ... farm enterprises operate in a highly competitive market. Increases in expenses, such as electricity, are largely not able to be passed on to consumers.

(National Farmers' Federation, 2014c)

In July 2014, the Australian Alliance to Save Energy (A2SE) commenced the Australian Energy Productivity (2XEP) Roadmap initiative with the support of governments, businesses, industry associations and thought leaders from a range of institutions.

Energy productivity is a stated policy priority for federal, state and territory governments. Improving energy productivity is about increasing the economic value added per unit of energy, as well as the dollar of energy spend. In a period of rapidly increasing energy prices in Australia, an holistic approach to energy productivity can make a major contribution to Australia’s overall productivity and hence competitiveness.

This report was prepared to provide an overview of issues that need to be addressed to substantially enhance energy productivity in the agriculture sector. It will also provide a starting point for discussion with stakeholders in the agriculture sector and development of the Agriculture Sector 2XEP Roadmap.

Why focus on energy productivity in agriculture?

Agriculture is critical to future global food security. In this increasingly globalised market for agricultural commodities, competitiveness is paramount if Australia is to retain its leadership position in many agricultural commodities.

The agriculture sector’s performance is a significant contributor to the Australian economy and the living standards of the Australian people. The recent Free Trade Agreement (FTA) with China is expected to lend further support to the red-meat, dairy, horticulture, wool and barley sub-sectors (Department of Foreign Affairs and Trade, 2014).

Agriculture is a large energy user, and the response of the sector to improving productivity, including energy productivity, will shape its future competitiveness and the extent to which it remains the anchor of Australia’s rural economy.

Significant unexploited energy productivity opportunities exist across the agriculture value chain in all sub-sectors. Savings of 20% or more are achievable in many instances, including farm vehicle fuel efficiency, electricity use in intensive farm operations such as dairy, as well as irrigation systems.

The rationale for Australia adopting an energy productivity target is strong:

- Overall productivity in many sectors of the Australian economy has been flat or declining in recent years. Although agriculture performed better than most other sectors, Australian agriculture’s export market share growth declined from 2005 to 2010 (Lydon, Dyer, & Bradley, 2014). This suggests a drop in the global competitiveness of Australian agricultural production.
Australia’s energy productivity lags that of other G20 countries, and is increasing at a lower rate (World Bank, n.d.). Energy prices have risen steeply since 2008 relative to other nations, eroding what was once a competitive advantage for Australia.

The 2XEP initiative

In response to these factors, the A2SE 2XEP initiative proposes doubling energy productivity across the Australian economy by 2030. This target is in line with other major economies, and needs to be achieved to avoid entrenching the competitive disadvantage that has emerged in recent years.

An appropriate 2030 energy productivity target for the agriculture sector needs to be set by the sector. A2SE will consult with a diverse range of stakeholders about what this target should be, the optimal pathways to follow for different sub-sectors within the agriculture sector, as well as how progress could be measured against such a voluntary target.

Consultation will also canvass collaborative action the industry could take to support a significant improvement in energy productivity and recommend actions required by governments to reduce or remove barriers to achieving such a target.

Potential strategies for improving energy productivity.

Energy productivity is typically expressed as the real economic output per unit of energy (usually primary energy). Consequently, the potential to achieve a voluntary energy productivity target could be influenced by adopting complementary strategies that could either increase economic output or reduce the relative energy consumption per dollar output. Energy productivity is not energy efficiency by a different name. Energy efficiency, which generally focuses on using less energy to deliver the same service, is, however, an important part of one the four key strategies, as illustrated below.

The key strategies to enhance energy productivity are summarised below:

- ‘Traditional’ energy management – e.g. improving energy efficiency through better management of energy use including the implementation of innovative energy-use technologies and demand-management initiatives, as well as best practice data-management and benchmarking practices to facilitate energy productivity decision making.
• Systems optimisation – e.g. focusing on energy aspects of the agriculture infrastructure design, production processes and extended value chain, including capacity optimisation strategies and the impact on water and waste streams. These changes may be implemented for reasons of broader productivity improvement, but greater value can be realised by bringing to them a deliberate energy competency and focus.

• Business model transformation – e.g. focussing on the energy aspects of fundamental longer term change in the business of agriculture – relating to the design, development and operation of agriculture, as well as trading and asset management.

• Value creation or preservation – e.g. focussing on increased production, yield and value add to products.

The agricultural sector has made significant investments in energy efficiency in recent years, with leading-edge research underway that will assist Australia in maintaining its position as a leader in agricultural production. However, by way of example, energy is currently not a central consideration in water efficient irrigation system design, which, if not addressed, will undermine water management programs and continue to drive up the cost of irrigation.

The agriculture sector stands to benefit from advances in precision agriculture and robotics, exploiting the wealth of data available for sustainable gains in productivity with considerations of yield, water, electricity and chemicals. Farmers are also realising the benefits of upstream and downstream collaboration, including the sharing of infrastructure at regional level, such as community bore pumps and solar photovoltaic installations, thus increasing the utilisation of assets, which influences the return on investment in energy efficient equipment.

Farmers are adopting innovative new business models that reduce costs through vertical integration, increased specialisation and scale whilst retaining the family character of the farm business, or enhance the resilience of the business to climate variability and natural resource constraints. For example, Sundrop Farms is effectively decoupling tomato production from weather variability, fresh water availability and soil quality. They use solar technology to generate power that is then used to desalinate seawater for irrigation, and for heating and cooling hydroponic greenhouses (Sundrop Farms, 2014).

Finally, as a sophisticated, but high-cost producer, with a reputation for ‘safe, sustainable and healthy food’ (Australian Trade Commission, 2013), Australia can exploit opportunities presented by high value, fast growing global niche markets. These markets increasingly subject the food supply chain to scrutiny, demanding traceability to verify how food is produced (e.g. employment practices, animal welfare and environmental footprint) (KPMG, 2013).

Clearly, there is no ‘silver bullet’ that will address the economic and energy productivity challenges facing Australia generally and the agriculture sector specifically. Rather, a consistent and sustained productivity agenda, which has
energy as a central tenet in the design and operation of primary food production systems, is required.

Benefits from 2XEP for agriculture

Many producers of agricultural commodities in the sector are price takers, with very limited value added or product differentiation options. The key strategies for optimising operating income are managing production costs and maximising yield.

Energy is already a significant cost to many agricultural producers. However, the convergence of high input cost, the strong Australian dollar and increasingly variable climatic conditions has resulted in a decline in the growth of Australia’s export share (Lydon et al., 2014) and placed pressure on profit margins across many Australian agriculture sub-sectors.

Across ANZSIC Division A: Agriculture, Forestry and Fisheries, energy spend is equal to about a third of pre-tax profit. Given prevailing margins of approximately 17%, saving one dollar in energy cost is equal to an additional $6 at the farm gate (Australian Bureau of Statistics, 2014a). Optimising energy productivity will, therefore, contribute to the increased resilience of Australian agricultural producers, helping farmers to better withstand the cyclical nature of the industry.

The benefits of a significant improvement in agriculture energy productivity will depend on the voluntary target and actions agreed by the sector, but could include:

- Energy efficiency improvements and cost savings for agricultural producers; this will improve profitability, and also reduce emissions.
- Improved utilisation of resources and equipment (i.e. capacity utilisation).
- Multiple dividends in terms of reduced maintenance and downtime, as well as reduced waste and improved water management.

Agriculture program objectives

A successful outcome from an A2SE 2XEP Roadmap process will be a realistic but challenging energy productivity target and a plan developed by the sector, with the support of a broad spectrum of constituent industry representatives, to lead changes in the sector and their individual businesses to achieve the target. It is envisaged that an A2SE 2XEP Roadmap will comprise:

- Definition of pathways to significantly enhance energy productivity, with reference to the different sub-sectors and scale of operations.
- Identification of opportunities to collaborate to enhance Australia’s leadership position in agriculture.
- Mechanisms to create greater awareness and adoption of emerging RD&E innovations that can help agriculture sub-sectors achieve a step change in energy efficiency, such as the recently launched Agrilnnovators website.
- Strategies to overcome the barriers to adoption of new, more efficient processing technologies.
- The initiation of new, or strengthening of existing, programs to support agricultural producers to achieve 2XEP.
- Recommendations proposed to federal, state and territory governments for policy changes to facilitate these activities and support 2XEP in agriculture.
Such changes could be achieved through a collaborative process, involving agricultural enterprises, researchers and industry associations, with government engagement to accelerate innovation, transformation and value adding in the sector.
Notes:

All dollars ($) are Australian dollars unless otherwise stated
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1. Introduction

This report aims to provide a preliminary compilation of sectoral thought leadership and analysis to support engagement with the agriculture sector in the Alliance to Save Energy (A2SE) Doubling Energy Productivity (2XEP) Roadmap process. (Refer to Appendix C for an overview of the different modules.) The report presents the rationale for action and summarises the key issues, opportunities and barriers, and lists potential industry-led energy productivity improvement initiatives in the agriculture sector.

Using this report as a starting point, it is envisaged that the project will build on existing expertise and initiatives in the sector to develop a sector Roadmap, guiding the in-depth analysis of opportunities and challenges pertaining to energy productivity, as well as policy recommendations. A2SE will canvass appropriate voluntary performance metrics and energy productivity targets that are realistic, but challenging. Coordination and support will be provided by the A2SE project team in this regard.

1.1. Boundaries of this report

Some energy productivity issues are common across the economy as a whole. A subset of issues is common across agriculture, forestry and fisheries. However, the coverage of this initial report is limited to agriculture. The key reasons for the single focus on agriculture are:

- Industry associations are generally, with some exceptions, different and may have different public positions on energy policy issues.
- Opportunities for improvements are completely different.

Energy data is generally not available for agriculture alone. In some instances, ANZSIC Division A data, which includes fisheries and forestry, is used as a proxy in this report.

1.2. Structure of this report

A background to the rationale of a doubling of energy productivity (2XEP) program is provided in Section 2, with specific reference to application in the agriculture sector. This section includes an overview of current trends in economic productivity, energy use and energy spend.

Section 3 provides an introduction to how the A2SE 2XEP initiative proposes to define and measure energy productivity, as well as considerations for setting energy productivity improvement targets in the agriculture sector. Potential strategies for achieving significant energy productivity improvements are also discussed.

In Section 4, a ‘selection’ of potential opportunities is highlighted in each of the energy productivity strategy areas.

Barriers to energy productivity in the agriculture sector are discussed in Section 5, followed by an overview of potential policy responses and other actions that could address such barriers in Section 6. Potential next steps are presented in Section 7.
2. The case for 2XEP in the Australian agriculture sector

The agriculture sector is an important contributor to the Australian economy. Attempts to address economic (including energy) productivity, without consideration of developments in the agriculture sector, will likely be ineffectual. In this context, key economic and financial factors framing the energy productivity debate in the Australian agriculture sector are introduced using the following structure:

- Significance of the sector in the Australian economy and energy market
- Australia’s international economic and energy competitiveness
- Competitiveness, productivity and energy use in the Australian agriculture sector
- Prevailing market conditions for key commodities and export trends

This section provides the context for a discussion of the technical building blocks of energy productivity for consideration in consultation with stakeholders.

2.1. Significance of the sector in the Australian economy and energy market

The majority of Australia’s farms are comparatively small, with the value of agricultural operations of more than half of the farms estimated to be less than $100,000. It is estimated that only 6% of Australian farms had an estimated value of agricultural operations in excess of $1 million (National Farmers’ Federation, 2014a). However, this belies the crucial role of the sector in the economic prosperity of Australia, as we will discuss below.

2.1.1. Impact on GDP and employment

Although only accounting for 2% of national employment, the agricultural sector accounts for 10% to 15% of direct employment in regional areas. The sheep and beef cattle sub-sectors the largest agricultural employer, followed by the horticulture and dairy sub-sectors (Commonwealth of Australia, 2014).

The value of agricultural production was $48 billion in 2012–13, increasing to $54 billion in 2013–14, equivalent to approximately 2% of Gross Domestic Product (GDP) (Australian Bureau of Statistics, 2014c; Commonwealth of Australia, 2014). Between 2010 and 2012, approximately 60% of Australia’s agricultural produce was exported (Anderson, 2014), with a positive impact on the balance of payments, as agricultural exports exceeded imports by a ratio of 8.5:1 (Lydon et al., 2014).

Australia’s agriculture sector comprises a diverse range of industries. Because of a relative abundance of land, Australia has a comparative advantage in extensive broadacre agriculture, essentially in non-irrigated crops, cattle and sheep grazing. Broadacre farms contribute 54% of the gross value of agricultural production and make up around 53% of agricultural businesses (Gray, Oss-Emer, & Sheng, 2014). As illustrated in Figure 1 below, cereal crops (primarily wheat), horticulture, beef, non-cereal1 crops and milk account for approximately 80% of the value of agricultural commodities produced (Australian Bureau of Statistics, 2014c).

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1 This includes cotton lint, peanuts, canola, sugar cane and other pulses and oilseeds.
2.1.2. Energy spend in the agriculture industry

Australian energy use in agriculture has been growing steadily at an average rate of 0.2% per annum over the last 10 years (Bureau of Resources and Energy Economics, 2014). The sector accounted for 1.4% of primary energy use (96 PJ) and 2.8% of Australia’s end-use energy spend in 2011–12 (Australian Bureau of Statistics, 2013b).

The relatively higher cost per unit of energy in the agriculture sector is due to the sector’s dependence on diesel and LPG, rather than grid-supplied electricity and reticulated natural gas. The transport cost associated with diesel and LPG adds further to the cost of these energy sources. Where farmers have access to a reticulated gas network and grid-supplied electricity, the volume used per site is relatively low, resulting in agricultural producers frequently paying for electricity and gas at rates that more closely resemble residential than industrial tariffs. However, for large electricity users with consumption greater than 160MWh per annum, such as the irrigators participating in the NSW Irrigators Council and Australia Cotton Trail, network charges account for more than 60% of the total cost (NSW Irrigators Council and Cotton Australia, 2013).

The key energy cost driver for agricultural producers is often diesel prices. Diesel accounts for 81% of agriculture energy use; this equates to 76% of total sector energy cost or $2.8 billion per annum, as seen in Figure 2 (Australian Bureau of Statistics, 2013b). The price of diesel has increased by about 40% since 2004–05, but has been relatively stable since 2011–12 due to the strong Australian dollar. This is now changing with diesel at terminal gate prices (TGPS) trending upwards by 9.5% during 2013–14 (Australian Institute of Petroleum, 2014).
A reduction in the diesel rebate (see shaded Box 1 below) would add further pressure to fuel cost. The potential disruption to diesel supplies is also a key business risk. With 91% of crude oil and refined fuels imported, Australian diesel prices (tracked by the global Singapore diesel price) are influenced by the Australian dollar exchange rate, as well as the level of government excise (and excise exemption). The NRMA predicts that Australia will have no refining capacity by 2030 (Blackburn, 2014). Disruption of supply routes due to natural disasters, regional conflict or other factors will become an important business risk to be managed by farmers as Australia’s in-country stockholdings of crude oil and refined fuels are as low as 23–30 days (Australian Institute of Petroleum, 2013).

**Box 1: Fuel taxation in the agriculture sector**

The agriculture sector receives a diesel rebate of $0.32 per litre as most diesel is for off-road use. A review of the rebate has been considered a number of times, including in the run up to the May 2014 Federal budget. The Minerals Council of Australia is lobbying strongly for the retention of the rebate on the basis that removal of the rebate will lead to “double taxation” (Deloitte Access Economics, 2014). The mining and agricultural lobby has been successful thus far to prevent the rebate from being scrapped.

Gas price movements are less material to the sector as a whole, but they could be material for individual operations. Western Australia gas prices increased rapidly over the last decade, before easing back somewhat in recent years. Now large users on the Australian east coast have to deal with a doubling of natural gas prices through to 2017–18, in addition to a 40% increase in real electricity prices for industrial users since 2005. This is double the rate of increase experienced by European industrial electricity users (A2SE, 2014). LPG prices are also likely to trend upwards as the Australian dollar continues its decline against the US dollar.
2.2. Australia’s international economic and energy competitiveness

Productivity, in its most basic form, is the ratio of input used to output produced. Productivity is a key expression of the relative competitiveness of nations; competitive economies tend to grow faster over time and their populations tend to enjoy a higher standard of living.

*The productivity level ... determines the rates of return obtained by investments in an economy, which in turn are the fundamental drivers of its growth rates.*  
(Schwab, Sala-i-Martin, & World Economic Forum, 2013)

Historically, productivity growth has been the dominant source of income growth in the Australian economy, with other sources of income growth being the terms of trade and labour utilisation. However, half the growth of Australia’s Gross National Income (GNI) over the period 2000–2012 is attributed to ‘one-off boom-time factors’ such as the favourable terms of trade during the extended mining boom\(^2\) (Gruen, 2012). This masked Australia’s virtually stagnant national multi-factor productivity (MFP)\(^3\) index in the period 1995–2013 (Australian Bureau of Statistics, 2013c). The competitive challenge for trade-exposed sectors was exacerbated by an exchange rate well above the historical average (Lydon et al., 2014). The cycle is now turning, as prices for key Australian commodities are declining from their earlier highs and labour participation rates are likely to remain flat due to an ageing population (Gruen, 2012). Therefore, the only option for improving national income is to improve MFP, namely capital, labour and intermediary inputs, such as energy.

Total energy spend by end-use sectors\(^4\) of the Australian economy was $109.4 billion in 2011–12, equivalent to 7.4% of GDP (Australian Bureau of Statistics, 2013a, 2013b). Energy productivity (see shaded Box 2 below) could therefore play a central role in a broad-based national strategy to lift GNI.

**Box 2: Measures of energy productivity**

Energy productivity, measured as real GDP per unit of primary energy input, is a complex measure that reflects efficiency gains, as well as the effect of shifts in the economic structure and increased economic output. The relative cost per unit of energy inputs adds a further ‘competitiveness’ dimension to energy productivity, which reflects the relative cost competitiveness of countries in the use of their energy.

Australia’s energy productivity, measured as GDP per unit of primary energy input, is 14% lower than the average of the G20 countries in US$ purchasing power parity terms, as illustrated in Figure 3. Over the period 1995–2012, Australia improved its energy productivity by a meagre 1.1% per annum (World Bank, n.d.). The latter part of this energy productivity performance coincided with significant policy support for energy productivity investment, which resulted in the improved energy productivity of some sectors (ClimateWorks, 2013). However, many of the Federal Government programs aimed at stimulating energy efficiency investments have been terminated, including the Clean Energy Technology Investment Program (CTIP) and the Energy Efficiency Opportunity (EEO) program.

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\(^2\) Ratio between the prices of Australia’s exports and the prices of its imports.

\(^3\) This refers to capital, labour and other resource inputs.

\(^4\) Excludes the cost of energy to the electricity, gas and petroleum refinery subsectors.
Figure 3: Energy productivity of selected G20 countries

Not only is the mean economic value per unit of energy consumed by G20 countries higher than for Australia, so too is the G20 mean growth in energy productivity. The leading regions, such as the European Union and USA, have also set aggressive improvement targets:

- The European Union targets a 20% reduction in energy intensity\(^6\) by 2020 compared to 1990 levels and is now discussing extending that target to 30% by 2030 (European Commission, 2013).

- The USA has adopted a target to double energy productivity by 2030 compared to 2005 levels (Alliance to Save Energy, 2013).

- China, although currently still lagging Australia on energy productivity, improved its energy productivity by 153% between 1990 and 2009. China is targeting a further improvement in energy productivity of 16% between 2011 and 2015 (Institute of Industrial Productivity, 2011; World Bank, n.d.).

In short, G20 peers are accelerating away from Australia at a time when domestic energy prices are increasing, and the prices in Europe and the USA are largely static or declining in real terms (A2SE, 2014a).

Consequently, the potential contribution of energy productivity improvement to Australia’s overall economic productivity is now at an historic high. The country is coming from a low productivity base, coupled with relatively high real energy prices. This means that the productive use of energy, as a production input, has a more material impact on the profitability of businesses and Australia’s economic growth compared to five or seven years ago.

\(^5\) Latest available data for all countries was 2011 or 2012.

\(^6\) This is the inverse of the energy productivity measure.
2.3. Competitiveness, productivity and energy use in the Australian agriculture sector

Over the last 200 years, Australian farmers have been adaptive, resilient and inventive with farming methods. Access to fresh water, massive clearing, over-grazing, legacy high fertiliser usage, distance from markets and associated transport costs, as well as feral animals, have challenged Australian farmers (Australian Government, 2013). In response, farming has become more sophisticated, which has enabled it to achieve substantial productivity growth over the past 50 years. Notably, major grain crops have been increasing in yield per hectare at 2–3% per annum since the early 1960s and cotton lint at 5% per annum. Data for wool production is not available, but pastoral industries also recorded significant improvement with the carcase weights per animal for lamb and beef increasing between 1–1.5% per annum, and for dairy, measured as litres of milk per cow, improving by 4.1% per annum.

Agriculture is the only sector rated ‘strongly competitive’ in a recent comparative study between Australia and America (Lydon et al., 2014). The relative competitiveness is also illustrated by a recent cross-country analysis of farm economic performance by the Organisation for Economic Co-operation and Development (OECD). On the basic measure of productivity – namely input-output ratio, as illustrated in shaded Box 3 below – the top 25% of Australian farms ranked second (Kimura & Le Thi, 2013).

**Box 3: Cross country farm performance comparison – average performance of 2004 and 2006–2009**

As illustrated below (reproduced from Kimura & Le Thi, 2013), Australian farms generate on average a similar level of output per dollar of input as the best performing countries in the OECD study, namely the USA, German and Belgian Flanders farms. High performers in Italy, Australia, Belgian Flanders and Germany achieve higher average output and input ratios than high performing US farms. The average output-input ratio of low performers in Australian is less than unity (1:1), meaning that revenue from agricultural production at the international price is on average not enough to cover the cash expenditure.

Average net operating income per unit of labour does not vary significantly between the most productive countries mentioned above. However, the average net operating income per unit of labour input of high performing US farms far exceeds those in other countries.
Technological advances, such as more disease resistant crops as well as larger and more advanced machinery that allow earlier sowing and retention of soil water, have contributed to productivity improvements in the agriculture sector. However, improvements are most frequently attributed to increased knowledge of cropping systems and the adoption of sustainable crop management practices. Farmers are now able to make more effective decisions regarding the efficient use of chemicals and fertilisers, choice of crops, crop rotations, weed management and soil management to optimise water retention (Robertson, 2010). Today, Australia boasts the highest adoption rate of conservation agriculture principles worldwide. The principles of diverse rotations, reduced- or no-till systems and the maintenance of surface cover make good sense in extensive, mechanised, rain-fed cropping systems on erosion-prone, structurally unstable soils. The most commonly stated reasons for adopting conservation agriculture principles by farmers in Australia are reduced fuel and labour costs, soil conservation and moisture retention (Kirkegaard et al., 2014).

However, the global comparative advantage of the wheat sub-sector, accounting for 20% of the value of Australian agricultural output, has been declining (Australian Bureau of Statistics, 2013d; Sarker, 2014). More broadly, in spite of the agriculture sector continuing to outperform most of the Australian market sectors, and nearly doubling its MFP since 1994–95 as illustrated in Figure 4, the rate of improvement has been slowing since the early 2000s (Australian Bureau of Statistics, 2013c; Robertson, 2010). This has coincided with extended periods of drought and flooding, as indicated in the figure below (Liddy, Elvery, & Spraggon, 2014).

Figure 4: MFP trend of the Australian agricultural, forestry and fisheries industry

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During this period, the strength of the Australian dollar has also placed pressure on the profitability of farms, which slowed investment in new technology. Furthermore, smaller incremental gains from new technology compared to the greater gains from reduced tillage and GPS based systems in the 1980s and 90s, a range of weed, pest and soil fertility issues, and static spending on agricultural research, development and extension (RD&E) were also factors that contributed to the slower pace of productivity improvement (Robertson, 2010).

Australia’s options to increase agricultural output to meet the growing global demand, whilst maintaining the historical rate of improvement in productivity, are limited due to a number of factors:

- **Increased volume**: Land constitutes 60% of the total net capital stock included in the sector MFP calculation (Australian Bureau of Statistics, 2007). The scope for expansion of land area devoted to key agricultural commodities is limited due to water constraints and the need to maintain enterprise diversity and non-crop phases in rotations. This constraint also applies to northern Australia, where it is estimated that there is only enough water to irrigate less than 1% of the soils suitable for agricultural use (Robertson, 2010).

- **Value of input**: Most farm businesses are sub-scale and cannot readily influence the prices of production inputs. With the forecast downward adjustment in the Australian dollar, agricultural producers will experience an increase in the price of imported production inputs, including diesel and LPG. Substitution of energy sources are, however, increasingly viable in some applications.

- **Value of output**: With very limited perceived value added or product differentiation by producers, most farm businesses are ‘price takers’ on the global commodity market or domestic market dominated by large retail buyers. However, some producers are adopting strategies to enhance buyers’ ability to ‘recognise’ quality (e.g. establish premium brands for fresh produce) and add value to produce on the farm (rather than food manufacturers, which are not within the scope of this report).

Consequently, the key strategies to ensure resilience and optimise operating income\(^\text{8}\) irrespective of periods of low commodity prices, droughts or the high Australian dollar are managing production costs and maximising output per unit of land.

Energy is already a significant cost to many agricultural producers, often the second or third highest operating cost after labour and seeds/fertiliser. Farmers participating in the NSW Farmers’ Association ‘Farm Energy Innovation Program’ are mostly engaged in family-owned enterprises, and reported that energy is more than 6% of the cost of production, with diesel for vehicles and irrigation pumping generally being the main costs (NSW Farmers’ Association, 2014). This is slightly lower than the aggregate for most dairy and broadacre sub-sectors tracked through the ABARES Farm Survey. Energy cost for most sub-sectors ranges between 7% and 9% of cash cost, which include less controllable cost such as the cost of seed (ABARES, 2014b). This is in line with more detailed studies of grain producers, which estimate that energy cost constitutes between 8% and 10% of the cash cost of grain producers (Australian Farm Institute, 2011a; Australian Farm Institute, 2011b). Energy cost for vegetable growers is also estimated at 10% of total cash cost (Valle, 2014).

The prices of energy inputs, as well as fertiliser,\(^\text{9}\) have been increasing at a faster rate than the growth in the prices received by farmers and the prices of other inputs. The ratio between prices received by farmers and prices paid by farmers, expressed as an index and presented as ‘Farmers’ Terms of Trade’ in the figure below, has remained more or less constant since the late 1990s. The fuel index,

---

\(^{8}\) Including GVA, although statistically a different concept to operating income.

\(^{9}\) Much of the cost of fertiliser is linked to natural gas usage.
on the other hand, more than doubled in real terms over this period, with the electricity index reflecting an 80% real price increase over this period (ABARES, 2014a).\(^\text{10}\)

Figure 5: Indexes of prices paid by farmers and Australian farmers’ terms of trade

Unlike most production inputs, energy costs are controllable and the lower the operating margin of a farm business, the more significant the contribution from increased energy productivity. For example, if an average farm business in Australia has a gross profit margin of 20% (see shaded Box 3), this implies that a $1 reduction in net energy cost is equal to $5 in additional sales at the farm gate. Many farmers have margins much lower than the average, making energy an increasingly important cost to be managed.

2.4. Prevailing market conditions for agricultural commodities

The primary purpose of the agriculture sector is extending beyond the provision of food, feed and fibre to now include bio-fuels. It is also a central pillar of governments’ rural development, emissions reduction (e.g. Carbon Farming Initiative) and environmental management (e.g. water and biodiversity) policies. The agriculture sector is, therefore, increasingly ‘multi-functional’ (KPMG, 2013) and its success is of growing importance to the economy and the social fibre of countries. 

*After being thought of as somewhat of a ‘backwater’ business in the 1970s, 80s and 90s, farming is now an attractive growth industry, reinvigorated by new technology and concerns over food security.*

\(^{10}\) The indexes for commodity groups are calculated on a chained weight basis using Fisher’s ideal index with a reference year of 1997–98 = 100. Prices used in these calculations exclude GST.
Beyond food security and food safety, another key driver of change is the rise in consumer activism, linked to health and other concerns, and extending to traceability of produce to verify how food is produced (e.g., employment practices, animal welfare and environmental impact). Many of these trends are still in their infancy, with organic production constituting approximately 2% of global production. However, the penetration of retailers into the agricultural value chain is driving improved traceability and information provision (KPMG, 2013).

Agriculture is, therefore, part of an increasingly complex global value chain, but it remains subject to the vagaries of weather, amplified by global warming. Real agricultural commodity prices, as tracked by the Reserve Bank of Australia's rural commodities, have been trending upwards, as illustrated in Figure 6 below (KPMG, 2013). However, prices for commodity prices are volatile, which is typical of a globally exposed industry with limited perceived value added and susceptible to adverse weather conditions that impact supply. In fact, research by the Australian Farm Institute identified that Australian farm businesses experience the highest annual revenue volatility of any Australian economic sector and the second highest revenue volatility of any international agriculture sector included in the study (Reserve Bank of Australia, 2014a).

**Figure 6: Reserve Bank of Australia rural commodity prices to October 2014**

Many agriculture sub-sectors have a strong export focus. Consequently, in addition to adverse global price movements, the agriculture sector also has an exposure to exchange rate movements. Historically the exchange rate tended to move with agricultural commodity prices, which helped offset the impact on farm business revenues when commodity prices declined. As illustrated in Figure 7, reproduced from the 2014 Commonwealth Agricultural Competitiveness Green Paper, this relationship has changed in the past decade, with an appreciating exchange rate but relatively stable farmers’ terms of trade (the difference between prices received for agricultural outputs relative to the prices paid for inputs). This change increases farmers’ risk exposure to adverse movements in world agriculture commodity prices (Keogh, 2014).
The recently negotiated Free Trade Agreement (FTA) with China is expected to lend support to red-meat, dairy, horticulture, wool and barley exporters in the coming years (Commonwealth of Australia, 2014). A more export driven agriculture sector will assist in filling the gap left by the end of the resources boom. However, Australia only produces 1% of the total global value of agricultural production, equal to feeding approximately 60 million people (Commonwealth of Australia, 2014). Consequently, rather than hoping to be the ‘food bowl’ of Asia, which some commentators mooted until recently, there is a growing recognition that Australia, as a relatively high-cost producer, is better placed as the ‘deli of Asia’, as coined by Craig Swanger at the recent AgriInnovators web portal launch. He suggests that Australia targets niche, but nonetheless large, high-value markets in Asia (Claughton, 2014; Commonwealth of Australia, 2014).
3. Energy productivity in the context of the agriculture sector

Reaching agreement on the voluntary metrics and associated targets will be a key aspect of the work to be undertaken by A2SE and stakeholders. This section introduces some of the technical building blocks for consideration to support an agriculture sector energy productivity Roadmap process. These concepts are discussed in more depth in the 2XEP Framing paper. However, a basic principle to highlight at the outset is that the 2XEP Roadmap is not engaged in the pursuit of energy productivity instead of capital or labour productivity. Energy productivity is an integral part of economic productivity. This has been discussed in the A2SE 2XEP Framing Paper, with only a brief rationale summarised in the shaded box below.

Box 4: The multiple links between economic productivity and energy

Energy productivity is an integral part of economic productivity, and typically defined by the three elements of the productivity equation, namely capital, labour and intermediate inputs. Energy use in the production process is included in the 'intermediate input' element of the equation, but a focus on energy productivity also impacts capital, labour and the productive use of other intermediate inputs. For example:

- **Capital Productivity:** Investment in energy-efficient equipment is embedded in capital input. In addition, consideration of energy productivity as a key step in the design, financing and operation of infrastructure and productive assets can support the optimal allocation of capital and enhance the return on assets over the life of the infrastructure or equipment.

- **Labour Productivity:** Energy investments not only directly contribute to job creation (i.e. increased labour-participation rate) in the energy services sector, but can also indirectly influence the output-per-unit of labour in the agriculture sector.

- **Intermediate Inputs:** The effective use of energy can also influence the effective use of other production inputs (e.g. water) and associated waste streams to be managed (e.g. sludge from piggeries). It therefore acts as a multiplier, with an IEA Study estimating that for every dollar saved in energy cost 2.5 x savings are realised elsewhere in the value chain.

However, the relationship between the elements of economic productivity and energy is not linear. Improving energy productivity is as much about efficiencies (i.e. doing the same things better or more cost effectively) as it is about innovation (i.e. doing things differently to achieve better, or even new, value added outcomes) (A2SE, 2014).

This section will introduce energy productivity, possible ways of measuring energy productivity, challenges of applying energy productivity to the agriculture sector and what they may mean in the context of doubling energy productivity. The discussion will be structured as follows:

- Defining energy productivity
- Measuring energy productivity improvements at the agriculture sector level
- What a doubling of Australia’s energy productivity might mean for the agriculture sector
3.1. Defining energy productivity

‘Energy efficiency’ and ‘energy productivity’ are frequently, but erroneously, used interchangeably. It is, therefore, useful to start by defining energy efficiency. Energy efficiency is the ability to deliver the same level of service or output using less energy. Energy efficiency is generally measured as end-use energy consumed (typically in GJ) per unit of output (typically tonnes).

Energy productivity aims to capture ‘multiple dividends’ accruing from investment in more efficient plant and equipment, including reduced operating and maintenance costs, as well as reducing downtime. In some cases, this also includes increased output or improved quality of output, but in all cases, it considers the qualitative dimensions of the societal impacts of production, including the management of water, chemicals and waste.

Energy productivity is a measure of the total economic value delivered from each unit of energy utilised. The classic equation used in the A2SE’s 2XEP Framing Paper to develop a preliminary estimate of the scale of the task involved in doubling Australia’s energy productivity by 2030 is presented below:

**Equation 1: Basic energy productivity measure**

\[
\text{Energy Productivity} = \frac{\text{GDP (2010 Real $)}}{\text{Units of primary energy (GJ)}}
\]

Energy productivity is thus more than traditional energy management, including energy efficiency, although traditional energy management is one of the strategies to be considered as part of the 2XEP Roadmap, as illustrated in Figure 8 below.

**Figure 8: Key determinants of energy productivity**

Factors directly impacting energy input

- Energy management
- System optimisation
  (incl. capacity utilisation and supply chain)
- Business model transformation

Output dimensions ($ or other perceived value)

- Quantity
- Quality

While it is understood that 2XEP may have a less direct influence on some elements included in the figure, it would nevertheless be valuable to bring a greater focus on the energy implications of initiatives targeting elements of both the input and output sides of the equation. The four energy productivity strategies are:

- **Strategy area 1**: ‘Traditional’ energy management – e.g. improving energy efficiency through better management of energy use, including the implementation of innovative energy-use
technologies and demand-management initiatives, as well as best-practice data management and benchmarking practices to facilitate energy productivity decision making.

- **Strategy area 2**: Systems optimisation – e.g. focusing on energy aspects of the agriculture production and distribution infrastructure design, production processes and the extended value chain, including capacity optimisation strategies and the impact on water and waste streams. These changes may be implemented for reasons of broader productivity improvement, but greater value can be realised by bringing a deliberate energy competency and focus to them.

- **Strategy area 3**: Business model transformation – e.g. focusing on the energy aspects of fundamental longer term change in the business of agriculture – relating to the design, development and management of agricultural operations, as well as distribution, marketing and asset management.

- **Strategy area 4**: Value creation or preservation – e.g. focussing on increased production/ yield and value-add to products.

Consequently, energy productivity is not just about reducing inputs, it is also about increasing the value and quality of outputs, which in some instances may lead to increased domestic energy consumption, but improved energy productivity.

3.2. Measuring energy productivity improvements at the agriculture sector level

3.2.1. Key challenges

Unlike most other sectors, the gross output value at current prices for this sector is available from the Australian Bureau of Statistics (Catalogue No. 5204, Table 50) (Australian Bureau of Statistics, 2014b). However, a number of key challenges remain at a macro level:

- **Weather variation/climate variability**: Due to variations in the weather, the relationship between agricultural outputs and inputs can be erratic from year to year. They can also result in the ‘nature of the task’ required to deliver the same output changing over time (i.e. irrigation may be required in some years, but not others).

- **Commodity price volatility**: The value of outputs (i.e. numerator) can change significantly due to changes in the price of commodities, which could, in the case of exports, also be influenced by the Australian dollar exchange rate. This was discussed in section 2.4.

- **Primary energy use and final energy cost**: Data is only available at ANZSIC Division A level for Agriculture as a whole, bundled with fisheries and forestry. Additional analysis is required to estimate the share to be allocated to agriculture.

At this stage of the 2XEP Roadmap program, we do not address farm-level metrics directly. However, the following are noted:

- At farm level, final energy rather than primary energy will be a more useful denominator.

- The interdependence between energy and other scarce resource inputs, such as water, is challenging, since the relationship could be positively or negatively correlated. For example, more water efficient irrigation systems tend to be more energy intensive. This highlights the need for a balanced approach at the farm level. Whilst long term sustainability of operations is paramount,
implementing energy-efficiency measures in system design and operation can make water-efficient systems significantly more cost effective to implement.

3.2.2. Conceptual integrated measurement framework for consideration

For the purpose of tracking energy productivity over time, it will be necessary to develop a framework that is flexible enough to accommodate the diverse issues impacting the sector, as well as counterbalance what is, in the short term, a volatile metric (e.g. by adopting a three or five year moving average). It is envisaged that an integrated framework will ultimately guide the cascading of metrics from consolidated (i.e. total sector) level down to individual farm level.

This flexibility, to ensure relevance of measures at sector, sub-sector as well as individual farm level, could be attained through the development of a ‘dashboard of metrics’ with three levels, as illustrated in Figure 9 below:

Figure 9: Conceptual overview of integrated measurement framework – applied to agriculture

- **Primary** (Sector and Sub-sector measure, as per Equation 2): This metric is intended to most closely align with a national measure of energy productivity used to set targets and compare relative energy productivity at an international level.

  \[
  \text{Equation 2: Proposed primary sector level energy productivity measure}
  \]

  \[
  \text{Primary Energy Productivity metric (agriculture)} = \frac{\text{Gross Value of Production (Real $)}}{\text{Units of Primary Energy (GJ)}}
  \]

- **Secondary** (Sector and Sub-sector measure, as per Equation 4): This is an indicator of energy price competitiveness – i.e. the value created for each dollar spent on energy – which could assist in reflecting the relative importance of energy as the operating margins of farmers fluctuate with the rise and fall of commodity prices. Also note that a further key difference between Equations 2 and 3 is that the denominator used below refers to delivered or final energy, whilst Equation 3 uses primary energy.

  \[
  \text{Equation 3: Proposed secondary sector level energy productivity measure}
  \]

  \[
  \text{Secondary Energy Productivity metric (agriculture)} = \frac{\text{Gross Value of Production}}{\text{Energy Cost}}
  \]

---

11 The A2SE Foundations Papers (A2SE, 2014) discuss these issues more extensively.
• **Tertiary** (flexible suite of measures applicable at sub-sector and farm level): A set of tertiary level index-based indicators can be developed. These measures – which include tonnes, dollars, hectares or any other output or input unit that is an appropriate measure of economic value added in a sub-sector – are unit insensitive, which can be particularly useful at farm level. Nonetheless, in some cases, simpler energy-efficiency metrics may suffice. For example, a composite yield and energy use (GJ) index may be a practical and a sufficient operational indicator of energy productivity at some farms.

These indexes could be rolled up into a higher level composite energy productivity index for agriculture, which, in turn, could be incorporated in a national index.

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**Please note ...**

Appropriate methodologies will be developed as part of the A2SE 2XEP Roadmap process.

In addition, the A2SE 2XEP team propose shadow measures to capture the benefit of on-site generation (i.e. reduced conversion and transmission losses) and lower emissions associated with renewable sources (i.e. reflect cost of externalities) to be included in the national level integrated framework. A2SE will canvass with stakeholders how these factors could be applied at a sector level.

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3.3. **What doubling of Australia’s energy productivity means for the agriculture sector**

An empirical analysis of 28 OECD countries spanning 32 years provides statistical evidence\(^{12}\) of the relationship between energy efficiency and GDP (Vivid Economics, 2013). Studies from organisations as diverse as the World Bank, McKinsey Global Institute and the US Alliance Commission on National Energy Efficiency Policy also analysed the relationship between economic growth and energy efficiency. Typically, the potential beneficial impact of adopting energy-efficient practices on global GDP by 2030 is estimated at around 2%, with 3.2% being the upper range of forecasts (A2SE, 2014). This is a significant contribution to GDP, given that the Group of 20 (G20) nations will aim to lift their collective GDP from all economic activity by more than 2% above the trajectory implied by current policies over the coming five years (G20, 2014).

In Australia, the 2XEP program is proposing to double energy productivity by 2030 as the key target for an economy-wide program. This target has been estimated to equate to an increase in GDP from $219/GJ to $438/GJ of final energy demand, based on preliminary analysis published in the A2SE Framing Paper. Including forecast savings from the minimum performance standards prescribed for residential, commercial and industrial equipment, this equates to a reduction in final energy consumption in 2030 of 1147 PJ compared with forecast demand (A2SE, 2014).

This reduction is reported to equate to a 3.5% per annum improvement in energy productivity across the economy. About 60% of this change is expected to come from structural changes in the economy, such as a decline in heavy manufacturing and an increase in services sectors. The remainder will need to come from energy productivity improvements – or a 1.4% annual improvement across the

\(^{12}\) The study found that there is a less than 1% chance that the statistical results have been obtained by chance.
economy. This is well above the overall long-term historical trend (0.4% per annum over the last two decades).

The energy productivity metric is sensitive to both commodity and energy prices, which in the case of agriculture, are sensitive to factors outside the control of the farmers, such as exchange rates. Consequently, maintaining energy productivity during adverse weather conditions or falling commodity prices may in itself be a significant achievement.

Calculating the baseline metric for agriculture is challenging, as actual energy use and dollar spend are not available for the agriculture sector. The baseline metrics will be calculated once analysis is concluded to make a reasonable estimation of the ‘agriculture only’ energy use and spend.

Modelling at the sectoral level will seek to develop robust estimates of the potential contribution from the agriculture sector. Whatever the agreed target is, it will be industry driven and voluntary. However, there are a wide range of opportunities available to farmers, as discussed in Section 4, across all four strategic areas that could support a range of pathways to improved energy productivity for all types of agricultural operations.

Please consider ...

Issues for consultation will include:

- whether research is required to better understand energy use and spend in the agriculture sector;
- a feasible energy productivity improvement target for the agriculture sector;
- how change should be measured; and
- the suitability of 2010 as a base year.
4. Potential for energy productivity improvements

The A2SE team compiled a preliminary collection of practices that could provide a starting point in considering pathways to improving energy productivity. This is by no means intended as a complete or comprehensive list of opportunities in a diverse and dynamic sector.

Furthermore, as highlighted below, there are significant data gaps, which make it impossible to estimate the potential energy-productivity gains at present.

Farms are major energy users. Pumps, tractors, cool storage for produce and other commodities, harvesting, maintaining crops and facilities for livestock all require major amounts of electricity, diesel and other fuels. Addressing these high-energy demands will help Australia meet targets for energy reduction as a country, while helping to pioneer practices that can be adopted around the globe. Additionally, improvements in energy innovation and efficiency will help Australian farmers maintain a competitive advantage within the agricultural sector.

(Energy Innovation program, NSW Farmers’ Association, 2014)

Energy productivity improvement opportunities are closely related to the type of commodity produced, as well as the climatic conditions and size of farm operations. Statistical baseline data on energy use at this level of granularity is not available in Australia. This presents a major hurdle to a credible estimate of the potential for energy productivity improvement at a whole-of-sector level. Therefore, rather than presenting whole-of-agriculture sector level estimates, this section:

- provides an overview of the energy spend per sub-sector using best available official data sources
- presents quantitative data on the end-use application of energy in sub-sectors based on available industry reports from the dairy and fruit (13 sub-sectors, complemented by insights from the NSW Farmers’ Association, as well as
- highlights the potential improvement in energy productivity with reference to case examples to illustrate best practice and emerging opportunities that, if more broadly adopted, could have a material impact on energy productivity in the sector. Improvement opportunities are discussed with reference to the four broad strategies supporting an energy-productivity agenda introduced in the previous section, namely:
  1. traditional energy management
  2. system optimisation
  3. business model transformation; and
  4. value creation/preservation.

It should be noted that two themes are common to all four strategic areas, namely innovation, be it technology, process or whole of business model; as well as data management, which is an increasingly central part of agricultural operations, enabled by technological advances.

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(13) Specifically the pear and apple sub-sectors
4.1. Application of energy in the agriculture sector

Broadly speaking the agricultural sector, from an energy consumption perspective can be split into two broad sectors:

- broadacre farming, which includes cropping and pastoral farming (i.e. cattle and sheep); and
- horticulture and intensive livestock farming operations, such as dairy, poultry, eggs and piggeries.

As highlighted in Figure 2, diesel accounts for 76% of energy use in the agricultural sector. It is the primary source of energy for the broadacre subsector, whilst electricity and gas feature more prominently in the intensive livestock farming and horticultural operations.

Based on a high level analysis using data from ABARES’s farm surveys, the main user of energy is broadacre, as illustrated in the shaded Box 5 below. Typical broadacre diesel end-uses are tractors, harvesters and other farm vehicles, as well as stationary engines such as pumping for irrigation (Yusaf et al., 2014). However, irrigators are switching to electric irrigation pumps where available. The pastoral cattle and sheep farming, being less energy intensive, provides fewer energy productivity improvement opportunities. Nonetheless, renewable energy is an attractive energy cost reduction option for ‘fringe of grid’ pastoral farmers as discussed in section 4.2.5.

**Box 5: Estimating energy spend by sub-sector in Australia based on ABRES Farm Surveys (2012–13, $-mil)**

Based on the most recent ABARES Farm Survey (2012–13), the agriculture sector has spent approximately $2.5 billion on liquid fuel, lubricants and electricity (ABARES, 2014a).

Based on the most recent farm surveys for the broadacre, dairy (ABARES, 2014b) and vegetable growers (Valle, 2014), the relative share of the agricultural sector energy spend is as illustrated in the graph to the right.

**Note:**

The data includes all liquid fuel (including lubricants, which are not classed as energy), but electricity spend for sub-sectors other than dairy and vegetable growers was not available. Broadacre energy spend is predominantly diesel. Electricity spend for the broadacre sector at a national level is, therefore, not material. Data for natural gas and LPG spend is also not available.

Intensive livestock farming and horticulture, such as mushroom farms and hydroponic fruit / vegetable greenhouses, are significant users of electricity, as well as diesel, LPG and natural gas depending on operations and geographic location. The equipment used by ‘intensive’ farming facilities are not that different from what commercial and industrial facilities would use, namely climate control (i.e. space heating, cooling and ventilation) refrigeration / cool rooms and hot water. For example:
• **Fruit orchards and packing sheds**: refrigeration 63%, grading equipment 21% and lighting 10%. Irrigation accounts for only 4% (Apple & Pear Australia Ltd, 2014a, 2014b).

• **Dairy**: milk cooling accounts for 43%, milk harvesting 22% and hot water 13% of energy use (Western Dairy, n.d.).

The following sections will consider energy-productivity improvement opportunities with reference to these priority energy end-use applications across the four energy productivity strategy areas.

### 4.2. Strategy area 1: Traditional energy management

The traditional energy-management strategy area includes the use of energy-efficient equipment, electricity- and gas-demand management, as well as energy data management and practices to embed energy efficiency into the way agricultural operations are managed. Opportunities exist in a wide range of areas, only some of which we will briefly discuss under the broad areas listed below; each offers savings opportunities in the region of 20%:

- Farm vehicle efficiency, with a focus on tractors
- Irrigation (Note: Opportunities pertaining to the water–nexus are discussed in strategy area 2)
- Electricity-based opportunities, focused on intensive farming facilities
- Data and general energy-management practices
- Alternative energy sources, including on-site renewables

This section only briefly introduces the opportunities, whilst significantly more detailed and practical guidance is available on the **NSW Farmers’ Farm Energy Innovation Program** website (see Box 6).

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**Box 6: NSW Farmers Farm Energy Innovation Program**

NSW Farmers, with funding from the Department of Industry under the Energy Efficiency Information Grant (EEIG) Program and technical support from Energetics, developed a suite of information papers as listed below:

- **Efficient farm vehicles**: Energy efficiency and farm vehicles, Adaptive driving, Tractor ballasting, Estimating tractor power needs, Tractor & tyre selection, Monitoring wheel slip, Purchasing a fuel efficient tractor, Tyre pressure and fuel efficiency
- **Energy in sheds**: Energy efficient farm buildings, Energy efficient coolrooms and refrigeration, Insulating farm buildings, Reflective roofs and energy efficiency, Energy efficient heating in poultry sheds, Energy efficient poultry shed ventilation, Refrigeration – variable evaporator fan speed, Compressed air systems: air leak reduction, Compressed air: minimising pressure drop, Advanced controls on grain dryers, Energy efficient farm lighting, Energy savings from high efficiency motors, Power factor correction, Voltage optimisation units, Solar hot water
- **Energy planning**: Farm energy planning, Farm energy planning calculator
- **Energy purchasing**: Purchasing liquid fuels, Effective energy purchasing – electricity, Natural gas purchasing
- **Renewable energy**: Renewable energy on farm, Solar photovoltaic energy on farm, Farm scale wind power

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*NSW Farmers & Doubling Australia’s Energy Productivity*
4.2.1. Farm vehicle efficiency

Fuel used in farming machinery is estimated to represent over one-third of the energy consumed in the agriculture sector. Introducing vehicle fuel-saving measures can therefore play a significant part in reducing the input costs of farm businesses. Tractors (using diesel) are the most common asset in this category and are a major contributor to farm energy use.

No data on tractor fleets is available, but given the lifespan of tractors and other farm equipment, farm businesses are locked into energy-use profiles for many years. Therefore, many farms are unlikely to have the most fuel-efficient models. Nonetheless, domestic and international experiences highlight numerous opportunities to significantly increase energy productivity by using existing equipment more efficiently. Key opportunities to improve the fuel efficiency of tractors are illustrated in Figure 10 (reproduced from the European Efficiency 20 Program). Savings up to 20% are readily achievable through improved equipment management practices and skills development (Ellis, 2012).

Figure 10: Tractor fuel savings opportunities

Whilst on-board performance-feedback technology is a key feature of most modern tractors, driver skill and awareness are central elements in achieving farm fuel efficiency. This needs to receive greater focus given the extensive use of ‘backpackers’ on some farms in Australia, as evidenced during the NSW Farmers Farm Energy Innovation program. Modern diesel-engine tractors typically maximise their efficiency when operated within 60 to 80% of their rated power output. Maintaining this range requires skill and attention from the operator (NSW Farmers’ Association, 2013a).

When the opportunity to invest in a new tractor does arise, energy efficiency should be a key selection criterion, as significant savings are possible over the life of the vehicle. This is evident by comparing results, albeit under test conditions, of market-leading models with standard models (available from the official US tractor test laboratory (Nebraska Tractor Test Laboratory, 2014)). Furthermore, farmers often buy their equipment based on the power available, rather than the most efficient model for the
task, and often then man the tractors with untrained backpackers (Flores, Hoffmann, Rostron, & Shorten, 2014b).

Realising savings from an investment in a more efficient tractor is, therefore, dependent on whether the tractor is optimally sized for the task and driven by a skilled operator.

4.2.2. Irrigation

Irrigation can account for upwards of 50% of a total farm energy bill (NSW Farmers’ Association, 2013c). Nonetheless, irrigation systems are often not well maintained, are frequently oversized for the task, and use old technology in many instances. (See the shaded Box 7 below.) Initial site investigations as part of the Queensland Irrigators Energy Savings project,14 indicated scope for efficiency gains of the order of 30% (Queensland Cane Growers Organisation Ltd, n.d.). Savings of a similar magnitude have been realised by fixing pumps at sites participating in the NSW Farmers’ Farm Energy Innovation Program (Flores, Hoffmann, Rostron, & Shorten, 2014a).

Box 7: Queensland Irrigators Energy Savings project

An initial round of farm audits illustrated the state of pumps often used alongside sophisticated irrigation systems on many farms as well as basic design flaws impacting pump energy efficiency (Dwyer, 2014).

14 A collaboration between the Cane Growers Organisation, Queensland Farmers Federation, Queensland Government and the electricity network provider, Ergon.
Common recommendations for improving the energy performance of irrigation systems include:

- Replacing old, inefficient pumps
- Improving the performance of existing large electrical pumps by installing variable speed drives (VSDs). Lowering the speed of a motor by just 20% can produce an energy saving of up to 50% (NSW Farmers’ Association, 2013e)
- Maintaining pumps. Pump efficiency deteriorates over time, leading to energy wastage. Efficiency losses of 5–15% can occur after 10 years of operation. Motors should be rebound. Blocked air filters (e.g. due to past flooding) could also lead to pumps overheating and running at reduced efficiency (NSW Farmers’ Association, 2013c)
- Optimising new irrigation systems by recalibrating pumps and installing the appropriately sized pump outlet pipes.
- Removing throttling of ‘gate valves’ to control the downstream flow rate.
- Implementing warning systems to inform farmers of system shut-down during night irrigation.
- Adjusting pressure and flow rates of pumps on pivot irrigation systems to cover the extreme boundary of an elevated field and scaling back pumping parameters when the same equipment is moved to lower elevations (Queensland Cane Growers Organisation Ltd, n.d.).

Significant energy savings can, therefore, be achieved on many irrigated farms, ranging from ‘quick wins’ to modification of practices and adoption of new energy efficient technologies. Importantly for adoption, these changes can be achieved without detriment to crop yield and often with increases in water efficiency.

Where feasible, farmers should also consider switching from diesel to electric pumps. Electric pumping is cheaper and much more efficient (70–80% efficiency) than diesel-driven pumps (30–40% efficiency), and can deliver financial savings of $250 per MWh (NSW Farmers’ Association, 2013b). However, some farmers cannot connect to the grid – in these cases solar PV pumping systems can complement diesel powered pumps, as discussed in Section 4.2.5.

4.2.3. Electricity related opportunities

Electricity is a small component of the agriculture sector level energy use, but it is the main energy source for many intensive farming operations such as dairies. Many farm homesteads also have access to grid-supplied electricity. Data from the NSW Energy Efficiency for Small Business (EESB) Program provides a good indication of the type of opportunities and the associated electricity savings applicable to small farms. (See shaded Box 8 below for more information on the program.)

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**Box 8: About the NSW EESB Program**

The EESB Program was launched in 2009, targeting businesses that have an energy use of up to about $20,000 (up to 160 MWh) per year or have the equivalent of around 10 full-time staff. The EESB Program provides a participating business with a customised energy assessment that identifies where electricity is being used and a tailored action plan with electricity and cost savings recommendations. Businesses also receive up to four hours free support to coordinate the installation of energy-efficiency technologies and equipment. This includes obtaining quotes, managing the installation and completing the necessary paperwork to apply for the subsidised payment.
On average, potential savings of more than 20% of electricity cost bills were identified for each of the more than 500 farm businesses participating in the NSW EESB Program. The opportunities most frequently identified related to hot water, refrigeration, electric motors and lighting. The table below summarises the results of the energy assessments for the farm businesses participating in the NSW EESB Program (NSW Office of the Environment and Heritage, 2014).

Table 1: Summary of the energy use and savings of farm businesses participating in the NSW EESB program

<table>
<thead>
<tr>
<th></th>
<th>Savings KWh Per Year</th>
<th>Employee Numbers</th>
<th>Baseline KWh Per Year New</th>
<th>Baseline Bill Cost Per Year $</th>
<th>Savings Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>16,473</td>
<td>3</td>
<td>77,900</td>
<td>15,381</td>
<td>26%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>7,588</td>
<td>1</td>
<td>32,721</td>
<td>6,603</td>
<td>16%</td>
</tr>
<tr>
<td>Median</td>
<td>12,748</td>
<td>2</td>
<td>59,318</td>
<td>11,344</td>
<td>23%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>22,101</td>
<td>4</td>
<td>90,792</td>
<td>17,556</td>
<td>32%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,516,355</strong></td>
<td><strong>1,606</strong></td>
<td><strong>40,274,449</strong></td>
<td><strong>7,952,155</strong></td>
<td></td>
</tr>
</tbody>
</table>

Electricity savings opportunities in intensive farming operations, mainly dairy cattle farming, accounted for 81% of the annual savings of EESB Program farm business participants identified in the table above. Due to the dominance of dairy farming in the agricultural sample, 80% of savings identified on farms related to hot water, electric motors, refrigeration and HVAC opportunities. However, as illustrated in Figure 11, the opportunities vary across intensive farm types with HVAC/ventilation and lighting the main opportunities for poultry, and refrigeration and lighting holding the most potential for fruit and nut growers. Hot water and refrigeration were the main opportunity areas for mushroom and vegetable growers (NSW Office of the Environment and Heritage, 2014).

Figure 11: Priority energy savings opportunities for small intensive farm businesses (NSW EESB program)

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15 Opportunities in this category typically also include variable speed drives on milk and irrigation pumps and other motors.
Notably, an energy survey\textsuperscript{16} of 48 members by the industry association for pear and apple producers and the evaluation report of Dairy Australia’s energy-management initiative under the Department of Industry EEIG Program provide details on the frequency (rather than MWh savings) of implemented and planned investment in energy infrastructure and equipment by end use. As illustrated in Figure 12 below, refrigeration/cool rooms and lighting were prominent for pear and apple producers (Apple & Pear Australia Ltd, 2013). For dairy farming, milk cooling (e.g. plate coolers, cooling towers and refrigeration), hot water and lighting appear to be the most common opportunities recommended and implemented by farmers (Dairy Australia, 2014). Thermal heat-recovery systems are also gaining support amongst dairy farmers (Western Dairy, n.d.), which we assume is bundled along with other hot-water solutions in the dairy dataset presented below.

Figure 12: Recent and planned energy related investments by energy-intensive farm businesses

\textsuperscript{16} The study provided detailed information on energy spend by fuel time and included large producers with energy costs in excess of $1 million.
The Apple & Pear Australia Limited (APAL) program identified savings equivalent to 14% of electricity use, which is, on aggregate, lower than that identified by the NSW EESB Program for Fruit and Nut Trees. This could be due to differences in the size and sophistication of participating orchards or other factors. However, looking at the frequency with which measures are recommended and implemented, rather than the MWh savings, the priority areas for improvement in energy consumption are not dissimilar from those identified under the NSW EESB Program, with few exceptions.

Notable differences when comparing the results for small farms from the NSW EESB Program with those of the Dairy Australia and APAL programs are, albeit unsurprisingly, the investments in improvements to grid-connected supply arrangements, demand management and renewable energy. Investments in these areas are likely to provide farmers with a hedge against the continued escalation in electricity cost and network demand charges in particular, as well as supply disruption, which is a common occurrence in regional ‘end of line’ areas (Meta Economics Consulting Group, 2013).

4.2.4. Data and general energy management practices

Best practice energy management pertaining to data collection, monitoring and control of energy consumption data is pervasive across all the areas discussed above. In this section, specific areas of potential improvement are highlighted for consideration during consultations:

- monitoring fuel usage and storage
- benchmarking and contractor management
- energy-supply contract management

In addition to driver skill and on-board performance-feedback systems on modern farm machinery, as discussed in Section 4.2.1, farmer motivation and leadership are essential to drive fuel monitoring. This is illustrated by the two quotes from farmers participating in the NSW Farmers’ Association Farm Energy Innovation Program, highlighting that:

- farmers need to focus the attention of drivers on opportunities to reduce fuel consumption

  *We had got into a set and forget mentality with our new tractor 2 years ago. We now realise ballast adjustments and more attention to tyre pressures and throttle settings over different country and applications will deliver cost savings*

  (Sarah and John Greer of Birrah, Moree, NSW, cited in Flores, Hoffmann, Rostron, Lister, & Shorten, 2014)

- logging and analysing fuel consumption needs to be integrated into standard day-to-day practices

  *Having learnt from the energy program that fuel use monitoring could deliver as much as 20% cost savings, we invested a modest amount of money and a bit of time and discovered we had been wasting energy and money for years.*

  (Joe Martin, Tahlee Farm – Gunnedah, cited in Flores, Hoffmann, Rostron, & Shorten, 2014a)

Fuel storage practices can impact the quality of fuel and, therefore, the performance of equipment, as well as maintenance cost. Basic actions such as painting fuel storage tanks in reflective white paint, use of pressure vent caps and positioning the tank in the shade could reduce evaporation by as much as 2%, depending on the current location and prevailing temperature (British Columbia Ministry of Agriculture and Lands, 2005).

Many farmers make extensive use of contractors, who in turn use different machines and drivers for the different activities throughout the seasons. These farm businesses do not have direct control over the energy used. However, a farmer at Moree in NSW has found that drawing up a table for each
machine and application enabled him to trial driving set up and wheelslip. He can now set key performance indicators per hectare and expect to achieve 5% fuel savings per annum (Flores, Hoffmann, Lister, & Shorten, 2014). With this type of information at hand, farm businesses are in a stronger negotiating position when procuring services and can include energy-efficiency targets in contracts.

Finally, demand charges can constitute more than 50% of electricity cost, as discussed earlier. Poor power factor and the variability in electricity demand by irrigators have been identified by network providers as impacting operations and planning (Dwyer, 2014), and tariffs are increasingly structured to address these concerns. Awareness of electricity tariff structure and strategies to minimise peak demand can make a significant contribution to energy cost savings. Common strategies include load shifting and improving the on-farm power factor. For example, an orchard in Batlow NSW was able to save 3% of its total electricity cost by installing a power factor correction (PFC) unit (Apple & Pear Australia Ltd, 2014b).

4.2.5. Alternative energy sources

The primary focus of this section is on on-site renewables. Nonetheless, compressed natural gas (CNG) may hold promise as an alternative fuel to diesel engines in the agricultural sector, with payback periods of less than four years estimated by a recent study. Consequently, it may be a viable alternative for diesel tractors and harvesters that is less than 10-years old, as well as stationary engines such as pumps (Yusaf et al., 2014). However, lack of data on equipment profile, as well as current trends and volatility in the natural gas commodity market complicates the assessment of the market potential of converting diesel equipment to CNG.

Many farmers have already invested in solar PV, incentivised by the once attractive feed-in tariff schemes in addition to benefits derived from Small-Scale Technology Certificates. The policy settings have changed, with further changes anticipated once the Federal Government considers the recommendations from the 2014 Renewable Energy Target (RET) Review Panel. However, solar PV is still an economically viable option for many applications. Useful case examples and guidance are provided by a number of industry bodies, as highlighted in the shaded Box 9.

Box 9: Sectors specific guidance when considering renewable options
Numerous agricultural research bodies and industry associations have been developing guidelines and case studies, including:
- Dairy Australia provides a decision-support framework in a guidance paper entitled: [Is renewable energy right for my farm?](https://www.dairyaustralia.com.au/)
- Pork CRC has developed a series of bio-gas capture and energy generation [feasibility studies](https://www.porkcrc.com/)
- NSW Farmers’ Association developed a series of renewable energy [information papers](https://www.nswfarmers.com.au/)

Whilst the winding back of feed-in tariffs for small-scale solar has made it unattractive for new connections to export power to the grid, battery storage for off-grid power supply to farmers on the fringe of the electricity network is becoming increasingly attractive. This will continue to support the adoption of solar PV, with the pace of change in the solar PV market expected to accelerate in coming years (Energetics, 2014).
Farmers have also started to switch from diesel, natural gas, LPG and electricity to renewable sources in core farming applications, both as a hedge against future energy price increases and also to mitigate the risk of electricity supply disruptions and power quality issues experienced at the fringe of grid. By 2012, an estimated 40% of dairy farms already had installed some form of renewable energy, such as heat pumps or solar thermal water heating, often with a booster (Clean Energy Finance Corporation (CEFC), 2014a). Savings of 40% can be made by using solar heat pumps to pre-heat water (Western Dairy, n.d.).

Heat and power generation from waste streams is also becoming commercially viable as an on-farm energy source, with the added benefit of reducing waste management cost and assisting farmers to meet increasingly strict environmental compliance standards. For example:

- **Biomass power generation**: Darling Downs Fresh Eggs is installing an anaerobic digester and generators to meet 100% of the company’s non-peak power requirements using chicken manure and other waste (Clean Energy Finance Corporation (CEFC), 2014b).

- **Biogas heat generation**: The pork industry has been at the forefront of biogas capture and heat generation for some time. Australian Pork developed a *Code of Practice for On-farm Biogas Production and Use (Piggeries)* in response to growing interest in biogas technology from Australian pig producers. It also provides comprehensive guidance to its members on participation in the *Carbon Farming Initiative* (Australian Pork, 2014).

Hybrid-renewable energy applications are also emerging as economically viable on-farm energy solutions. The two most common applications are:

- **Diesel-solar hybrid power generation sets**: These can provide a cost-effective and reliable supplemental power supply in remote and regional areas.

- **Solar-powered pumping systems**: Typically, diesel-powered pumps are used in areas where connecting to the electricity grid is difficult. Solar photovoltaic (PV) systems can be an attractive complementary energy source deployed alongside diesel pumps in areas with plenty of sunshine and where the cost to run power lines is high. These systems are best suited for transfer operations. Farmers with predictable and continuous irrigation energy demand (e.g. farmers on rivers, in the irrigation districts, or in horticulture) will benefit most from this type of solution (NSW Farmers’ Association, 2013d).

Continued increases in energy prices and declines in renewable energy generation and storage technologies, as they move up the maturity curve, will result in on-site renewables becoming more attractive over time.

**4.3. Strategy area 2: System optimisation**

Many farms already adopt a ‘whole of system’ view of energy, making trade-offs between energy cost and environmentally sustainable water- and land-management practices on an ongoing basis. Nonetheless, managing the complex interrelationships between yield and resource inputs remains a challenge for the sector as a whole. Some of the issues, tactics and strategies that can facilitate system optimisation at farm level, as well as beyond the farm gate across the value chain at industry level, are highlighted below.
4.3.1. Farm system optimisation

Adopting a system view of ‘everything that happens on a farm’ can unlock significant economic benefits. Areas of potential benefit include the added benefit of waste-to-energy systems mentioned in section 4.2.5, as well as the following areas briefly discussed below:

- consideration of the end-to-end resource input profiles;
- precision agriculture; and
- field robotics.

Optimising economic benefits at an on-farm scale, rather than individual pieces of equipment, requires consideration of the end-to-end resource input profiles during the planning and design stage of on-farm infrastructure (e.g. roads, irrigation systems, dams), as well as during the purchasing stage of farm equipment (e.g. ensure tractors are scaled for the task, as discussed in section 4.2.1). This principle is well illustrated on irrigated farms by the relationship between water efficiency and energy efficiency (or cost), emphasised by the quote from the peak body for agriculture in Australia:

>A key trade-off in irrigated agriculture is the balance between energy and water inputs. Often, technologies and systems that increase water use efficiency have higher energy requirements. The price of energy can be a barrier to adopting new practices.<n>(National Farmers’ Federation, 2014c)

A comparative analysis of water application and energy consumption on a NSW and South Australian farm found that converting from flood to pressurised systems can improve water efficiency by 10% to 66%, but energy consumption could increase by 163% (Jackson, Khan, & Hafeez, 2010). Consequently, as many farmers no doubt already know, an integrated optimisation approach that considers energy, water and crop yield is required to maximise the long-term net gain on an irrigated farm. Whilst farmers seldom have the luxury to re-design and re-engineer whole irrigation systems, there are opportunities to enhance the energy efficiency of water-efficient irrigation systems by focusing on key components that may impact performance, such as:

- switching from diesel to electric pumps where possible;
- sizing replacement pumps correctly;
- introducing variable speed drives; and
- considering pipe segments that are sub-optimally designed (e.g. sub-optimal diameters and avoidable bends that cause unnecessary friction).

Precision agriculture is also another field of development that enables the ‘whole-of-farm’ system to be optimised from a productivity perspective. Initially it was based on observing, measuring and responding to inter- and intra-field variability in crops. However, the field is expanding to cover all data and statistically driven approaches to efficiency in agriculture.

Precision agriculture now combines application of decision support and modelling science with agronomics and, increasingly, applied information technology. Data automatically collected by farm machinery can now be used in multiple ways, for example, to correlate water, fertiliser, agrichemical and fuel usage with yield. The figure below, reproduced from the AgInnovators website, illustrates a novel application of precision agriculture being pioneered at the University of Queensland to increase fuel efficiency in harvesting equipment (AgInnovators, 2014).
Researchers at the University of Sydney’s Australian Centre for Field Robotics (ACFR) are developing ‘intelligent systems’ with the capacity to map and monitor farmland, gather information continuously, provide accurate yield counts, advise on optimal harvesting times and perform routine tasks, such as pruning, weeding, mowing and spraying. These systems are anticipated to not only reduce labour cost, but to also improve energy efficiency and enhance the overall understanding of farm health (White, 2014a):

Robotics is offering a pathway to reduction in labour costs, more efficient operations and better land management approaches, with significant potential to improve productivity ... Linking robotics with farm-wide sensing systems, large-scale data analytics and new machine learning algorithms is providing unprecedented levels of information about the real-time status of the farm.

(Professor Salah Sukkarieh, professor of Robotics and Intelligent Systems at ACFR, cited in White, 2014a)

4.3.2. Industry value chain optimisation (beyond the farm gate)

Farm businesses generally lack the scale to influence downstream and upstream markets or regulations, including energy markets and regulations. Industry associations play a crucial role in providing farm businesses with the ‘market cloud’, which individual farm businesses lack. However, there are opportunities for farm businesses to collaborate at local level with other farmers, as well as a range of upstream and downstream partners.

Please consider ...

Do we understand the full benefit case for ‘big data”? Evidence of the ‘energy specific’ application of big data on farms is not readily available. Industry views and contributions to enhance the evidence base will be sought during the 2XEP consultation process.

4.3.2. Industry value chain optimisation (beyond the farm gate)

Farm businesses generally lack the scale to influence downstream and upstream markets or regulations, including energy markets and regulations. Industry associations play a crucial role in providing farm businesses with the ‘market cloud’, which individual farm businesses lack. However, there are opportunities for farm businesses to collaborate at local level with other farmers, as well as a range of upstream and downstream partners.

The factors are: (1) contour banks, (2) slope, (3) weight of the spreader, (4) soil type or steepness and (5) compaction from CP irrigator.
Collaboration typically provides economy of scale benefits, with reference to both capital and operating cost. Examples of regional collaboration include investment in shared infrastructure such as abattoirs and cool-room storage facilities, as well as energy infrastructure:

- shared distributed electricity networks powered by renewable energy sources in some regions that have a natural advantage in, for example, solar, wind or bio-energy, may be possible. Such networks could be designed to ensure electricity output matches the periods of peak irrigation demand in summer and autumn, backed by emerging energy storage technologies (Eyre, Alexandra, Richards, & Swann, 2014).

- community bore pump trusts, such as the 43-member community trust in Moree, which operates a large bore pump. This trust plans to re-assign surplus solar PV panels from individual farms at the conclusion of the NSW Solar Bonus Scheme in December 2016 to the trust bore. The benefit to the trust is estimated at $20,000 per annum, not taking account of the enhanced benefit once the battery storage is commercially viable for this type of application (Flores et al., 2014).

Upstream collaborations between farmers and suppliers are well established in some sub-sectors. For example, Monsanto and the Australian cotton and grain industry have a long standing collaboration through research and biotechnology products, including the introduction of Roundup Ready canola technology, and the Australian and New Zealand horticultural industry through Seminis and De Ruiter vegetable seed product range (KPMG, 2013; Monsanto, 2014b). Monsanto is now extending it in collaboration with farmers through the development of an Integrated Farming System (IFS) that ‘leverage science-based analytics to drive a step change in yield and reduced risk’, with pilots of IFS FieldScript® under way in the USA. IFS is Monsanto’s response to farmers’ concerns that they are increasingly ‘data rich’, but unable to exploit the predictive ability of this data in the practical application of resources (capital and operational) on a day-to-day basis (Monsanto, 2014a).

Given the distance from both domestic and international markets, downstream collaboration in distribution and marketing is essential. At a national level, addressing distribution infrastructure is also a key priority. In this regard the Productivity Commission highlighted the impact of the existing regulation of coastal shipping routes on the competitiveness of the agricultural sector. This included concerns about mandatory access arrangements for grain port terminals inhibiting competition in the grain supply chain. Tasmania is particularly vulnerable in this regard given its reliance on sea transport (Productivity Commission, 2014).

It is also worth noting the potential role of intelligent systems, discussed in the previous section, in assisting farmers to meet the increasingly rigorous standards of supermarkets and customers, demanding more and more information on the origin and safety of their food (KPMG, 2013).

Please consider ...

A2SE is interested to understand whether there are opportunities for:

- reducing the duration that fresh produce spends in the ‘cold chain’.
- other factors omitted in the high level commentary above.
4.4. Strategy area 3: Business model transformation

The increasingly global character of the food value chain will permeate through the Australian agriculture sector. Remaining a global leader in agriculture demands that the sector collectively, as well as at an individual farm level, continuously innovate the way it operates. This not only applies to technology and production processes, but also to the whole model typically used by the sector. New business models need to consider three key aspects:

- **ways in which to remove cost** from the value chain, as emphasised in the quote from an industry thought leader below, with an illustrative case example provided in Box 10 below:

  *We are a very fragmented industry ... If there’s a way for us to have fewer players, fewer mouths to feed between farm gate and market, then we’re going to get our costs down.*

  (Craig Swanger, Head of Markets, FIIG Securities (Former CEO of Macquarie Agricultural Investments), cited in Claughton, 2014)

**Box 10: Covino Farms in Gippsland integrate their supply chain from ‘farm to fork’**

Covino Farms invested in leading-edge processing technologies and an integrated supply chain to remain competitive, starting from its own seed nursery and ending with processed fresh food delivered to foot outlets. Investment in a no-touch drying system results in a premium product, with less cell damage, whilst the use of rapid cooling technology enables speed to market:

*For example Subway may order a lettuce today and we’ll go and harvest that lettuce, cool it, process it, shred it and dice it, bag it, package it and send it to our distribution centre so they will have it within 24 hours. “We have control of all parts of our business from the seed right through to distribution to the store and having control of all of that means we’ve been able to optimise wherever possible every step in the chain.”*

(Steven Covino, CFO, Covino Farms as cited in Regional Development Australia – Gippsland, n.d.)

- **specialisation and economies of scale.** The increased sophistication and global nature of the agriculture food value chain is placing increased demands on the skills and resources of traditional ‘family businesses’:

  *Separating farmland from the operating business can also attract different forms of capital into agriculture ... Splitting the focus of both parties can also drive efficiency gains by having each party focus on their relative strengths.*

  (PPB Advisory Pty Ltd submission to the Agricultural competitiveness Green Paper, cited in Commonwealth of Australia, 2014)

Farm businesses are exploring ways in which they can access specialist knowledge in skills to enhance their ability to compete. Whilst the ‘debate’ about the optimal size of farms is far from settled, many farmers are in commodities and segments that necessitate economies of scale to remain competitive. In some instances, the pursuit of specialisation and scale become synonymous. New models are emerging that allow farmers to remain in control of their land, whilst increasing specialisation and scaling the business to an optimal size. (See shaded Box 11.)
**Box 11: Embracing business models that retain the heritage of the family farm, whilst operating at commercial scale**

Two neighbouring farmers established Collaborative Farming Australia Pty Ltd with the aim to create economies of scale without losing the integrity and heritage of the family farm. The venture then established a joint farming partnership, Bulla Burra Operations Pty Ltd, which leases both families’ farms from trust companies owned by the two families. One farmer is the operations manager of the collaborative farming business and the other is the business manager. All machinery, previously owned by the two families, was sold privately. Bulla Burra bought its own equipment to suit the operation.

By combining the farms, the business achieved economy of scale advantages, as well as benefitting from specialisation in operations and business management. This gave the business the commercial strength to expand. Bulla Burra subsequently leased a further 2000 ha and operates another 2000 ha under a share-farming arrangement. The extra 4000 ha allows the business to operate two sets of machinery and hire an additional full-time employee. Machinery use is optimised across the 8000 ha under management, with efficiencies gained through rostering to ensure around-the-clock use of machinery in peak times.

*Reproduced from the Commonwealth Agricultural Competitiveness Green Paper (Commonwealth of Australia, 2014)*

**Box 12: Breaking farming’s dependence on finite resources?**

Sundrop Farms is building a 20 ha greenhouse facility in Port Augusta, South Australia that will use solar technology to generate power that is then used to desalinate seawater for irrigation and for heating and cooling the greenhouses. Clean Energy Finance Corporation (CEFC) financing of approximately one quarter of the project cost helped catalyse finance for the project, with further funding expected from the South Australian Government over the first three years (Clean Energy Finance Corporation, n.d.; Sundrop Farms & Coles Supermarkets Australia, 2014).

The facility is projected to produce over 15,000 tonnes of tomatoes a year starting in 2016 under a 10-year contract with Coles concluded in December 2014. When fully operational, Sundrop Farms will employ about 200 people and there are substantial opportunities for local and state-based businesses during the construction phase (Sundrop Farms & Coles Supermarkets Australia, 2014).

The system allows high-quality produce to be grown year-round – without concern about weather, season or soil quality – in hydroponic greenhouses using abundant resources, namely sea water and sunlight. It is therefore ideally suited for agricultural production in much of Australia.

All the above strategies will require farmers to critically evaluate which parts of the value chain they need to collaborate on, who to partner with and the most suitable form of collaboration. However, it is anticipated that ‘scanning activities and collaborative efforts’ will need to focus increasingly beyond agriculture to adjacent sectors, up and down the value stream (KPMG, 2013).
4.5. Strategy area 4: Preserve / increase output and quality

Quality in this context relates to both the produce itself, as well as the real and perceived impact of production on the environment and society in general. As discussed in Section 2.4, key drivers of the agriculture and food value chain include increased scrutiny of food, with reference to food safety as well as traceability of produce (KPMG, 2013). Failure to pass the scrutiny of increasingly sophisticated consumers will have real financial consequences to farm businesses.

Although much of the agriculture sector is ‘commodity driven price takers’, farmers have a number of strategic options available to them in this strategic area, including:

- increase perceived value in high-value niche markets
- increase value added on-farm, whilst reducing transport cost and downstream waste

Australia’s reputation as a safe food exporter is generally recognised and the Australian Government has embarked on a program to build the Australian Global Food Brand (Australian Trade Commission, 2013). The market for organic, free-range, chemical-free, hormone-free products and products certified to meet a range of standards pertaining to employment practices, animal welfare and environmentally sustainable production is still in its infancy, but growing (KPMG, 2013). This premium market, as well as other high-value niche markets, is particularly valuable to Australia as a relatively high-cost producer (Claughton, 2014). Retaining and further enhancing this status has the potential to be differentiated in the global market, but some commentators are concerned that standards may be compromised in regional trade negotiations (Barbour, 2014).

Increased upstream processing (e.g. packing of fresh produce) can add value at the farm gate, whilst reducing transport cost and downstream processing of waste. The spectrum of on-farm processing is broad, but includes:

- on-farm abattoirs and boutique meat-processing plants (Manson, 2014)
- packaging of fresh produce supported by well-developed infrastructure to support speed to market (Regional Development Australia – Gippsland, n.d.)
- the aggregation of waste on a regional scale to supply waste-to-energy enterprises can also provide a useful supplementary revenue stream for sub-scale farm operations that generate sufficient waste to run their own energy plants.

In addition, the choice of packaging material (i.e. weight, size and material used) also has downstream implications for transport cost and waste management. For example, a recent Italian study comparing strawberry packing options found that that a biodegradable packaging option enhanced the shelf life of the produce. In the vent of product deterioration, the cost of waste management was also reduced as the whole package able to be recycled as organic waste (Girgenti, Peano, Baudino, & Tecco, 2014).
Please consider ...

This section presented a range of opportunities, but we recognise that the type of agricultural produce, size and technological sophistication varies significantly from farm to farm. The pathways to energy productivity improvement are therefore likely to be different.

So, where is the common ground? Is there scope to continuously improve the sector’s productivity if the industry combines resources (i.e. time, knowledge and investment) in:

- promoting best practices and establishing performance benchmarks?
- progressing specific emerging technologies?
- other?

Ultimately, is there sufficient commonality to develop a series of pathways targeting energy-productivity opportunities and barriers for industry or ‘groups’ of farmers?
5. Barriers to energy productivity

It is imperative that the barriers to adoption of new technologies and energy productivity in general are overcome to improve return on research investment and maintain the competitiveness of the Australian agriculture sector. Primary reasons for the lack of focus on energy productivity in the Australian agriculture sector to date are:

- farmer balance sheet, high upfront cost and long payback periods;
- management practices and cultural barriers (i.e. the way things are, or have always been, done in the sector); and
- information, knowledge and expertise.

Each of these barriers will be briefly discussed.

5.1. Farmer balance sheet, high upfront cost and long payback periods

Rural debt levels have more than doubled over the past decade, with most of the rise occurring prior to 2008. Key drivers include increased borrowing to meet working capital requirements during drought periods, increasing farm scale, structural change towards more capital-intensive operations, and the availability of interest-only loans (Commonwealth of Australia, 2014).

Banks generally require farms to maintain their debt levels below 30% of owned assets. It is estimated that 91% of broadacre farms and 72% of dairy farms had equity exceeding 70% of assets on 30 June 2013. The aggregate debt-to-income ratio of the sector is approximately 2.25 years. Farm debt is concentrated, with around 70% of total broadacre debt attributed to 12% of farms, typically the larger farm businesses (Reserve Bank of Australia, 2014b).

Some of the large commercial farm businesses, critical to the overall output of this sector due to their size, are therefore capital constrained. Other farmers, based on feedback from financiers in discussion with Energetics, may be uncertain of future cash flows relative to core operational demands, are reluctant to borrow for energy-efficient equipment, which is often viewed as non-core as distinct to seeds, fertiliser and other production inputs.

Given the uncertainty of cash flow and the debt level of farmers, it is not surprising that 40% of participants in the Dairy Australia EEIG program rated cost as the biggest barrier to investing in energy-efficient equipment (Dairy Australia, 2014). Access to capital and long payback periods in excess of five years associated with transformational energy equipment, such as heat-recovery units in dairy farming, have also been raised as a major issue by the Victorian Farmers Federation (VFF) (Victorian Farmers Federation, 2014). The payback period was also rated as a barrier by 6% of...
participants (Dairy Australia, 2014). The longer payback period of energy-efficient equipment in agriculture relative to industrial operations is in part due to the more intermittent use of equipment (e.g. seasonally, or pumping is only required a couple of days a week). However, unlike the food manufacturing industry, intensive agriculture has not benefited from the previous Federal Government’s Clean Technology Investment Program (Victorian Farmers Federation, 2014).

Please consider ...

Are targeted energy-efficient financing solutions of help and, if so, what form should such assistance take?

- Are farmers aware of the potential benefits? Are they seeking finance for energy efficient upgrades? If they are, what payback or other criterion are they using? What is the threshold for investment decisions for the different farm types and segments?
- What should be the key energy-efficient financial product design features, given the prevalence of drought and, therefore, volatility in cash flow experienced by many farmers?

5.2. Management practices and cultural barriers

Well-designed policy interventions considering the whole-of-farm system, farmers’ knowledge of technologies and farming systems, as well as a demonstration of the benefits, are key to shifting prevailing practices and beliefs.

Farm energy planning pilots conducted by NSW Farmers found that farmers who were unwilling to adopt new technologies held personal beliefs that were almost opposite to current scientific knowledge (Eyre et al., 2014). This is evident in recent survey responses by dairy farmers, with 16% indicating they do not believe the recommended energy-efficiency measures will make a difference (Dairy Australia, 2014). Nearly a third of participants in the Dairy Australia EEIG programme indicated that the fact that their existing equipment is still in working order prevents them from making investments in more energy-efficient equipment (Dairy Australia, 2014). In some instances, such equipment may be beyond its commercially useful lifespan, as highlighted by the Queensland farm audits discussed earlier (see Box 7). However, NSW Farmers reported that when energy innovation staff worked with farmers who remain committed to inefficient technologies in the face of conclusive financial arguments to the contrary, such views tended to shift with the accumulation of learning experiences demonstrating the benefits (Eyre et al., 2014).

Energy efficiency is rarely given priority in the design of water-efficient irrigation systems. This approach is further re-enforced by government policies, which in response to drought, have focused on water savings, such as the On-farm Irrigation Efficiency Program (Department of the Environment, 2014), without adequate consideration of energy cost (Jackson et al., 2010). While many of these system upgrades have saved water, in some systems this has been at the expense of increased energy use. The more water efficient the irrigation, generally the more energy intensive it is; the average energy costs for pumping range from $8,000 per annum for a water-inefficient system, to nearly a $100,000 for a highly water efficient system (Eyre et al., 2014).

Likewise, very limited funds have been invested in RD&E and education on energy- and water-efficient irrigation design. Without this, many irrigators lack the knowledge and confidence to invest in new irrigation systems. As a result, the escalation in energy prices is now starting to impact negatively on water-efficiency programs (National Farmers’ Federation, 2014c). There are reports of farmers
delaying investment in more water-efficient systems because they are concerned about the increased energy costs and uncertainty around future energy pricing. Participants in a recent NSW project also provided anecdotal evidence of major farms that are considering decommissioning water-efficient systems and returning to flood or open-channel irrigation to avoid exposure to increasing energy costs (Eyre et al., 2014).

5.3. Information, knowledge and expertise

Many farmers are aware of the need to manage energy consumption and are aware of the trade-offs required in, for example, water-efficient irrigation system designs. However, they are largely unaware of how this increased energy consumption can be minimised and controlled, or how to select the most energy-efficient equipment for the task at hand. Due to the lack of practical information targeting farmers and the increased sophistication and complexity of energy solutions, they are often not empowered to make the optimal investment decision for their circumstances.

Farmers are often uncertain about many aspects of an investment in upgrading or replacing equipment or irrigation systems, including the life cycle cost implications of investment decisions pertaining to, for example, tractors and irrigation plant. This makes them heavily reliant on advice from consultants and irrigation system, energy equipment and renewable energy solution sales people. This lack of knowledge makes them vulnerable to ‘mis-selling’. The NSW Farmers’ Association identified instances where farmers who have been sold inappropriate, excessive capacity, or unreliable technology. For example:

- Many farmers have been sold solar PV systems that are unsuitable for the application and/or poorly installed.

- Tractor sales representatives often sell the ‘power’ of the vehicle rather than, what is inevitably a more complex sales process, the life-cycle cost of the tractor associated with sizing the tractor for the task and fuel-efficiency features.

- Whilst new irrigation systems are typically not optimised for both energy and water costs, with water costs and the protection of yield being the primary considerations, instances of deliberately inefficient designs have been reported. For example, certain irrigation system providers specify cheaper, too narrow pipes (to win tenders) without informing farmers of the increased friction and energy cost associated with such designs (Eyre et al., 2014).

These experiences have a negative demonstration effect, which is a hindrance to the uptake of both water- and energy- efficiency programs, with a negative impact on farm productivity in general. Lack of awareness of the structure of energy contracts and the impact that over-peak demand charges have on total cost of electricity, in particular, can also undermine energy productivity programs (e.g. energy savings do not translate into $-savings if consumption constitutes less than 50% of total electricity charges) (NSW Irrigators Council and Cotton Australia, 2013)

More broadly, there is no reliable breakdown of energy use in the agriculture sector and sub-sectors, nor information on the age or size of tractor fleets in operation and fuel usage per end use application. Work undertaken as part of the EEIG Program is starting to fill some of these gaps. Nonetheless, significant information gaps prevail. Without comprehensive baseline data about on-farm energy use, it is difficult to assess the savings potential at a sector level and individual farm level. Collection and analysis of this data is not a common practice. Therefore, building a business case to justify investment in more energy-productive systems is challenging, adding further risk to potential financiers in a sector subject to seasonal vagaries.
6. Overcoming the barriers

Please note ...
This section is intended to provide some ideas for stakeholders to address in developing the 2XEP Roadmap over the next six months. This section is not intended to prescribe solutions. It provides an initial list of potential program concepts for a co-ordinated industry-wide program.

Barriers cannot typically be addressed independently. Unless a farm business is confident about its future, it will not invest. For finance to flow and fund capital projects, there is a requirement for suitable data to inform business cases, farmers skilled in using information to design effective solutions, a regulatory environment supportive of improving access to new technologies and markets. Key areas for consideration are discussed under the headings of:

- Collaborative research and innovation
- Information and people capabilities
- Investment in energy
- Farm incentives and support
- Regulation and standards
- Data gaps and other considerations

6.1. Collaborative research and innovation

A recent report on industry research collaboration highlights that 80% of Australian business leaders believe that innovation is the main driver of a competitive economy and that businesses engaging in collaborative innovation with research organisations are more likely to report increases in productivity (NSW Business Chamber and Sydney Business Chamber, 2014).

The A2SE 2XEP Roadmap considers innovation in its broadest context, including technological, process and business model innovation. It is, therefore, central to all four strategic areas of focus to improve energy productivity. The high degree of variation across different farm systems, coupled with the diversity of stakeholders across farming, federal, state and territory governments, research and commercial bodies, demands a coordinated approach to maximise the impact of research.

There are numerous examples of research collaborations in the agriculture sector, often with the support of government. Rural RD&E funding is estimated at around $715 million per annum, with $250 million targeting Rural Research and Development Corporations (RDCs) (Department of Agriculture, 2014; Gray et al., 2014). However, there have been calls for increased consolidation of research corporations (Productivity Commission, 2014), as well as the need for a more integrated approach to research.

For example, the NSW Farmers’ Association is proposing a multi-state/national sustainable irrigation program to achieve integrated water, energy and productivity objectives by addressing whole of system energy (not just on-farm but throughout the water storage and distribution system). Such a program should centre on a suite of demonstration projects integrating established and prospective...
technologies, but should also include policy and economic elements. It should be explicitly located within both the Primary Industries Standing Committee (PISC) RD&E strategy and the COAG water reform process (Eyre et al., 2014).

Box 13: Northern NSW Grazier pilots NBN-enabled SMART farm

SMART = sustainable, manageable and accessible rural technologies

The University of New England, in conjunction with project partners the Australian Centre for Broadband Innovation (ACBI), NBNCo and the CSIRO, is transforming a typical grazier property into a high-tech demonstration site for new technologies and intelligent systems (University of New England, 2014).

The project is exploring ways to improve farm productivity through the use of immersive and sentinel vision and communication technologies, far-end control and autonomous systems such as remotely piloted aircraft systems (RPAS) and robotics, wireless cattle tracking and sensor networks that produce a ‘living map’ of soil moisture. This soil moisture data can be used to determine the precise water and fertiliser requirements, boosting crop and pasture yields while significantly reducing water consumption and energy use and shrinking the farm’s carbon footprint. The project partners will use SMART Farm to evaluate the impact of these technological innovations on farm productivity, profitability, safety and sustainability, determining their potential benefits and accelerating their adoption by farmers around Australia (White, 2014b).

Mechanisms through which business, industry and research institutions collaborate on innovative solutions, can also provide a platform for information sharing and capacity building. For example:

- The broadband connectivity that enables the SMART Farm, discussed in Box 13 above, is also used as a connected classroom where the community, as well as students of all ages, can access the latest data streaming in from a range of field, animal and machinery sensors (University of New England, 2014).

- Knowledge aggregation channels that bring together the many great initiatives already under way, whilst recognising the diverse communities of interest, such as the AgInnovators web portal launched in November 2014 (AgInnovators, n.d.). This portal could also enable farmers to see where the distribution and marketing sector is going in terms of niche markets, enabling them to start shifting in that direction, and it will connect farmers with the rest of the supply chain (AgInnovators, n.d.; Claughton, 2014)

Please consider ...

Innovation and knowledge hubs exist around the country and the globe. What need to be done to ensure knowledge is shared and linked, and funding does not duplicate existing programs?

6.2. Information and people capabilities

- Energy efficiency increasingly features on the agendas of industry associations such as Cane Growers and Cotton Growers in Queensland, the National and NSW Irrigators Councils, Dairy Australia, APLA, NSW Farmers’ Association and many more. The involvement of industry associations in shaping and driving the implementation of the energy-productivity Roadmap is essential. However, the importance of governments’ continued support for information campaigns, pilot studies, training, demonstration and capacity building should not be underestimated. There is broad-based support amongst industry stakeholders (National Farmers’ Federation, 2014c;
National Irrigators’ Council, 2014) for continued policy support for programs such as the Department of Industry EEIG program, as well as other state and sector level programs that support audits, energy benchmarking and demonstration projects to identify, as well as assist with the planning and implementation of, upgrades. (See shaded Box 14.) The success of these programs\(^{19}\) is to a large extent due to the focus on demonstrating the advantages of adopting energy-efficient technologies and management practices, directly engaging the farmer as leader of the change program.

**Box 14: Turning knowledge into action that can deliver sustained energy productivity**

The Department of Industry has invested in a range of energy-efficient information programs, assisting to build an actionable knowledge base. This includes the Department of Industry’s Energy Efficiency Information Grants (EEIG) program. Many agriculture sub-sectors and regions are benefiting from these programs. High quality resources are increasingly available from industry associations through the EEIG program:

- Apple and Pear Australia Limited
- Australian Meat Industry Council
- Cotton Research and Development Corporation
- Dairy Australia
- North East Farming Futures Group (Western Australia)
- NSW Farmers Association
- South Australian Wine Industry Association

The Carbon Farming Futures program of the Commonwealth Government also supports research, on-farm demonstration, extension and outreach activities that enhance productivity, result in economic gain and reduce greenhouse gas emissions (Gray et al., 2014).

There is also general support from the sector for the Federal Government’s proposed Industry Skills Fund and the Entrepreneurs’ Infrastructure Program (National Farmers’ Federation, 2014a). Farmers should be guided to reinforce energy-management practices by:

- Investing in formal and on-the-job training that has clear commercial benefits. For example, tractor training courses are available for as little as $200, with a return of $2,200 based on current driver practices used on some farms (Flores, Hoffmann, Rostron, & Shorten, 2014c).
- Including energy-productivity metrics in the contracts of service providers and employees.
- Introducing data collection, monitoring and control.

6.3. **Investment in energy programs**

Financiers are gradually coming to grips with some energy asset classes, often with the support of the CEFC. Some mainstream financial institutions are now offering attractive debt financing (particularly to their existing customers) with terms of up to seven years, whilst specialist agricultural financiers could provide interest-only loan terms of up to 15 years (Rabobank, n.d.). Off-balance sheet options are also becoming more common e.g. operating leases and third-party build/own/operate models, where clients enter into power purchase agreements on renewable energy projects. Nonetheless, there are still some major obstacles to turning energy-savings ideas into compelling business cases to secure

\(^{19}\) See case examples highlighted in earlier sections of this report.
financing (or convince the farmer it is worth investing in). This is in part a communication and knowledge issue, but other key obstacles include:

- Understanding of energy use in key processes on a farm across diverse geographies
- Reducing the perceived risk of energy projects, given the volatility of cash-flow streams typically associated with the sector and the introduction of innovative new technologies
- Overcoming the relatively small scale of many energy projects, which suggests there is potentially a need for intermediaries (as aggregators) to de-risk and scale investments to ensure energy-efficiency projects are more attractive to finance providers.

Where novel approaches are being developed to close the financing gap, it is critical that the approaches and lessons be widely communicated through case studies.

6.4. Farm incentives and support

Individual farmers and agricultural peak bodies in their submissions to the Commonwealth Energy White Paper and other channels have expressed concern about the rising cost of energy and the impact this has on the sustainability of the sector (Dairy Australia, 2014; National Farmers’ Federation, 2014; National Irrigators’ Council, 2014; Queensland Cane Growers Organisation Ltd, n.d.; Victorian Farmers Federation, 2014).

There is reliable evidence that incentive programs motivate businesses to invest in improved energy productivity. These programs can be in the form of grants, white certificate programs and other external funding. But these programs are expensive and need to be funded. Generally this funding comes either from consolidated government revenue (tax payers) or from energy users (through small environmental charges in retail or wholesale energy rates). The past two years have seen the repeal of most of the federal programs targeting energy efficiency and it is not expected that the current federal government will introduce major new programs (Department of Industry, 2014), with the exception of the Emission Reduction Fund (ERF) and Carbon Farming Initiative more specifically. The ERF, which is the planned centrepiece of the Commonwealth’s Direct Action Plan for reducing carbon emissions, provides incentive payments for energy-productivity improvements, but it is not likely to have an impact on energy project viability (Innes, 2014).

Government funding support for the sector includes the $100 million set aside for the four years commencing 2014–15 for a competitive grant program to deliver cutting edge technology and applied research (Department of Agriculture, 2014; Gray et al., 2014), funding for sustainable farm practices under the ‘Caring for our Country’ Program, as well as drought relief, water-efficiency loans, a range of tax concessions to smooth out payments and reduce assessable income, as well as targeted support to farmers in financial distress through financial counselling and short-term concessional loans (Department of the Environment, 2014; Gray et al., 2014). However, none of the funding targets energy productivity explicitly, nor is energy productivity a built-in criterion, for example, in the water-efficient irrigation program, as earlier discussed.

In Europe, government financial support has been tied to farmers’ compliance with the nitrogen reduction directive (KPMG, 2013). Australia could consider extending this type of approach to the adoption of energy-efficient management practices when financial support is provided to farm businesses, thereby ensuring they become more competitive. Furthermore, industry associations and farmers have put forward a wide range of proposals, from calling for direct grant funding for the sector, similar to the now suspended CTIP program for manufacturing (see shaded Box 15 below), white certificate schemes for irrigators using the project impact assessment method as defined under the NSW Energy Savings Program.
6.5. Regulation and standards

In the current political environment, regulation is not the preferred policy option to effect change in markets (Department of Industry, 2014). While the 2XEP program will prioritise other mechanisms to drive change, regulatory barriers to energy productivity and well-targeted and -designed regulation, must be considered.

First, where governments are extending support, the industry is calling for a more nuanced policy approach. In order to deal with the productivity challenges facing the agriculture sector, in the words of the NFF, the ‘complex nexus between water, carbon and energy’ needs to be recognised in policy design and implementation (Eyre et al., 2014; National Farmers’ Federation, 2014c).

Second, government also has a prominent role to play in building ‘Brand Australian’ in the global food market and facilitating access for farmers to new markets. The work of the Commonwealth in this regard is recognised (Australian Trade Commission, 2013) and support welcomed. However, distribution infrastructure is a critical element of global agricultural competitiveness and market access strategy. Regulatory changes recommended by the Productivity Commission to restore cost-competitive coastal transport has support from industry (National Farmers’ Federation, 2014b). In addition, strategic investment in rural transport is also central to energy competitiveness. The mode of transport (e.g. shipping, rail or road), as well as ‘congestion’, that results in longer storage, have direct energy-productivity implications.

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20 Cold storage is particularly energy intensive.
Third, the extension of minimum equipment performance standards to agricultural equipment can be cost effective in accelerating market transformation. (See shaded Box 16). The same principles could also be extended to an energy efficient certification or labelling system for pressurised water networks (Cabrera, Cabrera, Cobacho, & Soriano, 2014). Such a scheme has the support of some industry stakeholders (Eyre et al., 2014).

![Box 16: Performance standards for industrial equipment](image)

The Equipment Energy Efficiency (E3) program has been predominantly focused on domestic appliances. It was estimated in 2010 that minimum energy-efficiency performance standards (MEPS) applied to industrial and manufacturing equipment could save at least $1.5 billion per annum in industry energy costs and annual greenhouse abatement of up to 2.8 Mt CO\(_2\)e (COAG, 2010, cited in Smith, 2013).

Increasing coverage of industrial products beyond certain classes of motors and drives is being planned. Electric and gas process and industrial equipment standards are now projected to account for 33% of the estimated 101.9 PJ energy savings attributed to the E3 program between 2014 and 2030 (Kimura & Le Thi, 2013).

6.6. Other considerations

6.6.1. Data

Whilst there is sufficient information emerging from the EEIG Program and other data sets to develop a rough estimate of the scope for energy productivity improvement in key agriculture sub-sectors, data is not available to support the development of a robust national energy productivity strategy. The development of sector and sub-sector energy baselines, with reference to end use and geographic regions/farm types, is essential. An inventory of large equipment, such as tractors, would also enhance the development of targeted initiatives.

6.6.2. Address energy competitiveness issues from escalating energy prices

While not included in the formal scope of work for the 2XEP program, industry has expressed concern that this program also recognise and communicate the other element of the energy competitiveness issue i.e. how government should act regarding energy prices, as action to reduce energy prices in the medium term would greatly assist efforts to improve energy price competitiveness specifically and energy productivity more broadly.

It is proposed that 2XEP communicate the need for action to restrain energy prices to improve competitiveness alongside our main message of doubling energy productivity. Key issues in this regard include policy certainty on the diesel rebate and electricity tariff structures applicable to regional Australia.

6.6.3. Role of renewable energy

Defining the role of on-site renewables (wind, solar PV and solar thermal) in improving energy productivity in the agriculture sector needs further consideration. With regard to the secondary energy productivity metric, this could include consideration of renewable energy as a hedge against future energy cost rises.
7. **Next steps**

This report was prepared to form a starting point for discussion to address the opportunities, barriers, policy recommendations and proposed implementation plan for 2XEP in the agriculture sector. Key issues for consultation include:

- **Defining a data collection strategy.** This may include collection of better disaggregated data on tractor fleets, fuel usage by subsector and benchmarks on fuel usage per hectare for different end-use applications to provide a better understanding of the current state of energy use and energy productivity in the agriculture sector. This data could inform the establishment of achievable and sustainable future goals for energy productivity.

- **Agreeing the metrics for measuring energy productivity improvement in the sector (and determining whether different metrics are needed for sub-sectors), and cascading metrics down to farm level.**

- **Defining the scale of opportunities in the sector and agreeing an energy productivity improvement target for 2030 for the sector.** There is sufficient evidence that 2XEP is achievable, though challenging to justify with the existing dataset; it will be used as a starting point for discussion.

- **Whichever target is set, it will also be important to set milestones for achievement year by year and a process for tracking progress.**

- **Defining the key barriers (and they may be somewhat different across each sub-sector of agriculture) and developing a detailed and integrated sector-led program to overcome these barriers and support businesses to make substantial energy productivity gains.**

- **Implementing initial programs during the 2XEP Roadmap development activity if possible.** Particular consideration could be given to:
  - The viability of designing and launching a voluntary leadership and recognition program ('2XEP Challenge') in parallel with implementing the energy productivity pathways.
  - Continuation of currently funded information and education programs covering best technologies and energy use and management practices customised for key sub-sectors.
  - Pricing or regulatory reform that would help drive 2XEP in the sector.

- **Developing recommendations for government policy measures to facilitate 2XEP achievement in the sector.**

- **Modelling the costs and benefits of recommended measures for the agriculture sector.**

- **Communicating the outcomes of the industry Roadmap and marketing the benefits of implementing the program.**

- **Defining and agreeing the best means to engage companies on the journey.** This may vary by sub-sector and between large corporate and family/SME operations.

- **Delivering and measuring the outcomes.**

A2SE is looking forward to working with stakeholders to scope opportunities, consider options and drive change for the better.
References


NSW Office of the Environment and Heritage. (2014). *Small business energy efficiency program – Agriculture data set (Summary supplied to A2SE by NSW Farmers)*.


### Appendix A. Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<tr>
<td>AIP</td>
<td>Australian Institute of Petroleum</td>
</tr>
<tr>
<td>ANZSIC</td>
<td>Australian and New Zealand Standard Industrial Classification</td>
</tr>
<tr>
<td>boe</td>
<td>barrel of oil equivalent</td>
</tr>
<tr>
<td>BREE</td>
<td>Bureau of Resources and Energy Economics</td>
</tr>
<tr>
<td>CTIP</td>
<td>Clean technology Investment Program</td>
</tr>
<tr>
<td>EEO</td>
<td>Energy Efficiency Opportunity (Program)</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GVA</td>
<td>Gross Value Added</td>
</tr>
<tr>
<td>NRMA</td>
<td>National Roads &amp; Motorists' Association</td>
</tr>
<tr>
<td>RD&amp;E</td>
<td>research, development and extension</td>
</tr>
<tr>
<td>RD&amp;E</td>
<td>Research, development and extension</td>
</tr>
<tr>
<td>TGP</td>
<td>Terminal gate prices</td>
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<tr>
<td>US/USA</td>
<td>United States of America</td>
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Appendix B. Conversions

Reproduced from BREE (Department of Industry, 2014)

**UNITS**

<table>
<thead>
<tr>
<th>Metric units</th>
<th>Standard metric prefixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>J joule</td>
<td>k kilo 10³ (thousand)</td>
</tr>
<tr>
<td>L litre</td>
<td>M mega 10⁶ (million)</td>
</tr>
<tr>
<td>t tonne</td>
<td>G giga 10⁹ (billion)</td>
</tr>
<tr>
<td>g gram</td>
<td>T tera 10¹²</td>
</tr>
<tr>
<td>Wh watt-hours</td>
<td>P peta 10¹⁵</td>
</tr>
<tr>
<td>b billion (1000 million)</td>
<td>E exa 10¹⁸</td>
</tr>
</tbody>
</table>

**STANDARD CONVERSIONS**

1 barrel = 158.987 L
1 mtoe (million tonnes of oil equivalent) = 41.868 PJ
1 kWh = 3600 kJ
1 MBTU (million British thermal units) = 1055 MJ
1 m³ (cubic metre) = 35.515 ft³ (cubic feet)
1 L LPG (liquefied petroleum gas) = 0.254 m³ natural gas

Conversion factors are at a temperature of 15°C and pressure of 1 atmosphere.

**INDICATIVE ENERGY CONTENT CONVERSION FACTORS**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Conversion Factor</th>
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<tr>
<td>Black coal production</td>
<td>30 GJ/t</td>
</tr>
<tr>
<td>Brown coal</td>
<td>10.3 GJ/t</td>
</tr>
<tr>
<td>Crude oil production</td>
<td>37 MJ/L</td>
</tr>
<tr>
<td>Naturally occurring LPG</td>
<td>26.5 MJ/L</td>
</tr>
<tr>
<td>LNG exports</td>
<td>54.4 GJ/t</td>
</tr>
<tr>
<td>Natural gas (gaseous production equivalent)</td>
<td>40 MJ/m³</td>
</tr>
<tr>
<td>Biomass</td>
<td>11.9 GJ/t</td>
</tr>
<tr>
<td>Hydroelectricity, wind and solar energy</td>
<td>3.6 TJ/GWh</td>
</tr>
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</table>
Appendix C. A2SE 2XEP Roadmap

This report incorporates the agriculture sectoral overview, which is part of the Roadmap Foundation modules, as illustrated below.

Figure 14: The Energy Productivity Roadmap modules